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Some pedagogical implications of the Vygotsky School for Science Teaching[1]

Algumas implicações pedagógicas da Escola de Vygotsky para o Ensino de Ciências

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ABSTRACT
This article, based on a bibliographical research, presents some central concepts from Vigotski's work for Science Teaching, with the aim of proposing a reflection on how they have been used in research in Science Teaching, referred in publications directly translated from Russian originals, given the wide use in this area of edited translations with numerous cuts that mischaracterize this author's work. It seeks to synthesize central aspects of the origin of Superior Psychological Processes, of great complexity, to which it will be given an introductory treatment. Learning a system of scientific concepts is the basis of development, and one of the obstacles to this is that concepts are presented as empty words, without a link to the spontaneous concepts that students already have. It is discussed that Vigotski's ideas can be used in Science Teaching to overcome this obstacle, considering that the school's function is to provide students with systematized knowledge of all areas of knowledge and that the appropriation of this knowledge is the basis for the development of Superior Psychological Functions.

Keywords: Vigotski School; Mediation; Concept formation

RESUMO
Neste artigo, partindo de uma pesquisa bibliográfica, apresentamos alguns conceitos centrais da obra de Vigotski para o Ensino de Ciências, com o objetivo de propor uma reflexão sobre como eles vêm sendo utilizados nas pesquisas em Ensino de Ciências, referenciados em publicações traduzidas de originais diretamente do russo, tendo em vista a grande utilização nessa área das traduções editadas e com inúmeros cortes que descaracterizam a obra desse autor. Procuramos sintetizar aspectos centrais da origem dos Processos Psicológicos Superiores, de grande complexidade, aos quais daremos um tratamento introdutório. Aprender um sistema de conceitos científicos é a base do desenvolvimento, e um dos obstáculos frente a isso é que os conceitos são apresentados como palavras vazias, sem um vínculo com os conceitos espontâneos que os estudantes já possuem. Discutimos que as ideias de Vigotski podem ser usadas no Ensino de Ciências para superar esse obstáculo, considerando que a função da escola é proporcionar aos estudantes o conhecimento sistematizado de todas as áreas do saber e que a apropriação desses conhecimentos é a base para o desenvolvimento das Funções Psicológicas Superiores.

Palavras-chave: Escola de Vigotski; Mediação; Formação dos conceitos.

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1 Introduction

Vigotski's theory[4] has served as a theoretical support for a growing number of research in the context of Science Teaching, among other areas (GASPAR, 2014; PEREIRA; LIMA JUNIOR, 2014; BARBOSA; BATISTA, 2018; BONFIM et al., 2019; MILANI et al., 2020; SCHROEDER; BACELAR, 2022; MESSEDER NETO, 2022). Despite the criticisms raised by Duarte (2011), Gaspar (2014), Pereira and Lima Junior (2014), Prestes (2020) and Marques and Castro (2022), we verified, from a bibliographical research, the proliferation of publications that present problematic interpretations regarding the thought of Vigotski and his School, as is the case with the constructivist (socio-constructivist and socio-interactionist) and cognitivist classification, as well as the mediating teacher.

As Pereira and Lima Junior (2014) point out, it is very common to find works that rely on a theoretical articulation between Vigotski and cognitivist authors, or that classify Vigotski himself as a cognitivist. This misreading has led to "the trivialization of several important concepts in Vigotski's theory, such as development, mediation, social interaction, internalization and Zone of Proximal Development" (PEREIRA; LIMA JUNIOR, 2014, p. 522).

Prestes (2020) carried out a critical examination of the translations of key concepts present in Vigotski's first works translated into Portuguese (Thought and Language and The Social Formation of the Mind) and emphasized that the activity of translating, in addition to technique, must assume an ethical commitment towards the author of the original work. The author highlights that "[...] they didn't let Vygotsky speak for himself, they wanted to speak for him, they filtered what Vygotsky wanted to say" (PRESTES, 2020, p. 231).

According to Prestes and Tunes (2022), many of Vigotski's texts translated into English and Spanish in the 1990s contain numerous cuts and edits, and are still references for many academic works in Brazil - such as the books mentioned

[4] Aware of the different spellings for this author's name in academia, we consider it important to inform that we use the spelling Vigotski, with two "i", throughout this chapter; and we maintain the original spelling of the works cited.

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in the previous paragraph. The authors explain that no distortion was as great as in the collection The Social Formation of the Mind (2007). However, it is important to highlight that the organizers of this collection themselves explain, in the preface, that:

> The work of bringing together originally separate works was done quite freely. The reader should not expect to find a literal translation of Vygotsky, but rather an edited translation from which we omitted apparently redundant materials and to which we added materials that seemed important to us in order to make Vygotsky's ideas clearer (VIGOTSKI, 2007, p. XIV).

Prestes and Tunes (2022) state that we currently have several translated works available from reliable originals, due to efforts undertaken by several theory scholars, and question whether an edited translation would be necessary to make Vigotski's ideas clearer. "Despite this, the book The social formation of the mind, with all its distortions and adulterations, is still the most suitable for students taking their first steps in the study of historical-cultural theory" (PRESTES; TUNES, 2022, p. 3).

Duarte (2011) and Gaspar (2014) criticize the interpretation of Vigotski's work from a perspective that is close to the pedagogical foundations of constructivism (socio-constructivism, socio-interactionism). Gaspar (2014) emphasizes that, according to his perception, the failure of the constructivist proposal lies in the prescription, in which the teacher guides the students' actions (mediating teacher), encourages interaction, presents challenges, gives clues, but never teaches or defines concepts, presents ready-made content or solves problems. He argues that the belief that students can construct their own knowledge is false, as the human mind has, through genetic inheritance, all the thought structures necessary for this construction. The author recalls that "all scientific concepts and their definitions result from consensual choices made by scientists themselves, depending on the scientific and historical context in which they were established" (GASPAR, 2014, p. 79).

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In this sense, we consider that vigotskian theory rescues the explicit role of the teacher, considering his indispensable presence in social interactions (more capable partner) that develop in the teaching and learning processes, mischaracterizing the Vigotski School as constructivist, socio-constructivist or socio-interactionist. Gaspar (2014) highlights that this role implies a notable increase in the teacher's pedagogical responsibility, since the most capable partner in an interaction is not only the result of their technical competence, but also the recognition of the social group, which considers them so.

We will also discuss, throughout this text, that it makes no sense to say that the teacher is the 'mediator' of knowledge. From the vigotskian perspective, "mediation is a term designed to characterize the use of auxiliary means in solving psychological problems" (PEREIRA; LIMA JUNIOR, 2014, p. 523).

Our intention here is not to criticize authors whose published works contain the conceptions that we are endorsing the criticism, as we are aware that they were influenced by the available references, mainly between 1980 and 2010, and in which we include ourselves, as we have published works, referenced in Vigotski and with a cognitivist bias. We reformulated our convictions based on the criticisms raised by Professor Newton Duarte and Professor Zoia Prestes, anchored in the increasing access to translations directly from Russian, especially with the contributions of Professors Zoia Prestes and Elizabeth Tunes and researchers from the Grupo de Estudos e Pesquisas em Didática Desenvolvimental e Profissionalização Docente (Gepedi) da Universidade Federal de Uberlândia.

Faced with the great challenges imposed on Science Teaching in the 21st century, we believe that a coherent reading of the Vigotski School, based on reliable translation texts, can bring great contributions to the teaching process (obutchenie[5] – instruction) and learning, taking into account, to some extent, students' spontaneous concepts, situations that make sense to them,

[5] The word obutchénie was also one of the concepts that had different translations: teaching, learning or teaching-learning. Prestes (2020) considers that the most correct translation for the words obutchenie and obutchatsia is instruction and instruct yourself, respectively. The author explains the mistake of using it in translations as learning, as the verb to learn, in Portuguese, is transitive and cannot be reflexive, therefore, it does not meet any criteria of the Russian verb obutchatsia, which means to instruct oneself.

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situations that give meaning to concepts, the role of social interaction and imitation and learning as an essential factor for development cognitive.

2 The origin of Superior Psychological Processes

Vigotski sought to understand the human mind and, to this end, proposed the theory of Superior Psychological Functions (SPF) in order to explain the emergence of specifically human forms of psyche. He distinguished two lines of development, natural and cultural. According to him, SPF develop from natural processes, however, his emphasis was on analyzing development from the internalization of social practices. SPF are specifically human and historically and socially constituted.

FPS have a biological support and are shaped throughout the history of the species and the individual, and as a consequence the biological subject becomes a human subject through social relations (MARQUES; CASTRO, 2022). Toomela (2016) explains that he found eleven characteristics for SPF in Vigotski's works: (i) psychological systems; (ii) development from natural processes; (iii) forms mediated by signs; (iv) forms of psychological collaboration; (v) internalizations in the course of development; (vi) products of historical development; (vii) conscious forms; (viii) voluntary forms; (ix) environmental adaptation activities; (x) dynamic changes in development; and (xi) the ontogeny of SPF.

According to Vigotski (2021, p. 153), SPF or cultural processes include in their structure, as a central and main part of the entire process, the use of a sign: "In the higher structure, the sign and mode of its use is the functional determinant or focus of the entire process". SPF are mental processes mediated by signs, but, despite the need for the mediation of signs to create connections between the different SPF, this mediation needs to have a meaning for the subject, that is, it needs to make sense to provoke relationships and connections between the different SPF. mental functions (MARQUES; CASTRO, 2022). Thus, the new element that distinguishes cultural processes from natural ones is the sign.

For Toomela (2016), every cultural sign is defined by four characteristics: (i) a sign must be an object, act or behavioral phenomenon that can be perceived directly

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by the sensory organs. Signs are used for communication, and communication will be impossible if the signs produced by one are not felt by the other participant in the act of communication; (ii) the meaning of the sign must be shared between communicating organizations; (iii) signs refer to some object, event or phenomenon; (iv) it must be possible to use a sign in a different way or context than in which it was produced. The principles and context in which signs are used may be different from the principles and context in which they exist and interact with the world.

These characteristics help to distinguish natural signals from cultural signals: natural signals are defined by the first three characteristics (availability for meaning, conventionality and overlap in meaning). A sign becomes cultural when it acquires the fourth characteristic – it differentiates (not separates!) from its reference (TOOMELA, 2016). Cultural signs are used in accordance with the principles of social communication, that is, psychological cooperation, and not in accordance with the principles of the existence of the referents of these signs. Signs initially emerge as forms of social cooperation, which are passed on to the sphere of individual ways of acting. It is important to note that signs have two different roles: external or social and internal or intellectual.

According to Marques and Castro (2022, p. 177), "as signs are used according to different cultural modes, SPF emerge, first, as forms of psychological collaboration, in society and with others". Natural and cultural processes, or lower and higher psychological processes, differ fundamentally in the incorporation of signs into the structure of the mind. Every act of internalizing the meanings of signs is related to the emergence of something new – which means bringing the sign into another set of relationships (TOOMELA, 2016).

According to Vigotski (2021), SPF initially emerge as forms of social cooperation, which are passed on to the sphere of individual ways of acting. Its development emerges in psychological cooperation (signs acquire meaning only when they are understood), that is, they are forms of cooperation before becoming individual. Therefore, as we said, it is important to note that signs have two different roles: external or social and internal or intellectual. The inclusion of

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cultural signs in the structure of the mind causes (structurally) the emergence of a whole with new qualities; it becomes possible to make sense of the world, to think about the same sensory experiences differently.

According to Vigotski (2021), the process of internalization of cultural forms of behavior is related to radical changes in the activity of the most important psychological functions and the reconstruction of psychological activity based on sign operations. Natural psychological processes are incorporated into this behavioral system, now reconstructed on a psychological-cultural basis to form a new entity. This new entity must include these previous elementary functions, which, however, continue to exist in subordinate forms, acting in accordance with new laws characteristic of the entire system. In the result of the internalization of the cultural operation, we find a qualitatively new combination of systems that clearly distinguishes human psychology from the elementary functions of animal behavior (VIGOTSKI, 2021).

The fundamental difference between natural and cultural psychological processes or lower and higher psychological processes lies in the incorporation of (cultural) signs into the structure of the mind. According to Toomela (2016), the internal reconstruction and external structure of the environment can never be fully overlapped, that is, the qualities of the elements change when they are synthesized into a higher order whole. In this way, signs change when included in the structure of the individual mind and through internalization, recording that the qualities of the external sign also change and, therefore, communication with signs acquires new aspects.

Every act of internalizing the meanings of signs is related to the emergence of novelty; every act of externalization, which means bringing the sign into another set of relations, implies the emergence of newness again. Thus, no message in human communication can be fully understood by others; meanings always change when messages are interpreted, that is, when they are constructed by individuals who communicate (TOOMELA, 2016).

The central defining characteristic of SPF is the fact that they are

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mediated by signs, in addition to the fact that their development is historical and consists of the internalization of the meanings of signs in psychological cooperation.

3 The formation of scientific concepts at school

We understand that Vigotski's work on the development of scientific concepts in childhood is an extremely important topic, as it contributes to the understanding of the instruction process (teaching and learning) and, consequently, human development. This work integrates the relationships between thought and speech, the mediating role of culture in the development of SPF and the process of internalization of historically elaborated knowledge.

Vigotski (2001) considered that understanding the development of scientific concepts at school age is, above all, a practical issue and of vital importance for the role that the school must perform, as it must guide educational practice for the child's initiation in the system of scientific concepts. The author warned of the need to expand this understanding, saying that: "what we know about this issue is impressive due to its poverty" (VIGOTSKI, 2001, p. 241).

The Russian theorist criticized most of the investigations of his time aimed at studying the formation of concepts, as they were focused only on those acquired by children outside of school, in their daily lives. This is because, at that historical moment, it was assumed that the development of concepts learned at school was in no way different from the development of all other concepts that are formed in the process of the child's own experience. Vigotski (2001, p. 252) expressed his criticism as follows:

> [...] the development of scientific concepts in the mind of the target child of the school teaching process in no way differs essentially from the development of all other concepts that are formed in the process of the child's experience itself; consequently, the very delimitation of both processes is inconsistent.

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According to Vigotski (2001), Piaget was one of the first researchers who, when faced with the problem, established a clear separation between those childhood notions of reality, which are developed by the child through their own mental effort, and those that are decisively influenced by the people around them (adults). Piaget calls the first group "spontaneous concepts" to distinguish it from the second, the "non-spontaneous". In this regard, he went further and deeper than any other scholar of children's concepts.

Vigotski adopts Piaget's criteria, despite criticism of his interpretation, classifying the concepts acquired by children and adolescents into two broad categories: spontaneous and non-spontaneous (scientific). However, from a cognitive point of view, the distinction he establishes between spontaneous and scientific concepts is different: the first are those that the child acquires in their daily experience, which includes the influence of adults (not considered by Piaget). Scientific concepts (non-spontaneous) "are those that the child acquires through school instruction, in formal education, equally influenced by adults, with the difference that, in this case, these are almost always teachers" (GASPAR, 2014, p. 127). Piaget considerava que os conceitos espontâneos eram irrelevantes para a aquisição de conhecimento sistemático (conceitos científicos). Piaget considered that spontaneous concepts were irrelevant to the acquisition of systematic knowledge (scientific concepts).

Regarding this, Vigotski (2001, p. 261) shows that:

> The development of spontaneous and scientific concepts are closely interconnected processes, which influence each other. On the one hand, the development of scientific concepts must necessarily rely on a certain level of maturation of spontaneous concepts, which cannot be indifferent to the formation of scientific concepts simply because immediate experience teaches us that the development of scientific concepts only becomes possible after the child's spontaneous concepts have reached a level typical of early school age.

Vigotski (2001) considers that the development of spontaneous and scientific concepts is a unique process of concept formation, which takes place

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under different internal and external conditions. There is no antagonism in the process and development of concepts, that is, "scientific concepts (higher concepts) cannot arise in the child's head except from pre-existing elementary and inferior types of generalization, and can never be inserted from outside into the consciousness of the child" (VIGOTSKI, 2001, p. 262).

To study the complex relationships between the development of scientific and spontaneous concepts, it is necessary to be aware of the extent to which we intend to develop our comparison. To understand these relationships, Vigotski planned research carried out by his student and collaborator Zhozephina Shif, in 1932, trying to combine theoretical interest with the social demands of the time, to experimentally test the specificities of the development of scientific concepts in comparison with spontaneous concepts (VERR; VALSINER, 2014).

The investigation was based on the assumption that concepts, that is, the meanings of words, cannot be assimilated by the child immediately, but must undergo a certain development. He also considered that it would be incorrect to apply the results obtained in a study on spontaneous concepts to scientific concepts. To test this hypothesis, he developed an experimental procedure that included structurally similar tasks that could be described through the use of spontaneous or scientific concepts, using the conjunctions "because" or "although", for second and fourth grade children. As children were admitted to Soviet primary schools at the age of seven, the age of the researched subjects varied between seven and eleven years old (VERR; VALSINER, 2014).

In the study, tests were presented, which, for spontaneous concepts, related everyday life situations and, for scientific concepts, dealt with social science content. These tests were complemented by an analysis of the child's academic performance and level of conscious understanding of scientific concepts. In the second year class, all children were interviewed individually and, in the fourth year class, they all wrote their answers at the same time, being interviewed later (VERR; VALSINER, 2014).

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In all tests, the percentage of correct answers involving scientific concepts was higher than the percentage of correct answers with spontaneous concepts. Vigotski (2001; 2010) considered this result unexpected and, from them, inferred the following conclusions: (i) the child's cognitive mastery of scientific concepts is always ahead of the cognitive mastery of spontaneous concepts; (ii) the child's advancement in the cognitive domain of their spontaneous concepts is due to the formal learning of scientific concepts; and (iii) a child's cognitive mastery of scientific concepts depends on his or her familiarity with related spontaneous concepts.

According to Vigotski (2010), children become aware of their spontaneous concepts through learning scientific concepts at school. In classes, she learns to establish logical relationships between concepts, "but it is as if the movement germinates inwards, that is, it is linked to the experience that, in this sense, exists in the child" (VIGOTSKI, 2010, p. 529).

Vigotski (2010) clarifies that the development of spontaneous concepts in children has an ascending direction, while the development of scientific concepts has a descending direction, that is, spontaneous concepts arise in the child's mind when he or she is faced with a concrete situation, whereas scientific concepts are imposed on the child's mind through their interaction with the teacher or a more capable partner. Therefore, the development of a spontaneous concept must reach a certain level so that the child is able to assimilate the scientific concept related to it. In this way, scientific concepts have their basis in everyday (spontaneous) concepts, and as soon as the child master's scientific concepts, they begin to transform the spontaneous concepts, taking them to a higher level of understanding.

Vigotski (2010, p. 540) explains that both concepts (spontaneous and scientific)

> can exist separately in the child, there can be the concept of water both as a concept formed in life and obtained in natural science classes. [...]. The knowledge that a child has about water, obtained in life and acquired at school, cannot be unified at once.

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According to Vigotski (2001, 2010), every day and scientific concepts involve different experiences and attitudes on the part of children. The strength of scientific concepts lies in their deliberate, conscious and intentional character, while spontaneous concepts[6], on the contrary, are strong with regard to a given situation, what is empirical and practical.

It is important to add that Vigotski (2021) analyzes childhood as a special moment to begin analyzing the development of Superior Psychological Functions, as this is when they begin to constitute a moment of intense biological development. In other words, this phase represents just the beginning of a process of transformation that lasts a lifetime. Thus, when we talk about children's development, we can generalize, in general terms, to other stages of school education. However, as guiding activities change, the new formations that govern development in a given phase change, the degree of self-control of conduct changes, the level of abstraction of thought changes, etc. Therefore, certain generalizations are not so direct or even possible between phases.

4 Relationships between school teaching and cognitive development

To determine the relationships between instruction and development, Vigotski (2001) created four groups of studies related to learning to read and write: grammar, arithmetic, natural sciences and social sciences. These studies led him to a unified conception of the problem of instruction and development. According to the author, instruction and development are neither two completely independent processes, nor a single process, that is, they are two processes with complex interrelationships.

Vigotski investigated the psychological functions and the level of cognitive development of these functions so that children could learn some of these contents at school. Their research has expanded understanding of the development of oral and written speech in early school age, helped identify stages in the development of word

[6] In a metacognitive analysis, this does not mean that spontaneous concepts are not always conscious; they can be at the lowest levels of consciousness, as is the case with knowledge acquired through empirics.

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meaning understanding, provided data on the influence that learning grammatical structures has on the course of cognitive development, and clarified the relationship between the nature of social and natural sciences at school.

The most important questions addressed through this research concerned: (i) the maturity of specific mental functions when instruction begins; (ii) the influence of instruction on their development and the temporal relationship between instruction and development; and (iii) the nature and meaning of instruction as a formal discipline.

Among the results of this investigation, we highlight: (i) the writing of an eight-year-old child resembles the speech of a two-year-old child; (ii) in no case were the psychological functions necessary for learning these contents present in the children's minds when they began to be taught; (iii) teaching is always ahead of cognitive development, that is, it is teaching that triggers the formation of mental structures necessary for learning; (iv) all the basic contents of school education act as a formal discipline, each facilitating the learning of the others; (v) learning is an essential factor for cognitive development.

Therefore, the teaching of new content must anticipate the existence of the psychological functions necessary for learning these contents in the child's mind, as it is through this learning that these functions are formed. To try to explain what the limit of this anticipation is, and questioning the Intelligence Quotient (IQ) test, which fails as the child solves it individually, Vigotski (2001) proposed a new approach, in which the test was solved in collaboration to a more capable partner. Research has shown that in collaboration, children solve problems that would be beyond their actual development as measured by IQ tests. Sign learning occurs with participation in social interaction situations with people who are more competent in using these symbol systems and, in this way, development goes through an external phase.

In development, every function (intelligent actions and thoughts that we only find in man – voluntary attention, mediated memory, imagination, verbal thought, speech, consciousness, voluntary perception, emotion, will, concept formation, etc.) appears twice, first in social level (interpersonal) and then on an individual level (intrapersonal). From this perspective, one of the most important

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concepts in Vigotski's theory emerges, which is the Zone of Imminent Development (ZID)[7], the theory whose essential characteristic is to convey the possibility of development (PRESTES, 2013).

> The blijaichego razvitia zone is the distance between the level of the child's current development, which is defined with the help of questions that the child solves on his own, and the level of the child's possible development, which is defined with the help of problems that the child solves under the guidance of adults and in collaboration with more intelligent companions (VIGOTSKI, 2004, p. 379 apud PRESTES, 2020, p. 204).

According to Prestes (2013, p. 299), we can state that, "when carrying out a task together, with a child or a teenager, or an adult, there is a possibility that, at some point in the future, he will independently do what he did it with our help." In this way, what we did in collaboration will be on the verge of being done autonomously: "Collaborative collective activity (with colleagues or other people) creates conditions for this possibility" (PRESTES, 2020, p. 299).

In this way, Vigotski (2001) clarifies that it is necessary to study the child's possibilities, and not what he already has or knows (current level of development), because, investigating what he does autonomously, we are studying yesterday's development, what the child or person already has or knows. The ZID defines the functions that have not yet matured, but are in the process of maturing, the functions that will mature tomorrow, that are today in an embryonic state (PRESTES, 2020). As children learn more in collaboration, within the range of their Zone of Imminent Development, and with this collaboration they go beyond what they would if they were studying alone, Vigotski (2001) explains that this occurs through conscious intellectual imitation and in collaboration. According to him,

[7] The best translation for Zone "Blijaichego Razvitia", although several authors use Zone of Proximal Development (ZPD), or even Zone of Immediate Development (ZID). The words "proximal", "near" or "immediate" do not convey the essential characteristic of the concept, which is the possibility (imminence) of development (PRESTES, 2013, p. 3). Nor is there any mention in Vigotski's work of the Zone of Potential Development, used by several authors when dealing with this topic.

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> You can only imitate what is within your own intellectual potential. [...]. If I know arithmetic, but have difficulty solving some complex problem, showing the solution can lead me immediately to my own solution, but if I don't know higher mathematics, showing the solution of a differential equation will not make my own thinking take a step forward. in this direction. To imitate, it is necessary to have some possibility of going from what I know how to do to what I don't know (VIGOTSKI, 2001, p. 328).

For many educators, even Vigotskians, the explanation that learning occurs via imitation, in addition to being surprising, is embarrassing, and it is rarely cited, and therefore few know about it, some perhaps even censor it (GASPAR, 2014). According to Vigotski (2001, p. 328), "in old psychology and common sense the opinion was consolidated according to which imitation is a purely mechanical activity".

Gaspar (2014) emphasizes that, for Viygotski, imitation is not, as laymen in psychology believe, just a mechanical activity, which almost all people are capable of doing if they have someone to imitate. If it were possible to imitate anything, any child would be able to solve any problem with the assistance of a more capable partner, which is not the case. In collaboration with another person, "the child more easily solves tasks closer to his level of development, then the difficulty of the solution grows and finally becomes insurmountable even for the collaborative solution" (VIGOSTKI, 2001, p. 329). The ease with which she is able to move from independent problem solving to assisted problem solving is the best indicator of the dynamics of her development.

> The development arising from collaboration via imitation, which is the source of the emergence of all specifically human properties of consciousness, the development arising from learning is the fundamental fact. Thus, the central moment for the entire psychology of learning is the possibility of collaboration rising to a higher level of intellectual possibilities, the possibility of moving from what the child can do to what he cannot do through imitation. The entire

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> importance of learning for development is based on this, and this is what constitutes the content of the concept of zone of imminent development (VIGOTSKI, 2001, p. 331).

Vigotski (2001) explains that animals, including the most intelligent ones, are incapable of developing intellectually through imitation or learning. In other words, an animal "can acquire new and complex skills, but is not capable of generalizing them and, by itself, acquiring other skills from them" (GASPAR, 2014, p. 143). Imitation, in the animal, does not produce learning (in the specific human sense), but training. In humans, the development of SPF essentially results from cooperation, teaching and imitation: "Learning is possible where imitation is possible" (VIGOSTKI, 2001, p. 332).

According to Vigotski (2001), the main difference between solving tests with spontaneous concepts and scientific concepts is the fact that, in the case of the latter, the child must solve the task with the teacher's help, via conscious and collaborative intellectual imitation. The author argues that,

> [...] when we say that the child acts by imitation, this does not mean that he looks another person in the eye and imitates. If I saw something today and do the same thing tomorrow, I do it by imitation. When a child solves problems at home after having seen the sample in class, he continues to act collaboratively, even though at that moment the teacher is not next to him. From a psychological point of view, we are allowed to see the solution to the second test – by analogy with the solution to homework – as a solution with the help of the teacher. This help, this moment of collaboration is present, it is contained in an apparently autonomous way in the child's resolution (VIGOTSKI, 2001, p. 342).

As the essence of imitation is in social relationships, including the teaching and learning process, the presence of imitation allows us to consider that the human being is formed in social and cultural relationships and has a central role in the development of Superior Psychological Functions.

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5 Pedagogical Implications

For Vigotski, SPF are of social origin and develop from the appropriation of material and psychological instruments (signs), characteristic of school activity, which makes the task of teaching somewhat more complex than simply organizing strategies. According to Vigotski (2001; 2010), the only good teaching is that which precedes development. It is, therefore, about understanding how SPF develop, which allow the formation of concepts that change depending on this development.

Leontiev (1991) and Vigotski (2001) criticize tests that are limited to establishing whether a student answered a question correctly or incorrectly, as they are inadequate for evaluating that student's intellectual capacity. According to the authors, the student is capable of carrying out much more complex tasks when in collaboration, and for this it is necessary that both he and the teacher have active participation in the process. Thus, the teacher needs to understand that his activity is intentional and that this lack of intentionality restricts him to a mere executor of technical procedures.

Gaspar (2014) explains that the internalization of language (speech) only occurs if there is a reason for the subject to be willing to take on the task, and, therefore, to learn it is necessary to think. One way for the teacher to motivate students is by trying to understand the spontaneous concepts they have in relation to the content. We remember that scientific concepts are formed by explaining their relationships with other concepts that already exist in the student's cognitive structure (spontaneous concepts). In other words, the student learns based on what they already know.

Vigotski (2010) discusses that the teacher's work is not restricted to making the student think and assimilate content; it is also up to you to make the student feel. Emotional reactions must form the basis of the educational process. Before presenting new content, "the teacher must arouse the student's emotion and be concerned that this emotion is linked to the new knowledge" (VIGOTSKI, 2010, p. 144). The author continues by mentioning that: "The moment of emotion and interest must necessarily serve as a starting point for any educational work" (VIGOTSKI, 2010, p. 145).

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From this point of view, learning is only possible when it is based on the student's interest, and not on external influences, such as prizes, punishments, fear and desire to please, among other examples (VIGOTSKI, 2010). The author emphasizes that recognizing the student's interest does not mean following it in a linear way. When organizing activities, the teacher intentionally interferes actively in the processes of developing interests, so that he must influence all student behavior. However, your rule will always be: "before explaining, be interested; before forcing to act, prepare for action; before resorting to reactions, prepare your attitude; before communicating something new, raise the expectation of something new" (VIGOTSKI, 2010, p. 163).

Therefore, learning is the necessary and fundamental aspect for the development of specifically human and culturally organized characteristics, and, therefore, instruction occupies a prominent role in Vigotski's School. The teacher, as the most capable partner in a collaboration process, must guide his activities towards: (i) respecting the limits of the students' ZID, so that they can learn; (ii) motivate students so that they want to learn; (iii) ensure the sharing of questions and intended answers; (iv) guarantee the sharing of the language used; and (v) allowing students to imitate themselves, so that they can start learning (GASPAR, 2014).

Thus, as the development process produced by teaching is always mediated, whether by tools (from the inside out) or by signs (from the outside in), it makes no sense to call the teacher a mediator, that is, the mediation is done by instruments and signs. He is the professional responsible for enhancing the appropriation and use of tools and signs by students at school, greatly contributing to their intellectual development and their insertion and participation in society (MARQUES; CASTRO, 2022).

Thus, the instruction process needs to be organized with appropriate procedures, in such a way that allows the active participation of everyone involved, in order to promote the development of students' FPS, and, in this way, Vigotski's school constitutes an approach to cultural transmission as well as development.

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6 Final Considerations

Vigotski's theory brings the primacy of the social aspect over the biological in the development of SPF, valuing the transmission[8] to students of historically produced and socially accepted content. It is through the mediation of instruments (physical and psychological), mainly through language (speech), that individuals internalize these culturally structured elements. In this way, it is evident that the student, in the school context, appropriates the intellectual activity produced by humanity over the centuries.

From this perspective, learning is the driver of development, and thus we can understand the importance of instruction and teaching work, which allow students to appropriate the cultural instruments (signs) produced by humanity historically, characterizing the process of humanization and development. Individual development consists, in large part, in progressive access to these signs and sign systems, or, in other words, in the progressive learning of signs and their use. The more cultural instruments one learns, the more the range of activities that the subject can learn expands.

Another important aspect of Vigotski's work concerns the concept of Zone of Imminent Development, "which is closely linked to the relationship between development and instruction and the collaborative action of another person" (PRESTES, 2020, p. 190). According to Prestes (2020, p. 190): "Vigotski does not say that instruction is a guarantee of development, but that it, when carried out collaboratively, whether by adults or between peers, creates the possibility for development". The essential characteristic of the ZID is the field of possibilities for the development of SPF in guided activities.

Vigotski's theory shows the importance of the role of the teacher, whose presence is essential in the social interactions that occur in the

[8] We are aware of the criticisms made regarding the use of this term, which often refers to Freire's (2005) banking education. The word, in our context, is used considering that, during this process, the teacher and the student have active participation, encouraging the activity of thinking.

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classroom, implying a great pedagogical responsibility. This is because the teacher is the most capable partner, especially in relation to the content of his discipline (GASPAR, 2014). In this way, its role is to provide students with access to the historically produced cultural collection, in addition to teaching them how to use it.

Algunas implicaciones pedagógicas de la Escuela Vygotsky para la Enseñanza de las Ciencias

RESUMEN
En este artículo, a partir de una investigación bibliográfica, presentamos algunos conceptos centrales del trabajo de Vygotsky para la Enseñanza de las Ciencias, con el objetivo de proponer una reflexión sobre cómo han sido utilizados en la investigación en la Enseñanza de las Ciencias, referenciados en publicaciones traducidas directamente de los originales. Ruso, dado el amplio uso en este ámbito de traducciones editadas con numerosos recortes que caracterizan erróneamente la obra de este autor. Intentamos sintetizar aspectos centrales del origen de los Procesos Psicológicos Superiores, de gran complejidad, a los que daremos un tratamiento introductorio. El aprendizaje de un sistema de conceptos científicos es la base del desarrollo, y uno de los obstáculos que enfrenta esto es que los conceptos se presentan como palabras vacías, sin vínculo con los conceptos espontáneos que ya tienen los estudiantes. Argumentamos que las ideas de Vygotsky pueden ser utilizadas en la Enseñanza de las Ciencias para superar este obstáculo, considerando que el papel de la escuela es brindar a los estudiantes conocimientos sistematizados de todas las áreas del conocimiento y que la apropiación de estos conocimientos es la base para el desarrollo de la Educación Superior Funciones psicológicas.

Palabras clave: Escuela de Vygotsky; Mediación; Formación de conceptos.

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