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The teaching of the function concept from the perspective of the Logical-Historical Movement: an analysis of the nexus of interdependence in the High School Mathematics Club[1]

O ensino do conceito de função na perspectiva do Movimento Lógico-Histórico: uma análise do nexo de interdependência no Clube de Matemática Ensino Médio

La enseñanza del concepto de función desde la perspectiva del movimiento lógico-histórico: un análisis del nexo de interdependencia en el Club de Matemáticas de Educación Secundaria

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ABSTRACT
This article discusses the function concept teaching from the perspective of Historical-Cultural Theory, focusing on the understanding of its Logical-Historical Movement based on the internal nexus of interdependence. The objective consists in analyzing a task developed in the context of the High School Mathematics Club, investigating how the elements of need, collectivity, and meaning contribute to students' appropriation of the conceptual nexus of interdependence. The analyzed material is composed by reports produced by teachers participating in the project and student records. The analysis indicates that the situation mobilized needs related to the definition of quantities, cost estimates, and decision-making, requiring the articulation between different variable magnitudes. The results suggest that organizing teaching guided by conceptual nexuses can favor the understanding of interdependent relationships between magnitudes and contribute to the formation of theoretical thinking in mathematics.

Keywords: Concept of function; Historical-Cultural Theory; Logical-Historical Movement.

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RESUMO
Este artigo discute o ensino do conceito de função a partir da perspectiva da Teoria Histórico-Cultural, tomando como foco a compreensão de seu Movimento Lógico-Histórico a partir do nexo interno de interdependência. O objetivo consiste em analisar uma tarefa desenvolvida no contexto do Clube de Matemática do Ensino Médio, investigando como os elementos necessidade, coletividade e sentido contribuem para que os estudantes se apropriem do nexo conceitual de interdependência. O material analisado é composto por relatos produzidos por professoras participantes do projeto e dos registros dos estudantes. A análise indica que a situação mobilizou necessidades relacionadas à definição de quantidades, estimativas de custos e tomada de decisões, exigindo a articulação entre diferentes grandezas variáveis. Os resultados apontam que a organização do ensino orientada pelos nexos conceituais pode favorecer a compreensão de relações de interdependências entre grandezas e contribuir para a formação do pensamento teórico em matemática.

Palavras-chave: Conceito de função; Teoria Histórico-Cultural; Movimento Lógico-Histórico.

RESUMEN
Este artículo aborda la enseñanza del concepto de función desde la perspectiva de la Teoría Histórico-Cultural, centrándose en la comprensión de su Movimiento Lógico-Histórico a partir del nexo interno de interdependencia. El objetivo es analizar una tarea desarrollada en el contexto del Club de Matemáticas de Educación Secundaria, investigando cómo los elementos de necesidad, colectividad y sentido contribuyen a que los estudiantes se apropien del nexo conceptual de interdependencia. El material analizado comprende relatos elaborados por los docentes participantes en el proyecto y registros de los estudiantes. El análisis indica que la situación movilizó necesidades relacionadas con la definición de cantidades, la estimación de costos y la toma de decisiones, lo que requirió articular diferentes cantidades variables. Los resultados sugieren que organizar la enseñanza en torno a nexos conceptuales puede fomentar la comprensión de las relaciones de interdependencia entre cantidades y contribuir al desarrollo del pensamiento teórico en matemáticas.

Palabras clave: Concepto de función; Teoría Histórico-Cultural; Movimiento Lógico-Histórico.

1 Introduction: Teaching Functions from a Logical-Historical Perspective

The teaching of mathematics, especially the function concept, has historically been constituted as one of the main challenges in Brazilian High School. Although your centrality on the curriculum, the teaching of function is frequently presented on a fragmented and formal way, reducing the manipulation of formulas, graphs and algebraic procedures devoid of meaning for the students, which influences the formation of a more elaborative and meaningful theoretical thought.

Despite its centrality in the curriculum, the concept of function is often presented in a fragmented and formal way, reducing it to the manipulation of formulas, graphs, and algebraic procedures devoid of meaning for students, which compromises the formation of more elaborate and meaningful theoretical thinking.

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In this way, the importance of the teaching of function on High School is based on the fact that this concept performs a structuring role in understanding the interdependence between quantities. However, when education prioritizes only external aspects of the concept, such as the variable, the formation law or graphical representations, without exploring its core essence, such as interdependence and fluency, the students tend to develop a limited and instrumental comprehension of the content, wich can compromise their ability to generalize and abstract.

In light of Historical-Cultural Theory, it is understood that the appropiation of scientific concepts do not occur through simple exposure formal definitions or instrumental manipulations, but rather through participation in intencionally organized collective activities that create learning needs, mobilize the Collective, and enable the production of meaning for the concept being studied. From this perspective, we defend that a education guided by the Logical-Historical movement of concept directs the students to understand its internal connections and its historical genesis, enabling the formation of theoretical thought.

Therefore, recent researches on Mathematics Education field has emphasized the necessity of didatic approaches that promote the comprehension of concepts in their logical-historical genesis, contrasting with formalist methods which reiforce instrumental perceptions of mathematical knowledge. Researches suh as Dias', Fermino's and Turcati's (2024) highlights that the logical-historical movement of concepts reaffirms the origin and change of concepts, which contributes to the teaching and learning of mathematical concepts at different levels of schooling.

Similarly, Klein, Lopes, and Pozebon (2024) also reflect about the importance of organizing the education based on the logical-historical relationship, as a way to guide both the theoretical analysis and the practice of pedagogical activity. For the authors, understanding the teachers formation and organization of teaching from this perspective enhances the education and contributes to teacher training. Another preponderant debate on this conception is fostered by Spacek, Ortigara and Damazio (2024), when reflecting on epistemological issues related to the relationship between the logical and the historical in the knowledge process. The authors mention that the organization of education should consider the knowledge function as a historical product of humanity, with its logical structure internalized by the subjects in activity, which becomes necessary

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to transcend formalist approaches to a perspective that articulates conceptual genesis and meaning, aligned with the assumptions of Historical-Cultural Theory.

Although this research highlights the relevance of understanding mathematical concepts in their logical-historical genesis and organizing teaching based on this framework, further studies are needed that analyze in more depth how such assumptions materialize in teaching tasks, especially in the context of High School.

In this context, the High School Math Club project presents itself as a formative space that seeks to break the logic of the fragmentation of mathematical knowledge, especially the concept of function, by organizing pedagogical work around intentionally planned tasks, based on Historical-Cultural Theory, Activity Theory, and Teaching-Oriented Activity. The project is configured as a collective learning space, in which basic education students and mathematics teachers in initial training interact, through learning-triggering situations that mobilize mathematical concepts in their relationship with reality, creating conditions for study needs.

In this way, the project is developed in 1st year high school classes, over ten weekly meetings, with the central proposal of the virtual story being the creation of a restaurant by the students. In each meeting, a task is presented to the class with the aim of discussing, problematizing, and deliberating on fundamental aspects for the dynamics of a restaurant's operation, such as initial investment, salary definition, and profit calculation, in the form of a triggering problem. Through these tasks, we seek to address, in an articulated and intrinsic way, the internal and external connections of the concept of function.

Furthermore, we understand that mathematics should be treated as collective knowledge, built throughout history from social needs. Therefore, all tasks proposed during the meetings are carried out in small groups, and each decision is made after collective discussion by the class.

Among the tasks developed in the project, this study focuses on the task carried out in Meeting 1, which some situations are mobilized that make it possible to discuss the nexus of interdependence between quantities, considering it a central element in understanding the concept of function. Thus, this article aims to analyze a task developed in the context of the High School Mathematics Club, investigating how the elements of need, collectivity, and meaning contribute to students appropriating the conceptual nexus of interdependence. To this end, the task performed is taken as an instrument of analysis,

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understood as a central element in the organization of teaching in the Guiding Teaching Activity. In this sense, the analysis of tasks developed in this context becomes relevant, due to allows us to understand how the intentional organization of teaching can mobilize learning needs and favor the appropriation of conceptual connections.

Thus, the article is organized by this way: on section 2, it is discussed pedagogical work from a historical-cultural perspective, emphasizing the logical-historical movement of the concept and the formation of theoretical thought. Section 3 describes the task developed in the project, explaining its context, organization, and pedagogical intentionality. On section 4 it is analyzed the task based on the categories of need, collectivity, and meaning attributed to the concept. Finally, section 5 presents the considerations of this work's reflection, summarizing some of the study's contributions and implications for teaching in High School.

2 Pedagogical work from a historical-cultural perspective and the Logical-Historical Movement

Understanding the teaching of function concept, within Historical-Cultural Theory, requires recognizing as a historically constituted human production organized within a logical system that expresses its essence. In this direction, the relationship between the logical and the historical cannot be understood as dichotomous, but as a dialectic of the knowledge process.

As discussed in Silva (2023), human knowledge does not develop linearly or cumulatively, but through a movement in which social needs drive the production of new forms of thought. The logical constitutes the theoretical expression of this historical movement, revealing the essence of the object beyond its empirical manifestation. This understanding finds support in the ontological approach to the relationship between the logical and the historical, in which Duarte (1987, p. 13) shows that,

> The logical reflects the historical because the logical was formed throughout the historical process. Logic, therefore, is the starting point for the study of history, insofar as logic reflects the essential stages of the historical process. But this reflection is neither direct nor immediate, because otherwise, historical study would be unnecessary (Duarte, 1987, p. 13).

Thus, the logical-historical movement is not reduced to the chronological presentation of the emergence of the concept, but to its reconstruction, the need that

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engendered it, and the contradictions that demanded its elaboration, systematization, and synthesis. In addition, understanding the logical-historical movement of the concept of function becomes fundamental for the organization of teaching, as it allows us to identify the essential relationships that constitute the concept and to guide the development of learning-triggering situations that enable students to appropriate its conceptual genesis. In case of the concept of function, its constitution is linked to the necessity to understand relationships of interdependence between variable magnitudes at the several contexts of life.

Considering this distinction, this study takes as its analytical focus the internal connections of the function concept, especially the relationship of interdependence between variable quantities, understanding that it is in this relationship that the conceptual unity that sustains different representations of the concept resides. Organizing teaching from the perspective of the logical-historical movement means enabling the student to reproduce, at a formative level, the process of constituting the concept, appropriating its conceptual connections and understanding the multiple determinations that structure it, which directly dialogues with the thinking of Klein, Lopes and Pozebon (2024, p. 20),

> Thus, if the teacher has access to the logical-historical movement of the mathematical concept, when organizing the teaching he has the possibility of fulfilling his social function of bringing the student closer to the more elaborate culture through the appropriation of the concept in its totality (essence). And this is the student's right.

This conception shifts the focus of teaching from the mere formal presentation of the concept to the explication of its conceptual connections. In this sense, conceptual links correspond to the structuring relationships that constitute the concept in its internal unity and its articulations with the broader system of knowledge. These are not superficial characteristics or external properties, but essential determinations that reveal the internal logic of the object.

Pereira et al. (2026), in the book Clube de Matemática Ensino Médio em Movimento: uma experiência com o ensino de funções (High School Math Club in Motion: an experience with teaching functions), discuss that conceptual links can be understood in two complementary dimensions: internal links and external links. Internal links refer to the essential relationships that organize the concept in its own constitution, that is, to the determinations that express its essence and guarantee its logical unity. External links, on the other hand, concern the articulations of the concept with other concepts of the mathematical

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system and with different fields of application, highlighting its historical and social insertion in various contexts. In the case of the concept of function, the internal links reside, fundamentally, in the relationship of interdependence between variable quantities, a relationship that confers unity to the different possible representations. The external links, in turn, manifest themselves in the articulations with concepts such as proportionality, equations, analytical geometry, modeling of phenomena, and in the multiple forms of algebraic, graphical, and tabular representation. The systematization of these links can be organized using the following table.

Table 1: Summary of the conceptual links of function

	NEXUS	CONCEPT
INTERNAL	FIELD OF VARIATION	The space traversed by the variables of a function, that is, the universe that the function inhabits. It is the space imbued with time, in which movement occurs. The most important aspect of this internal nexus is not only the limitations imposed by real situations within this space, but also the possibility of analyzing the possible relationships within it.
	FLUENCY	It is the imposition of impermanence that generates movement. It is what makes a variable both be and not be all that it can be within a field. It is like the constant forces that make a liquid be a liquid inside a recipient.
	DEPENDENCY RELATIONS	Cause and effect relationship, dependency. Relationship which one (or some) needs/depends on one or/and one (or some) needs/depends on several/all.
	INTERDEPENDENT RELATIONS	Relationships inserted in a network of relationships. Relationships between anything and everything, between everything and anything, between objects and objects, between the universe and the objects within it, between an object and the universe, and, most importantly, between the universe and other universes.
EXTERNAL	DOMAIN	The set of all possible values that the variable can take.
	COUNTERDOMAIN	The set of all possible values of the function.
	IMAGE	The set of all real values of the function.
	FORMATION LAW	An algebraic expression that defines the relationship between the elements of the domain and the image of a function. In other words, the expression that governs the universe.
	VARIABLE	If interdependence is the relationship, then a variable is the thing or object that is present in the universe or outside of it.

Source: Pereira e outros (2026).

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The table presented summarizes the main conceptual links of the concept of function, highlighting the distinction between its internal determinations, related to the interdependence between variable magnitudes, and its external articulations in the system of concepts. The distinction between internal and external conceptual links is central to the organization of teaching, as it allows us to understand that the formal definition of function as a correspondence between sets constitutes an endpoint of the historical process of systematization, but does not, by itself, reveal what is essential and sustains the concept. The formal definition represents a historical synthesis of a long process of systematization; however, when presented in isolation, it can be reduced to a statement devoid of meaning for the student, especially when the internal links are not made explicit. It should be emphasized that, even though this distinction is important, the relationship between these two categories of conceptual links should be promoted as a dialectical unity.

In this direction, Historical-Cultural Theory and Activity Theory have foundations for understanding the role of necessity in the organization of teaching. As discussed by Silva (2023), by inferring that there is no human activity devoid of necessity, it orients the subject towards the object, constituting the motive of the activity and determining the meaning that the action assumes for him, in various aspects, such as: the need to become culturally human, basic survival needs, the needs of the teacher's social function in teaching, and needs surrounding the logical-historical movement of the concept itself, as Silva (2023) indicates when studying historiographies on the concept of function in,

> Howard Eves (1997), who studied the historiography of the concept of function in his work, analyzing objective reality through the history of the elements that composed it. The author begins by pointing out the difficulties faced by great mathematicians, starting from the logical elements defined by Euclid. The first criticism raised reflects the fact that Euclid sought to define all technical mathematical concepts, that is, the fixation of a set of primitive, or basic, conceptual elements, in which there are no doubts or possibilities of questioning. Later, this fact was called axiomatics. The movement generated was established by the need to replace primitive concepts with symbols, thus disconnecting them from their concrete meanings, whose basis is systematized logic without the intervention of intuitive factors, and which was given the name postulate (Silva, 2023, p. 64).

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Based on these examples that articulate various aspects of needs in the context of the activity, we can infer that when teaching does not mobilize real needs, learning tends to be restricted to the mechanical execution of procedures, which does not raise the quality of theoretical thinking. Creating a need, therefore, does not mean proposing artificial problems, but organizing intentionally designed situations so that students experience the "insufficiency" of their empirical knowledge.

The emergence of necessity occurs when explanations based solely on the comparison of external characteristics prove limited in understanding a phenomenon of variation, as in the function that the case of external links to the detriment of internal links. The formation of theoretical thinking requires overcoming empirical analysis and seeking approximations of conceptual links, especially internal ones, which involve the object in its genesis and development, as shown by Sousa and Moura (2019, p. 1098) when,

> To analyze and understand regular and irregular movements of life; to develop laws of formation that govern the regular movements of life; to understand a powerful instrument for reading and understanding the various variations that insist on dominating our reality, whether scientific or not; and to think scientifically, in order to develop theoretical thinking about the reality that surrounds us.

In this way, in the teaching of functions, empirical thinking manifests itself when the student identifies functions only by their algebraic expression or by visual characteristics of the graph. However, the internal links of the concept reside in the relationship of interdependence between variable quantities. It is this relationship that gives unity to the different representations such as tables, graphs, algebraic expressions, and that allows us to understand the concept as an instrument for analyzing reality.

Thus, the appropriation of internal links implies understanding the essential relationship that organizes the concept, recognizing it as a synthesis of multiple historically produced determinations. As Klein, Lopes, and Pozebon (2024) point out, it is in the collective organization of activity that conditions are created for the formation of theoretical thought, through conceptual appropriation, since it is in socially organized activity that the subject appropriates historically produced meanings, transforming them into instruments of their own thought.

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Thus, collectivity makes it possible to explain the contradictions generated in needs, the confrontation of ideas and strategies, and the negotiation of meanings. This movement favors the transformation from the interpsychological to the intrapsychological level, a condition for the formation of higher psychological functions.

Another central element refers to the distinction between meaning and sense. According to Silva (2023), meaning corresponds to the socially crystallized content of concept, while sense refers to the position that this content occupies in the subject's system of motives. Learning takes place when social meaning finds correspondences in the student's needs and motives. Thus, the concept of function acquires meaning when the student recognizes it as a necessary instrument to understand phenomena intrinsic to the movements of life, and not just as a formal definition to be memorized.

However, articulating logical-historical movement, need, collectivity, and internal links implies understanding teaching as an intentionally organized activity, oriented towards the formation of theoretical thought. Such formation is characterized by the possibility of appropriating the essential relationship of the object by generalizing it as an instrument to analyze the movements of life.

In the context of the High School Math Club, this organization takes on a formative character by enabling students to experience learning-triggering situations that require the analysis of the essence of the concept of function, participate in collective discussions and elaborations, produce meaning for the content, and approach its historical and logical essence.

In light of these discussions, the following section presents a task developed in the High School Math Club project, intentionally organized from the logical-historical movement of the concept of function. The following will be described: the task's development context; its organization and work dynamics; and the pedagogical intentionality that guided its elaboration, highlighting the relationship between need, collectivity, and the meaning attributed to the concept based on the internal nexus of interdependence. The analysis of the task will highlight how the didactic organization can enhance the formation of theoretical thinking, by creating conditions for students to appropriate the nexus addressed in collective activity.

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3 From the Methodological Procedures of the Investigation to the High School Mathematics Club as a Space of Organizing Teaching

This study is characterized as research grounded in the assumptions of Historical-Cultural Theory and Activity Theory, focusing on the analysis of the organizing process of the function concept teaching in the context of the High School Mathematics Club, through a formative experiment.

As a methodological structure of the investigation, we organized the formative experiment, understood as a mode of organizing research aimed at understanding the processes of human development in motion, especially within pedagogical activity. As indicated by Silva (2023), the formative experiment is constituted by seeking to understand the psychological processes in their development in the relationships between teaching, learning, and transformation of subjects.

From this perspective, the experiment presented here reflects the intention of an organization that allows for the analysis of the conceptual formation movements produced in collective activity as a possibility to understand the genesis and development of concepts in concrete human life.

Thus, the investigation sought to analyze the appropriation of the conceptual nexus of interdependence of the concept of function, considering the transformations produced in the collective activity developed in the High School Mathematics Club. The didactic organization of the experiment was based on the elaboration of learning-triggering situations, intentionally structured to mobilize the need for study, promote collective actions, and articulate the production of meanings for the investigated concept.

The research was conducted in the second semester of 2025, in a 1st-year high school class at a public school participating in the High School Mathematics Club. The project took place over ten weekly meetings, lasting 2 hours and 15 minutes each, involving basic education students and mathematics teachers in initial training.

For this article, we selected for analysis the task developed in Meeting 1, entitled "How food moves the world," organized from a learning-triggering situation related to the collective creation of a restaurant. The choice of this task was due to its elements that allow for the analysis of the process of appropriating the internal nexus of interdependence of the concept of function.

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The data produced for the investigation are composed of reports prepared by the teachers participating in the project, written records produced by the students at the end of the meeting, and observations made during the development of the task. The reports were produced from audio recordings made by the teachers after the meeting and subsequently transcribed and systematized collectively. The students' records consist of written responses referring to the reflections developed throughout the task.

The data analysis was carried out in light of the assumptions of Historical-Cultural Theory, taking as analytical categories need, collectivity, and meaning, understood as constitutive of the movement of conceptual appropriation and the formation of theoretical thought. In this direction, the aim was to analyze evidence of the transformation of students' thinking during the development of the task, considering the unity between the logical-historical movement of the concept, the organization of teaching, and the learning processes produced collectively.

When conducting a brief analysis of the context in which the task was developed, it was necessary to explore these elements together in the very process of appropriation of the concept by the educators, since they themselves realized that they needed to experience this appropriation process, and be convinced, in order to think about tasks that, together with their pedagogical interventions, would convince the students.

In this sense, a driving need of this process, which guided the pre-service teachers to carry out their teaching activity, refers to the elaboration of a triggering problem that contemplated the logical-historical movement of the concept of function, which was studied and discussed throughout several meetings that preceded its effective elaboration. This need emerges in the context of the Guiding Teaching Activity. From this perspective, Giacomelli, Binsfeld, and Klein (2022, p. 49) highlight that "[...] in the AOE movement, the teacher is equipped with knowledge that allows them to create a triggering problem capable of putting the child's thinking into action, based on the need that led humanity to develop such a concept, rescuing its essential relationship."

The collective was also present, since this triggering problem would not be created by just one person, but by a collective of individuals who influenced and influence all processes until the emergence and development of the task, being an essential element not only for teacher training, but for the human being. Thus, we

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agree with Silva (2023, p. 24) that “It is through collectivity that the human acquires the ability to attribute meaning, to establish relationships between the purposes of the activity, the objects of the actions performed and the objectives sought” because teaching is a socially organized activity, and when carried out by the subject in a collective it is potentiated.

And the meaning, in which, through collectivity, human is able to acquire the capacity to attribute it (Silva, 2023). However, this attribution refers to a more personal aspect of the subject, as it concerns the place that this situation occupies in the set of their motivations, and thinking about the project and the creation process of the task of Meeting 1, it concerns how each participant in the project understood themselves in this creative movement and the position that this experienced movement occupied in their formative process.

Through this interaction between these elements, Meeting 1, entitled "How Food Moves the World," was created with the overall objective of presenting the triggering problem, which is the opening of a restaurant, promoting debate to highlight the importance of collectivity, and establishing relationships of dependence and interdependence between the variables that make up the restaurant creation project. Initially, the meetings were planned to take place once a week, lasting 2 hours and 15 minutes, with 1st-year high school students. However, the development of the task does not always occur within the planned time, which happened in Meeting 1 of the class analyzed in this article, requiring two meetings.

Thus, the first part of the meeting consists of presenting the story in which the triggering problem is contained. The story is presented through an illustrated video, narrated and edited by the team of teachers from the High School Math Club, as highlighted in the following figure.

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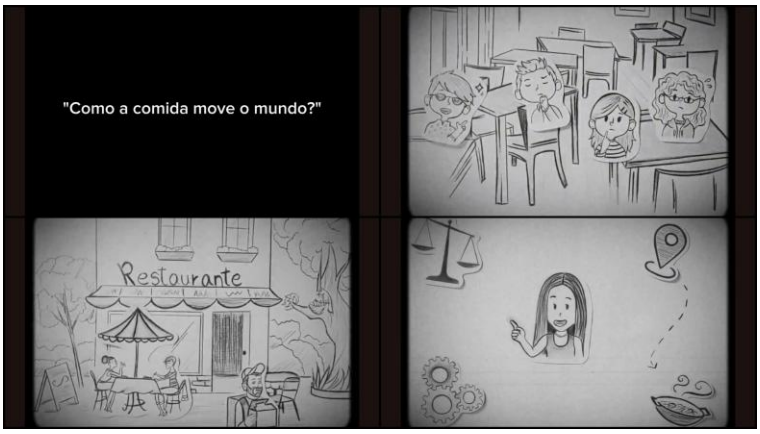
Figure 1: screenshots of the video presented in Meeting 1



Source: authors' collection.

The narrative begins with a group of friends questioning: how does food move the world? Realizing they shared the same thought, one of the friends suggests opening a restaurant. Since everyone was in a good financial situation, the group decides to invest in the business, but delegates the responsibility for planning the establishment to others, from choosing the location to the final dish served to customers, so that they could later evaluate whether the investment corresponded to what they imagined. In this context, the students discover that they would be responsible for planning the entire structure of the restaurant. The summary table below presents the description and objectives of this and the other moments of the meeting.

Table 2: Summary of the moments of Meeting 1

Moment	Description of actions performed	Goals of the moment
First moment: Presentation of the story	The problem is presented through an illustrated video, narrated and edited by the teaching staff of the High School Math Club. The narrative features a group of friends who want to open a restaurant and assigns the responsibility for planning the establishment to the students.	To immerse students in the problem situation, spark their engagement with the activity, and create learning needs related to the organization and operation of the restaurant.
Second moment: Assessing the restaurant's needs	Collective discussion to categorize and select the five priority needs of the restaurant, organized into: location, kitchen equipment, dining room equipment, suppliers, staff and customers. The students' ideas were recorded in a word cloud.	Collectively identify the essential elements for the restaurant's operation and organize the categories that guide the project's development.

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Third moment: Organizing the groups and developing the proposals	The class was divided into five groups, each responsible for a different category of the restaurant. The students developed proposals considering feasibility, costs, functionality, and customer experience, with the support of technological resources such as the Chromebooks provided by the school.	To develop proposals for the restaurant, encourage teamwork, and foster an understanding of the relationships of dependence and interdependence between the different elements that make up the creation of the restaurant.
Fourth moment: Socialization and collective synthesis	Presentation of the proposals developed by the groups, followed by discussion and collective voting to define the choices that would be implemented in the restaurant. At the end, a summary of the meeting was made and a record with questions for the students to answer was given out.	To promote collective debate, argumentation, and democratic decision-making, as well as to synthesize the knowledge produced throughout the meeting.

Source: Authors' own work.

Although each group is focused on a specific topic, one of our goals is for students to realize the need to communicate and share ideas among the groups, in order to ensure that the different proposals integrate harmoniously, highlighting the relationships of dependence and interdependence between the variables that make up the restaurant creation project.

Returning to the pedagogical intentionality of the task of promoting the understanding of the internal interdependence of the concept of function, the elements of need, collectivity, and meaning are also present throughout the planning of Meeting 1, thinking from the students' point of view. When analyzing the study activity that the meeting aims to motivate, the necessity present in the triggering problem is the creation of a restaurant, which guides the students in their learning activity, which, at the time of the meeting, is the learning of the concept of function, since through the story they will be inserted in this movement of appropriation of the concept.

Collectivity is present precisely when working on the internal nexus of interdependence, because, just as in the concept of function, where the result depends on the variable and other dependency relationships that constitute it, in a collective, decisions and proposals depend on the subjects involved in this process. In Meeting 1, this is expressed at the beginning of the creation of the restaurant, as it is a socially organized process within the collective that seeks to motivate students to carry out their learning activities.

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And finally, the meaning that the concept of function takes on for the student, when he perceives its usefulness in interpreting and explaining relationships present in different everyday situations and in the processes that make up life. Thus, it ceases to be just a formal definition to be memorized and becomes understood as a conceptual resource that helps in understanding these phenomena.

Thus, the planning of Meeting 1 aimed to foster conceptual understanding among students, highlighting the elements of necessity, collectivity, and meaning. Therefore, in the following section, an analysis of the reports produced by the project participants and the students' productions based on the task will be carried out, with the objective of highlighting the beginning of the process of appropriating the concept of function, which occurred in Meeting 1, through the internal nexus of interdependence. Furthermore, the aim is to analyze how the elements of necessity, collectivity, and meaning contributed to this process and constituted intrinsic aspects of its occurrence.

4 Task Analysis: Need, Collectivity, and Meaning

The task analysis developed in the described meeting is based on the following axes: need, collectivity, and meaning. These axes are articulated with the understanding of the internal nexus of interdependence that structures the concept of function. Furthermore, it establishes that the formation of theoretical thought does not occur only through the formal exposition of the conceptual synthesis, but through the intentional organization of learning-triggering situations that mobilize real needs within the collective activity.

For this discussion, we present below two reports produced by the participants of the High School Mathematics Club project, one for each day of Meeting 1 in the second semester of 2025, which took two days to complete. These materials were prepared through a synthesis of the observations of six teachers who recorded audio reflections on the formative moment, and then one of them gathered the files, compiled, transcribed, and transformed them into a text.

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Table 3: Reports from Meeting 1 described

Reports: High School Math Club - 2025/02 Edition

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[...] Teacher 1 started the meeting, recalling the importance of collectivity as well as the contract. After this moment, the introductory video was shown and the students watched attentively. At the end of the video, Teacher 1 reinforced that our objective would be to create a restaurant and, starting from the question "what do we need to start?", a word cloud was constructed with the students' answers. At this moment, the students participated a lot and the other teachers were there to help ensure that all the words were heard and also that the most shy students participated. In addition, Teacher 1 reported the importance he attributes to this moment, since in a way, it was the first time that the students saw in practice that we are not expecting or seeking a correct answer, but that we want to hear them and that they are part of what is being built, which led him to let the moment last a little longer.

[...] At the end of the word cloud creation, the entire chart had been filled (with emphasis on words related to marketing), and then Professor 1 raised the possibility of grouping related ideas so that we could work within the 5 groups formed, which was accepted by the students and so it was done. At the end of the word grouping process, the categories formed were: suppliers, staff/costumers, structure, and location. As the students did not reach the "kitchen utensils" group, Professor 2 asked for the floor and intervened with a question about a difficulty that could arise if we left the kitchen utensils in the "structure" category, since these are more specific items that require more attention, and from this, the 5th category was created.

After the categories were defined, we moved on to choosing who would be responsible for each one. Initially, we opted to leave it open for the students to choose according to their preference, but this was not possible, as different groups of students showed interest in the same topic. At that moment, a student suggested that the division be made by affinity, which everyone agreed with, but this was also not possible, as there were many students interested in one category, while there were no interested in another. Thus, after discussing it among ourselves, we decided to hold a draw.

[...] We divided ourselves so that there would be one teacher per group [...]. At that moment, we realized that the students are not only very creative, but also proactive, as most were very involved and interested in the proposed task, and so it didn't take long for the perception of the need to dialogue with others to emerge in their own speeches.

Teacher 3 reported that she faced a problem with her group, as they were frustrated and no longer wanted to do the task because they did not get the category they wanted. However, she talked to them, and participation and ideas began to emerge. In addition, Teacher 3 also reported that mathematical thinking was very present in their discussions while they talked about the task. There was also an issue with the location group, as they had initially chosen the Bueno sector, but later decided to change to another location because they did not like the places they had found. This led to a disagreement between them and the supplier group, as they had already chosen the most expensive suppliers because it was a prestigious sector. Furthermore, Teacher 4 reported that since all the groups wanted to know where the restaurant would be, at one point all the groups were surrounding the group responsible for the location, which made them uncomfortable and nervous to some extent. However, they were asked to be left alone for a while, and Teacher 4 then mediated the moment so that they could calm down.

[...] At the end of the meeting, all the groups already had their ideas underway, and then we informed them that they would have a space in the marketing class to finalize the presentations, which would be held at the next meeting, and soon after the bell rang.

23/09/2025

Right from the start [...], Professor 5 reinforced that the team reduced the number of tables, formed the five necessary groups, and instructed the students to sit with the same colleagues from the previous meeting, to continue the tasks already started.

With everyone organized, the team explained that the meeting would begin with the completion of the previous task, even though some groups had not finished the slides or research as we had requested, as highlighted by Professor 4, and were recommended to present what they had. To avoid confusion or long lasting in choosing the order of presentation, we held a quick draw to determine who would start. Professor 5 added that the first group drawn was the structure group, which presented the cost estimates for the physical assembly of the restaurant. According to Professor 3, the group had prepared slides with detailed calculations, but due to internet connection problems, it was not possible to project them. Even

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so, the members orally explained what they had planned. Professor 5 highlighted that, although the students had done good research, some items were still missing, and the class was invited to estimate together the values that would complete the proposal, with mediation of questions asked by Professor 2, Professor 1, and other PET students.
The second group to present was the staff and costumers. Professor 1 reported that Student A, who had not participated in the previous meeting, and Student B had difficulty deciding who would speak, since the person responsible for the original slide had been absent. [...] Student B remained calm and, with the mediation of Professor 5, who even offered his cell phone with the previous version of the slide for support, the group managed to present their ideas [...].
After this presentation, a discussion began about the number of employees needed in each restaurant team. Professor 3 described this moment as one of the most intense of the meeting, as the students disagreed considerably about how many waiters, cleaners, administrators, and cooks would be necessary. She highlighted, for example, the controversy over who should clean the tables, the waiters or the cleaners, which directly impacted the definition of how many employees each sector would have. Professor 1 recalled that, at the beginning, he was nervous because he hadn't understood that Professor 2's question was about the number of people in each team, and not about the number of c
stomers. But, soon after, Professor 2 took over the mediation of the conversation, guiding the class until they reached a consensus. This process, according to Professor 3, was fundamental to saving time in later stages, such as defining salaries. Professor 2 wondered if this moment had taken more time than it should have in the meeting, but if it hadn't happened, they would probably have taken longer to decide on these issues when carrying out the task of determining salaries.
Next, it was the suppliers' group's turn, who, according to Professor 3, presented meticulous research on the necessary inputs, including different types of meat, charcoal, water, and beverages. They calculated minimum and maximum purchase values, comparing different customer scenarios. Professor 1 emphasized that the girls even reviewed suppliers to adjust costs to the market and that, in addition to the calculations, they made detailed notes in notebooks, which ensured a very complete presentation. [...]
Next came the presentations from the kitchenware group and the venue group. Teacher 2 and Teacher 5 reported that the kitchenware group also faced internet problems and was unable to project their slides, but managed to present orally based on notes. The venue group presented two proposals: renting a space for a lower price or buying the lot for around two hundred thousand reais, and according to Teacher 4, returning to the initial idea of it being held in Bueno. Teacher 5 said that this presentation generated a debate, as some students believed that buying meant acquiring a ready-made structure, while others argued that the value was only for the land. The group defended their arguments in favor of buying well, to the point of convincing colleagues [...] who initially preferred renting, to change their minds. Teacher 1 and Teacher 4 said that this group also defined details such as the color of the restaurant and the name of the business, which would be Corte Real Churrascaria.
With all presentations completed, Professor 5 took over the final synthesis of the task, discussing with the students the interdependence between the groups and how each decision affected the collective functioning of the restaurant. Professor 4 and Professor 2 commented that even with the short time, the record should be kept. Then, the students received the task recording sheets. Professor 3 highlighted that some students showed insecurity in writing their answers, especially one student who seemed intimidated by her classmates and who, according to her, was frequently mistreated during discussions. Professor 1 observed that, despite some doubts, the records were made sincerely and carefully. Professor 4 highlighted the class's focus on answering the questions| and the interaction among them to answer them. Professor 2 tried to control the time quite a bit at this point, being quite strict about the 15 minutes.

Source: project archive.

From the perspective of Historical-Cultural Theory, there is no human activity without necessity. Necessity guides the subject to the object, constitutes the motive of the activity, and enables the production of meaning. It is not an external impulse or a requirement of the teacher, but an objective condition that emerges from the very

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organization of the activity. It is in this movement that the object ceases to be something alien and becomes part of the subject's field of meanings.

In the case analyzed, the task was organized based on the proposition of creating a restaurant, broken down into categories such as structure, kitchen equipment, suppliers, location, staff, and customers. Each of these categories required the definition of quantities, cost estimates, and collective decision-making, since the project did not concern isolated restaurants per group, but the construction of a restaurant as a whole. From the initial moment, when the question is asked, "what is necessary to make a restaurant?", a learning-triggering situation is established that focuses the students' energy around a concrete problem involving quantitative relationships, shifting the focus from an abstract definition of function to a real problem that requires coordination between variables.

In this context, the need is not imposed externally. It emerges as an internal requirement of the triggering problem. To decide on quantities of staff, number of employees, or investment values, the students needed to consider that the choices of one group implied adjustments in the others. This point emerges from the internal nexus of the concept of function called interdependence. When the groups realize that the quantities depend on each other, a qualitative indication of conceptual elaboration occurs: the variation ceases to be thought of in isolation and begins to be perceived as a relationship.

This movement corresponds to the transition from recognizing external links, which are observable characteristics and specific decisions, to seeking internal links that explain the phenomenon. By changing the sector where the restaurant would be installed, for example, the group responsible for the location directly impacted the values worked by the group of suppliers. Similarly, the discussion about who should clean the tables, waiters or cleaners, altered the total number of employees and, consequently, the salary costs. The decisions proved to be relationally structured. The need experienced was not only about how much to put in, but how one quantity alters another.

In this manner, Caraça (2002) states that the essence of the function consists of the correspondence between sets, directed by the essential characteristics of interdependence and fluency. These characteristics do not exclusively concern the mathematical domain, but are articulated to the human condition itself, insofar as they

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express modes of relationship and transformation present in social life. Above all, interdependence, understood in the sense that "[...] all things are related to each other; the world [...] is a living, unified organism, whose compartments communicate and participate, all in the life of one another" (Caraça, 2002, p. 103).

In the development of the task, this interdependence ceased to be an abstract formulation and became a concrete experience. The relationships of dependence were not limited to empirical description; they required generalization. The need experienced in the task is close to the historical need that engendered the concept of function. Historically, the concept emerges from the investigation of regularities in variable phenomena. Since the first civilizations, the need to understand climatic cycles and quantitative patterns has already evidenced algebraic elements (Silva, 2023). With the development of societies, new demands have driven the advancement of Algebra and the generalization of relationships. As Silva (2023, p. 67) points out,

> [...] the introduction of symbols was an instrumental tool to facilitate the manipulation of algebraic expressions, but above all it was a symbology that allowed for generalizations, replacing fixed or point quantities with a symbol that represented a well-defined set of quantities. The theoretical thinking behind the concept of a function is much broader than its representations in analytical form, f(x), and graphical form.

Thus, the movement observed in the task reproduces, on a formative scale, this historical dynamic. By comparing minimum and maximum customer scenarios, by reviewing suppliers and recalculating estimates, students operate implicit generalizations: the quantity of inputs depends on the number of customers; the number of employees depends on the expected flow; the total cost depends on the articulation between all these variables. Interdependence begins to assume the role of organizing principle of the situation.

This process is inseparable from the collective dimension of the activity. The organization into groups, the choice of representatives, the exchanges between teams and the debates in the presentations configured the activity as essentially collective. The report highlights intense moments of negotiation, conflicts and confrontations of proposals. The activity was entirely organized collectively. From the formation of the groups to the presentation of the proposals, the work required negotiation, argumentation and mediation.

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The initial difficulty in choosing the categories, which culminated in a draw and generated frustrations and resistance, these moments of tension reveal the contradictory nature of the collective activity. The mediation carried out made it possible for frustration not to interrupt the process, but to be incorporated into the dynamics of the task.

Thus, the collective proved to be even more decisive during the presentations. The debate about the number of employees was one of the most intense moments of the meeting. The disagreements between the students were not merely opinions: they were rooted in the structure of the problem. Defining how many waiters would be needed implied reconsidering the number of cleaners, the flow of customers and the total costs.

This movement highlights the shift from the interpsychological to the intrapsychological plane. It is in the confrontation of arguments that the essential relationship between variables becomes the object of conscious reflection. The mediation exercised did not consist of providing ready-made answers, but in formulating questions that would lead to the explication of the relationships.

The discussion about buying or renting the land is another significant example. Some students believed that the advertised value referred to a ready-made structure; others argued that it was only the plot. The debate led to the revision of assumptions and the change of opinion of some colleagues. This argumentative process made it clear that financial decisions were directly linked to the structural project and the overall costs.

Thus, the collective was not merely an organizational arrangement, but a condition for interdependence to become visible. It is in the interaction that contradictions emerge and require overcoming. The function, as a relational structure, begins to be understood when decisions cease to be thought of in isolation and begin to be evaluated within their conceptual system.

Regarding the meaning attributed to the concept of function, the report shows evidence that some students began to understand it beyond the formula. The social meaning of the concept, in terms of the relationship of dependence between variables, becomes an instrument of thought when it finds correspondence in lived needs. By recognizing that quantities depended on each other, students make a generalization that goes beyond the execution of isolated calculations.

From the point of view of conceptual formation, this is an indication of the articulation between social meaning and personal sense. The social meaning of the

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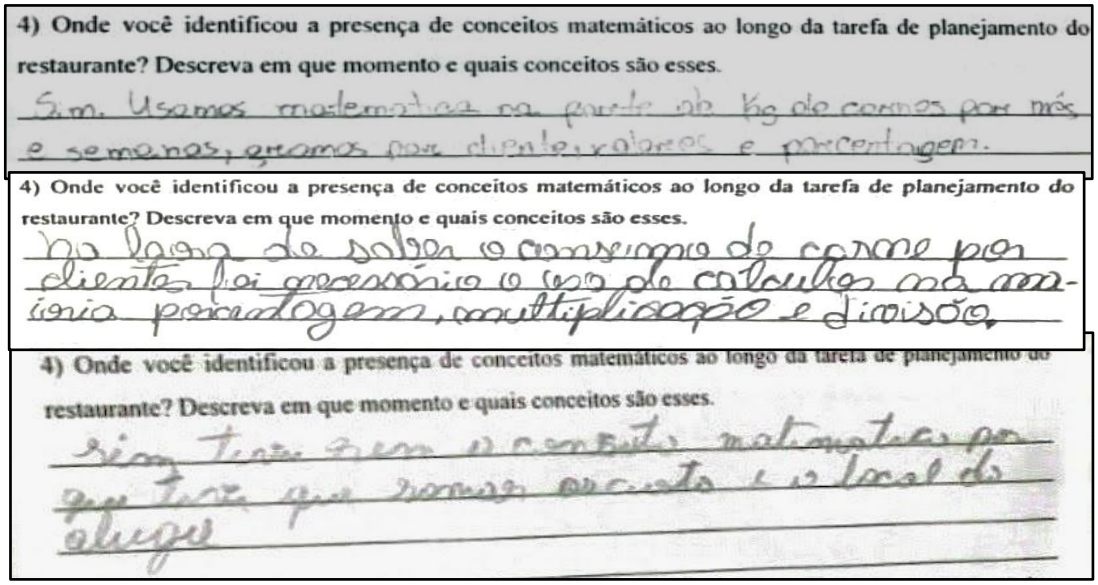
function, in the relationship of dependence between variable quantities, finds correspondence in the needs experienced by the students. Interdependence ceases to be an abstraction and becomes an instrument for organizing decisions.

The written records made at the end of the meeting revealed commitment and reflection, even if accompanied by insecurities on the part of some students. This data reinforces that the formation of theoretical thought is a gradual and mediated process, requiring successive systematizations.

Other records highlighted below show evidence of understanding the relationship between sets and their dependence, when writing "meat consumption per customer", "per month and week", "grams per customer". These records indicate the perception of relationships between quantities that vary together. However, when relating to mathematics, students mainly highlight the calculations performed using "percentage, addition, multiplication and division". In this movement, the relationship established between quantities does not appear as emphasized as a mathematical concept. This aspect highlights the importance of teaching concepts through conceptual connections in a continuous manner across multiple sessions.

Figure 2: Responses to question 4 of the record[5]



Source: authors' collection.

[5]Translation of figure 2: "When it came to knowing the meat consumption per customer, it was necessary to use calculations, mostly percentages, multiplication, and division"; "Yes. We used math for the kg of meat per month and week, grams per customer, values, and percentages"; "Yes, there was indeed a mathematical concept because I had to add the costs and the rental space."

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Thus, the reports and records also reveal limitations regarding the sufficient time to have quality at each moment of the discussion. Such absence can restrict the conscious explication of the internal connection, reinforcing the importance of the intentional organization of teaching including specific moments of systematization that transform the experience of need into conceptual generalization.

The analysis carried out allows us to understand that the three axes proposed in this section, need, collectivity and meaning, manifest themselves in an articulated way in the task developed, since it is organized from a triggering situation that mobilizes real needs, structured collectively and oriented towards the explication of internal connections, creating a movement that is potentially formative of theoretical thought. Interdependence begins to be experienced not as a formal definition, but as an objective need of the reality analyzed. It starts from the essence of the concept as an initial foundation to then advance in the movement of generalizations and in the conscious appropriation of the algebraic languages that historically constitute it.

5 Final Considerations

In summary, when we return to the article's objective of analyzing a task developed in the context of the High School Math Club, investigating how the elements of need, collectivity, and meaning contribute to students' appropriation of the conceptual nexus of interdependence, we can highlight the implications of the movement experienced during the task for student learning.

The contributions revolve around the perception of the dependence between variables, approaching the nexus of interdependence, the generalization of variables during restaurant planning, and the learning movement itself as a whole. This movement proves to be potentially formative of students' theoretical thinking, since the pedagogical intention of the task consisted precisely in favoring the understanding of the internal nexus of interdependence of the concept of function, highlighting elements such as need, collectivity, and meaning.

Therefore, the potential of the highlighted task and the proposals developed in the High School Math Club for teaching functions is based on the process experienced by both students and educators, as the project proves to be a formative

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space in which both have the possibility to develop their respective activities, which are dialectically related in a collective mobilized by the actions developed in that same space.

The Teaching-Oriented Activity, as a theoretical-methodological principle of the project, is one of the enablers of this mutual development, insofar as "although the subjects (teacher and student) [...] occupy different places, the guiding dimension of the TTA mediates the development of both" (Giacomelli; Binsfeld; Klein, 2022, p.48).

From this perspective, the analyzed task points to evidence that it is possible to think about and carry out the teaching of functions beyond algebraic manipulations and ready-made "formulas," aiming at teaching that puts students into activity, organizing conditions so that the internal connections of the functions emerge through the needs generated by the triggering problem.

Thus, the experience lived in Meeting 1 of the project, reported and analyzed throughout the text, highlights the need for an organization of teaching that mobilizes real needs, combined with collective work and teacher guidance, so that students attribute meaning to the concept and advance towards the generalization of the relationships involved and the conceptual appropriation during mathematics classes.

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