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The Use of the Ontosemiotic Approach to an Analysis of Geometry in Brazilian Curricular Materials

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ABSTRACT

The present article aims to present some partial results of the master dissertation titled "Geometry in Brazilian Curricular Materials by the Ontossemiotic Approach", under development in the Professional Master Program of Science and Mathematics Teaching of the Cruzeiro do Sul University in São Paulo. As presuppositions a research perspective that aims to qualitatively analyse curricular materials of the 5th year of an elementary school in the scope of geometry. For the analysis in question, frameworks were developed based on didactic adaptations (epistemic, mediational and ecological) from the assumptions of the Ontosemiotic Approach. In this way, the article will discuss the abovementioned didactic adequacy frameworks in order to offer subsidies so that teachers can be guided when analysing curricular materials.

Keywords: Geometry. Curricular Materials. Ontosemiotic Approach.

A Utilização do Enfoque Ontossemiótico para a Análise da Geometria nos Materiais Curriculares Brasileiros

RESUMO

O presente artigo tem como objetivo apresentar alguns resultados da dissertação de mestrado intitulada "A Geometria nos Materiais Curriculares Brasileiros pelo Enfoque Ontossemiótico", desenvolvida no Programa de Mestrado Profissional de Ensino de Ciências e Matemática da Universidade Cruzeiro do Sul em São Paulo, tendo como pressupostos uma perspectiva investigativa que visa analisar qualitativamente materiais curriculares do 5º ano do Ensino Fundamental no âmbito da geometria. Para análise em questão, foram utilizados quadros desenvolvidos a partir das adequações didáticas (epistêmica, mediacional e ecológica) oriundas dos pressupostos do Enfoque Ontossemiótico. Dessa forma, o artigo discorrerá sobre os quadros de adequação didática supramencionado visando oferecer subsídios para que professores possam guiar-se ao analisarem materiais curriculares.

Palavras-chave: Geometria. Materiais Curriculares. Enfoque Ontossemiótico.

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INTRODUCTION

Brazil has one of the most advanced programs for the acquisition and free distribution of didactic books for the public-school system (PNLD), which guarantees students wide access to this valuable educational resource. Considering the magnitude of this program, we believe that research that covers the analysis of curricular materials still needs to be expanded, considering the importance of these resources for Brazilian education.

In the same way, we consider the study of geometry as highly relevant to science, since it develops reasoning through forms and allows us to broaden our vision and spatial orientation, as well as its wide application in daily life, helping even in understanding and solving questions of other areas of human knowledge.

Thus, the analysis of geometry contents in Brazilian curricular materials can contribute to reflect on the way these contents are approached, as well as on how they are adapted to the curricular prescriptions and what resources are used to foment the teaching process-learning. In order to tackle these and other issues, we will apply the components and underlying indicators of the ecological, epistemic and mediational adequacies from the Ontosemiotic Approach.

ONTOSEMIOTIC APPROACH

The Ontosemiotic Approach was developed at the University of Granada in the early nineties and arose from the need to clarify and compare the different perspectives of mathematics didactics. Godino and his collaborators understood that it was necessary for the didactics of mathematics to consider the diverse contributions of disciplines such as psychology, pedagogy, philosophy, and sociology, studying in greater depth the dialectical relations between thought (of mathematical ideas) and language (system of signs) of problem situations, in order to define a unified model of cognition and mathematical instruction.

The theoretical tools which constitute the Ontosemiotic Approach (EOS) are based on the formulation of an ontology of mathematical objects that takes into account the triple aspect of mathematical activity: as a socially shared problem-solving activity, as a symbolic language and as a logically organized conceptual system (Godino, Batanero & Font, 2008).

The EOS proposes an articulation of the epistemological and cognitive perspectives through the structuring of its theoretical base in five components, which are: 1 – systems of practices, 2 – configuration of mathematical objects and processes, 3 – didactic configuration, 4 – normative dimension and 5 – didactic adequacy.

However, in this article, we will apply only the notion of didactic adequacy (Godino, 2011), since this is the component which deals with a set of instruments for intervention and analysis of curricular materials, which we will address in this research.

DIDACTIC ADEQUACY

According to Fonseca (2013), the notion of didactic adequacy ("didactic suitability") was introduced in the Ontosemiotic Approach as the systemic approach responsible for the conception, implementation and evaluation of teaching and learning of mathematics. This notion allows us to move from a "descriptive – explanatory didactics to normative didactics, that is, didactics that is oriented towards an effective intervention in the classroom" (Godino, 2011, p.5). The didactic adequacy, therefore, comprises the articulation between the adaptations: epistemic, cognitive, mediational, interactional, emotional and ecological.

Below are the descriptions of the adjustments:

> Epistemic adequacy: refers to the degree of representativeness of the institutional meanings implemented (or intended) in relation to a reference meaning. For example, the teaching of addition in primary education can be limited to learning routines and exercises of algorithm application (low adequacy), or to take into account the different types of additive situations and to include justification for the use of algorithms (high adequacy)
>
> Cognitive adequacy: expresses the degree of meanings intended/implemented in the zone of proximal development of the students (Vygotsky, 1934), as the proximity of the personal meanings reached with the intended institutional meanings. A teaching-learning process with a high degree of cognitive adequacy would be the study of arithmetic operations with numbers of three or more figures, in which the teacher makes an initial evaluation to know if the majority of the students dominates the numbers of one and two figures and, in case they do not master, the instruction process begins (class) working these numbers.
>
> Interaction adequacy: a teaching-learning process will be better adapted from the interactional point of view if the didactic configurations and trajectories allow identifying potential semiotic conflicts (which can be detected a priori), and on the other hand to solve the conflicts that are produced during the teaching process. For example, a process of study carried out according to a sequence of situations of actions, formulations, validations and institutionalizations (Brousseau, 1996), have potentially higher semiotic adequacy than a master process (which refers to the classic way of teaching mathematics, i.e. presentation of content by the teacher, followed by application exercises for students), because the master process does not take into account the difficulties of the students.
>
> Mediational adequacy: the degree of availability and adequacy of the material and temporal resources necessary for the development of the teaching-learning process. For example, if the teacher and the students had available digital resources relevant to the subject in question (Cabri, for flat geometry), the teaching-learning process that relied on these resources would potentially have greater mediational adequacy than another based only on the use of picture, pencil and paper. Similarly, an example of a teaching-learning process with a high degree of mediational appropriateness in relation to temporal means would be a master class (of traditional classes), in which the teacher would reproduce in full his interaction with the students by the meaning required.

> Emotional adequacy: the degree of involvement (interest, motivation) of the student in the teaching process. Emotional adequacy is related to both the factors which depend on the institution and the factors which depend on the student and their school history. For example, the process based on the use of situations-problems that are of interest to the students would have high emotional adequacy.
>
> Ecological adequacy: Degree in which a teaching process fits the educational process in force in society. It concerns everything outside the classroom (society, curriculum, school, pedagogy, didactics of mathematics). (Godino, Batanero & Font, 2008, p.14, our translation)

The authors conclude that, for the overall adequacy of the teaching-learning processes, it is required that the components of adequacy are integrated, and this is possible through reflection and investigation by teachers and other agents who share responsibility for teaching.

Likewise, they consider these adaptations useful for the analysis of projects and teaching experiences, and for them, the elements can interact with each other, which suggests the extraordinary complexity of teaching and learning processes.

Figure 1 summarises the criteria which make up the didactic adequacy, and the regular hexagon corresponds to the intended or programmed teaching processes, whereas the internal irregular hexagon corresponds to the adequacies effectively achieved in the implementation of a teaching and learning process. At the base, according to Fonseca (2013), are the epistemic and cognitive adaptations, because the study process is related to the development of specific knowledge.

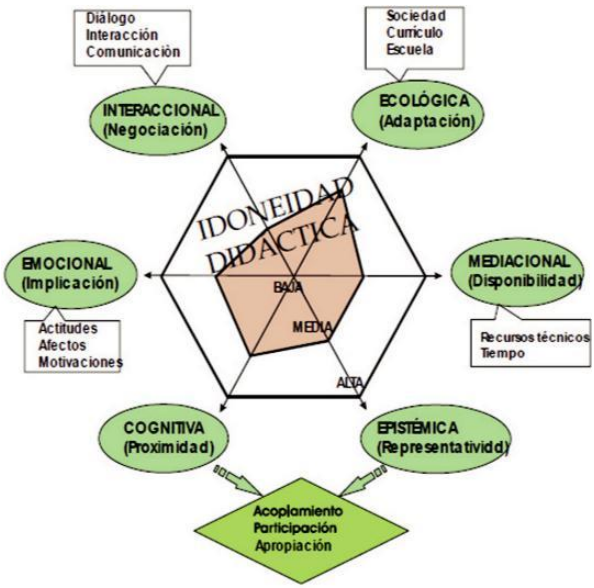

Figure 1. Components of didactic adequacy (Godino, Batanero & Font, 2008, p.16).

In the following sections, we will detail the analysis tables constructed from the perspective of the epistemic, mediational and ecological adequacy (Tables 1, 2 and 3). The cognitive, emotional and interactional adequacy will not be addressed in this study, since they are focused on the learner practice, on the teacher-student relationship.

In addition, as we will not consider the cognitive, emotional and interactional adequacies, we will not analyse the overall adequacy, which includes the analysis of the six adequacies, according to Figure 1.

For the epistemic, ecological and mediational adjustments, we will detail the components and indicators from the tables.

MATERIALS AND METHODS

In order to analyse the epistemic, mediational and ecological adequacies of the curricular materials selected for this research, we opted to develop a new data research instrument, to cover the didactic reality of Brazilian books. For this, we rely on the adaptation of the analysis grids of Fonseca (2013), the analysis tables of Santana (2017) and the indicators proposed by Godino et al. (2013). Below are the tables which we will use for the collection of research data:

Table 1
Epistemic Adequacy Analysis Table.

EPISTEMIC ADEQUACY (*Idoneidad Epistémica*)		
Categories	**Subcategories**	**Analysis of Curricular Materials**
1. Transparency of underlying conceptions		Does the book explain the intention of mathematical/ pedagogical activity?
2. Organisation and sequencing of activities	**2.1. Type of organisation: linear, spiral or interlaced.**[1]	Are the contents presented in a linear, spiral or interlaced manner?
	2.2. Rationale for order and sequencing of activities	Does the book justify the way the activities were organised? Are there any suggestions for sequencing activities?

[1] According to Santana (2017), the organization and sequencing of activities category comprises three subcategories: linear, spiral or interlaced.
In linear organization the contents are approached in a rigid and linear sequence, that is, it comprises the idea of a prerequisite, in which a theme can only be approached when the antecedent subject has already been presented. The interlaced organization consists of several points that are interconnected by different branches, in which, according to Pires (2000), each point constitutes a knowledge to be constructed by the students in the classes of mathematics, and the ramifications are the relations between the points, considering the different paths that can be traveled to connect one point to another. Finally, in the spiral organization each theme is initially developed in a simple way, and then reintroduced at higher levels. (Santana, 2017 apud Pires, 2000).

EPISTEMIC ADEQUACY (*Idoneidad Epistémica*)			
Categories	**Subcategories**		**Analysis of Curricular Materials**
3. Anticipation of student responses			Does the book explain how students can interpret a particular situation? Do you reflect on possible student responses and difficulties?
4. Learning situations	**4.1 Introduction / Motivation**		The situations they use to introduce/motivate a theme of geometry: are they situations of mathematics itself? Of other sciences? From real-life situations? Do they have a resolution?
	4.2 Examples (resolved tasks)		Are the examples presented before or after the formal definition? What do you want with them? Is the resolution complete or incomplete? Formal or intuitive?
	4.3 Tasks (which authors propose to the student)	**Previous knowledge**	Do they propose tasks to review the prerequisites of the activity?
		Emerging knowledge	**1 – Figural representation:** Constructions of geometric solids, representations in the Cartesian plane, in checkered meshes, construction of geometric figures.
			2 – Calculation: Calculation of areas, volumes, perimeters, measures of sides, angles, etc.)
			3 – Exploration: Problems that involve the selection of the most appropriate tools to solve a problem.
			4 – Application of the definition: Applies the definition to solve the tasks, makes use of lemmas, theorems, postulates and axioms.
			5 – Application of a property: interprets and applies a particular property in a task
			6 – Conjecture and argue: presents a logical discourse as an answer to the tasks/activities
			7 – Proof: logical-deductive, inductive or empirical procedures used to validate a proposition.
			8 – Mathematical Modelling: Situation contextualised and lived by the reader who seeks to find ways to solve certain situations.
5. Language			Verbal, numerical, figural, algebraic or tabular.
6. Concepts			Are the concepts presented in a formal or intuitive way? Are the proposed concepts developed from a single definition?
7. Propositions	**7.1 Type of exposure.**		Formal or intuitive?
	7.2 Proves or not.		If they prove, justify or only expose?
	7.3 Used or just exposed.		Is the property used in enforcement activities or other situations?

EPISTEMIC ADEQUACY (*Idoneidad Epistémica*)		
Categories	**Subcategories**	**Analysis of Curricular Materials**
8. Procedures	**8.1 Several approaches are used.**	Do they use various resolution procedures? Or just one for each case?
	8.2 They are justified or not.	Are the procedures justified?
9. Arguments	**8.3 New technologies are used.**	Software, graphing calculators, etc.
	9.1 It uses a discursive practice to convince the validity of certain properties, based on natural language, graphic, ...	Is there a discursive language justifying the procedures? If so, which language?
	9.2 Type of proof used.	Empirical, inductive, logical-deductive, counterexamples, equivalences, etc.

Adapted from Fonseca (2013) and Santana (2017).

Table 2
Table of Analysis of Mediational Adequacy.

MEDIATIONAL ADEQUACY (*Idoneidad Mediacional*)		
Categories	**Subcategories**	**Analysis of Curricular Materials**
10. Material resources (manipulables, calculators, computers)		Do they use manipulatives and digital materials? Do the situations involve concrete models, visualisation, rich tasks and adapted to the intended content?
11. Organisation (scheduling of time for each activity and room layout)		Does the book suggest the time spent applying a particular activity? Does it indicate the layout of the classroom? Should activities be done individually or in groups?

Adapted from Fonseca (2013) and Godino (2013).

Table 3
Ecological Property Analysis Table.

ECOLOGICAL ADEQUACY (*Idoneidad Ecológica*)	
Categories **Subcategories**	**Analysis of Curricular Materials**
12. Adaptation to the prescribed curriculum	Does the content correspond to the curriculum guidelines? Do you review prerequisites according to the curriculum?
13. Openness to didactic innovation	Innovation based on research and reflective practice? Integrates new technologies?
14. Socio-professional and cultural adaptation	Does the content contribute to the socio-professional training of students?
15. Education in values	Does it contemplate the education of democratic values and critical thinking?
16. Intra and interdisciplinary connections	Do the contents relate to other intra and interdisciplinary content?

Adapted from Fonseca (2013).

RESULTS

Analysing, therefore, one of the selected books (which we will refer to as book L1), they present the following results:

In the first three categories, which are transparency of adjacent conceptions, organisation and sequencing of activities and anticipation of students' responses, it is inferred that L1 presents in a succinct way the themes of the tasks but does not present a clear organisation or justification for the order and sequencing of activities. Thus, we highlight the concern of Santana (2017), according to whom for an Interlaced organisation, as done in book L1, it is necessary to make the connections from one point to another, it is recommended to show the justification of order and sequencing of activities. In addition, although it allows the interaction between students, student-teacher, there is a reflection of the possible answers of the students.

In the learning situations, it is highlighted that introducing or motivating a theme, favours the contextualization of the contents and the interaction between students; it is also observed that some content starts with problem situations, exercising the ability to explore, understand and memorize what has been seen; however, sometimes the process becomes very directive, which may weaken the arguments.

Likewise, the number of activities proposed for the area of geometry receives little attention from the book, treating the entire contents of the 5th grade in only one chapter, privileging the study of numbers and operations to the detriment of this area of mathematics.

In the emerging knowledge, the figural representation and the application of the definition are emphasised, as shown in Figure 2 below:

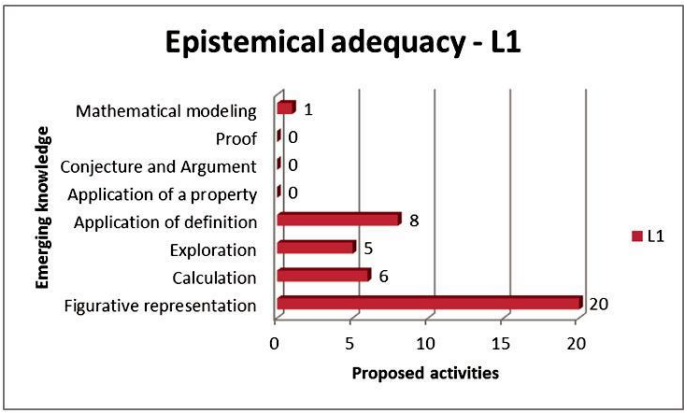

Figure 2. Emerging knowledge of L1.

In terms of the categories of language, concepts and propositions, the contents and statements are clear, and the vocabulary used is simple and appropriate to the audience at which they are aimed. In relation to procedures and arguments, it explores well the visualisation of concepts, has a directive approach and makes use of manipulable materials.

Finally, analysing the mediational appropriateness, L1 makes use of the resources, especially of the manipulable materials, which offers through a "highlight and make" book the manual part, suggests the teacher-student dialogue to organization of time and classroom, only needing to insert more technological/digital activities to really understand the categories of mediational adequacy. As for the ecological suitability, it needs to adapt to the curriculum, since it does not present a series of contents foreseen for the area of geometry due to the focus that it gives to the contents of numbers and operations, but presents reflective and interdisciplinary content aimed at the education of values.

CONCLUSIONS

In view of the analysis presented on this paper, we highlight the positive aspects of the L1 book, such as the formalisation of concepts in an adequate language, concern with applications and interdisciplinary issues, as well as encouraging the use of concrete materials, with diverse activities and games.

We also emphasise the use of the didactic adequacy frameworks of the Ontosemiotic Approach as a tool for the analysis of curricular materials, since these compile several categories which may assist teachers in handling these materials.

All of these categories, when classified by the analysis framework, become a guide for easy visualisation and understanding of the perspectives of a given curricular material, causing the teacher to identify in which item to complement the information contained in the material, or to improve your lessons with the use of this valuable resource.

REFERENCES

Brousseau, G. (1996). *Fundamentos e Métodos da Didática da Matemática.* In: Brun, J. Didática das Matemáticas. Tradução de: Maria José Figueiredo. Lisboa: Instituto Piaget.

Fonseca, Carla Isabel Teixeira Tavares Rebimbas da. (2013). *As Funções Exponencial e Logarítmica nos Manuais Escolares do 12º ano*. (153f). Dissertação (Mestrado em Didática) – Departamento de Educação, Universidade de Aveiro. Aveiro, Portugal.

Godino, J. D, et al. (2013) *Componentes e Indicadores de idoneidad de programas de formación de professores em didáctica de las matemática* s**.** Revista Eletrônica de Educação Matemática, Florianópolis, (v.8, n.1, p.46 – 74), DOI: 10.5007/1981-1322.2013v8n1p46.

Godino, J. D. (2011) *Indicadores de la idoneidade didática de processos de enseñanza y aprendizaje de las matemáticas.* XIII CIAEM – IACME, Recife, Brasil.

Godino, J. D., Batanero, C. & Font, V. (2008). *Un Enfoque ontossemiótico del conocimiento y la instrucción matemática*. Berlim, v.39, n.1, p.127-135. Disponível em: http://www.ugr.es/~jgodino/funciones-semioticas/sintesis_eos_10marzo08.pdf. Acesso em: 06. Jan. 2018.

Godino, J. D., et al. (2009). *Aproximación a la dimensión normativa en didáctica de las matemáticas desde un enfoque ontosemiótico***.** Enseñanza de las Ciencias 27 (1), 59-76. Disponível em: http://www.ugr.es/~jgodino/eos/dimension_normativa.pdf. Acesso em: 04. Jan. 2018.

Santana, Kátia Cristina Lima. (2017). *Relação professor – materiais curriculares em Educação Matemática: uma análise a partir de elementos dos recursos do currículo e dos recursos dos professores*. 163f. Dissertação (Doutorado em Educação Matemática), Pontifícia Universidade Católica de São Paulo, São Paulo.

Vygotsky, L. (1934). *Pensamiento y lenguaje.* Buenos Aires: Paidós, 1995.