

Towards a formal model of the pedagogic discourse and the Zone of Proximal Development (ZPD) of Vygotsky

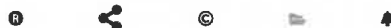
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Abstract:

This article uses conceptual devices from different theories of communication, discourse analysis of Pêcheux and Zone of Proximal Development (ZPD) of Vygotsky, to present a formalization of a new pedagogical discourse based on the pedagogic transformation through a meaning-effect. The formalization of the main components of the pedagogic discourse takes into account the imaginary formations, languages and discursive process of teaching and learning, which allow us to orient ourselves towards producing a more diverse model. Finally technological artifacts created (new technological tools in education, virtual classrooms and new materials) become powerful tools daily in mediating our communication and our activities. Thus new forms of code -according to some communication models- seem to take on increasing significance. Is also described in this paper a proposal incorporating technological resources as elements in imaginary mediation and discursive composition.

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Towards a Formal Model of the Pedagogic Discourse and the Zone of Proximal Development (ZPD) of Vygotsky

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Abstract

This article uses conceptual devices from different theories of communication, discourse analysis of Pêcheux and Zone of Proximal Development (ZPD) of Vygotsky, to present a formalization of a new pedagogical discourse based on the pedagogic transformation through a meaning-effect.

The formalization of the main components of the pedagogic discourse takes into account the imaginary formations, languages and discursive process of teaching and learning, which allow us to orient ourselves towards producing a more diverse model.

Finally technological artifacts created (new technological tools in education, virtual classrooms and new materials) become powerful tools daily in mediating our communication and our activities. Thus new forms of code -according to some communication models- seem to take on increasing significance. Is also described in this paper a proposal incorporating technological resources as elements in imaginary mediation and discursive composition.

1. Introduction

Different societies have distinguished by features of communication like written and oral traditions. Within an oral tradition, the oral transmission is done due to the fact the individuals involved share a common context. When writing was invented, the context itself

was transformed. The writings and books, vehicles of decontextualization, were the first index of a universal form. The books were at the same time a new channel of communication between one or more authors and recipients potentially universal. With the invention of computers the communication has increased, introduced artifacts such as the introduction of systems and databases have changed the activity and history of institutions and companies. Computing has redefined each of the primary disciplines as our own technological capacity.

We are witnesses of permanent transformations, today the permanent only thing is the change. For example, changes in education: new learning theories; the enlargement of the concept of classroom (both physical and virtual)¹; the displacement of the teaching task of that encyclopedic mentor who was transmitting information, towards that one that it faces, which there guides (tutor), who teaches how to learn; the displacement of the treatment of the information cut away and classified to the treatment of big heaps of available information, etc.

All these changes, and the technological rhythm, seem overwhelming. Nevertheless, depending on how we appropriate of the changes and how we use them in the educational and discursive task, is how we will achieve the aims that we seek. The discursive process is a process that involves various stakeholders in a meanings game. The task of communication is mainly based

¹extending the *euclydean* view of the classroom by the vision of a more *topological* approach: area of approaches or contiguities, area of intersections and meetings.

on pooling meanings. And the educational task today does not consist of transmitting so much a learning object (or technological artifact) but in teaching what we can do with them, and thus the importance of conveying meaning.

So much in the task of educational, as in the communication or discursive one, every day we deal not only with objects or real subjects but also ideals, or imaginary. E.g. in the teaching task, is so important what the subject knows, as what the student is potentially able to do (its zone of proximal development). Moreover, in the teaching task it is important the imaginary and cognitive formation of the teacher of what he or she expects from the students (expectations in function the competences to be reached). Hence the need to bear in mind the imaginary formation that occurs in the teaching-learning process, which is nothing but a continuous process of transformations that takes into account the conditions of production of the involved ones (stakeholders) and makes use of an appropriate selection and combination of components of a common contextual system.

This article will discuss the first steps towards a formalization of the pedagogic discourse. Formalization that will use Jakobson's communication model, discourse analysis of Pêcheux and conceptual devices of different authors from science education and computer science. The formalization is used to model an important aspect of an early study on intelligence, the zone of proximal development of Vygotsky. As Wang [20], [18] remarks Lev Vygotsky presents a communication view that perceives intelligence as inter- and intra- personal communication in a social context.

The article is divided as follows: Section 2 describes the communication model of Pêcheux based on speech, also address concepts related to language and the reason of studying the discourse in relation to social practices and the educational work. Section 3 presents the pedagogical discourse and outlines a framework for formalizing it, while section 4 shows an extension to model the ZPD considering a formalization of technology resources and their involvement in the discursive process. Finally, Section 5 presents some conclusions of the work and describes future work.

2 Communication and Discourse

Communication studies are an interesting field, with diverse problematizations and foundations. Communication studies integrates aspects of both social sciences and the humanities. From the traditional sense of management of disciplines, communication studies not have

a definable area of empirical objects as does the rest of the sciences (which leads to Calletti to think of it as an impossible discipline).

So communication studies should be considered as an interdisciplinary field, with a gray area of objects themselves. In an attempt to determine which objects are inherent to communication studies, we must refer to the Latin etymology of the concept of communication: it means *to share, to put in common*. That is, whenever we are sharing not only we are putting in common but also communicating.

From a wider point of view, not only we *put in common* on having spoken but also when we establish any kind of contact [1]. To understand more clearly is necessary to study *the problem of the significance*, since the problem of communication is closely tied those of the significance [1]. And, to speak about significances implies speaking also about an ideal object associated with a real empirical object and this has implications in the proper observation (the relation of the subjects with these objects) and cognition aspects.

2.1 Overview of the Jakobson Model

The Jakobson model describes the information that is transmitted as a *message*. He introduces the information schema which has the advantage of differentiating both the protagonists and the referent of discourse. The constitutive factors of any act of verbal communication in his schema where (also used as the basis of the Pêcheux model): **The addresser sends a message to the addressee. To be operative the message requires a context referred to (the referent), apprehensible by the addressee, and either verbal or capable of being verbalized; a code fully, or at least partially, common to the addresser and addressee (or in other words, to the encoder and decoder of the message); and, finally, a contact, a physical channel and psychological connection between the addresser and the addressee, enabling both of them to enter and stay in communication [6].**

The schema thus becomes:

$$A \xrightarrow[\underset{R}{\quad}]{\overset{(L)}{D}} B$$

where Table 1 describes its main components:

Jakobson describes the information that is transmitted as a *message* (according to the information theory which provides the basis for the schema) however Pêcheux uses the term *discourse*, implying that we are not necessarily dealing with the information transmitted but with a meaning-effect between A and B [15]. And this is the perspective from which we will

Table 1. Constitutive factors of the schema

A	=	addresser
B	=	addressee
R	=	referent
(L)	=	linguistic code common to A and B
→	=	contact established between A and B
D	=	verbal sequence sent by A to B

focus when we say that we are communicating: we communicate when we transmit meaning and when we put it in common.

2.2 Overview of Pêcheux model

Pêcheux uses the Jakobson model as a basis and according to Helsloot [5] he transforms sociologically the original model. Pêcheux model is described as follow: A and B designate something other than the physical presence of individual human organisms, they designate determinate *positions* within the structure of social formation. The sociology can describe the bundle of objective features that characterize them. These positions are *represented within the discursive processes*, i.e. the position are present, but transformed. In the discursive process is configured with a *series of imaginary formations designating the positions which A and B ascribe to themselves and to one another, the imaginary they have of their own position and of the position of the other* [15]. Pêcheux defines rules for projection within the mechanisms of any social formation. The rules establish both the situations (defined objectively) and positions (representations of situations). Their correspondence is not biunique, **different situations can therefore correspond to a single position, and a single situation can be represented by several positions.**

Any discursive process presupposes the existence of imaginary formations which can be designated as in Table 2, which outlines the manner in which the position of the protagonists of a discourse intervenes as a condition of production of discourse. The referent R (the context or situation in which the discourse appears) is also a condition of production. Pêcheux stress that the referent is an imaginary object (a subject's viewpoint) and not a physical reality.

As Helsloot argues in [5]: 'What matters is the place² that each of them attributes to itself, to the

other and to the *referent* (the object of which they speak). Such positions are imaginary, not in the sense of being *unreal* but of being related to images which produce material effects. The protagonists are not *free* in the choice of these images, which depend on structural relations (such as between worker and boss) and on what is said earlier and/or elsewhere. Such restrictions account for the relative stability of discourse through different occasions. This implies that *meaning* is more or less stable through such occasions, but that it changes when the conditions of production change, which is the case, e.g., when the same speaker speaks to another person or to the same person on a different subject'.

We will return later the formalization of imaginary formations and the conditions of discourse production by Pêcheux. The next subsection explains why the discourse, the language and imaginary positions are important in the pedagogic task.

2.3 The discourse

It is important to study the discourses or speeches because they are the product of concrete social practices and their effects are linked to the production of power relations [11]. Its comprehension from its exterior side give us a broader point of view.

The speeches have an impact and build places for the subjects, in fact the subjects did not actually exist outside of those discursive practices (eg. Modern pedagogy has somehow created *the place* of the teacher, student, and many other categorizations, etc.).

This means that the language not only predates the subject instead also contributes to give it a place, contributes to give him an existence.

There are devices that allow a speech last in the social grid over time, such as school-family partnership, children, etc. These devices or vehicles are called trans-discursive vehicles by Manolakis.

Manolakis [11] referring to Foucault, describes that one of the fundamental changes in modern society has been the shift of low-based regulatory devices to rule-based regulatory devices. This shift is characterized by a negative conception of judgment behind the first, while in the latter this view is positive. This is a logical shift.

²Caletti [1] argues the place condenses the complex set of so-

cial, cultural, economic, political factors that defines the position of any stakeholders in a given circumstance

Table 2. Imaginary Formations

Expression designating imaginary formations	Signification of expression	Implicit question (the answer to which subtends the corresponding imaginary formation)
$I_A(A)$	Image of position A for the subject placed at A	Who am I to talk to him like that?
$I_A(B)$	Image of position B for the subject placed at A	Who is he for me to talk him like that?
$I_B(B)$	Image of position B for the subject placed at B	Who is he to talk to me like that?
$I_B(A)$	Image of position A for the subject placed at B	Who am I for him to talk to me like that?
$I_A(R)$	A's view of R	What am I talking to him about like that?
$I_B(R)$	B's view of R	What is he talking to me about like that?

In the former, the *rule* is intended to be merely a descriptive concept (the mean, the regular, etc.). Initially pedagogic discourse was normative in the sense it performs the same operation steadily: the exclusion of some that deviate from the norm, and the inclusion of others if they approach [11].

This evolutionary mechanism of selection is still exclusive and discriminatory. Today, there exists new pedagogical approaches to education for diversity, to work in social network, etc. We may be witnessing a paradigm shift of the pedagogic discourse.

In this sense, discourses structure our sense of reality and our notion of our own identity [12]. But the speeches are modified with the same practices. There are social practices that generate certain forms of speech that allow mutation in the evolution of the speech itself, and therefore in production relations.

2.4 The Language

Pêcheux reintroduces the value theory of Saussure and applies it to the conditions of discourse production. The theory of value explains the meaning of words by their relationships with other words of the language. The meaning of words in a speech (eg. In a text or verbalization) is explained by their relations with other words unspoken, words that could have been said but were not, words that were said before (on the same occasion or another time) and words that could not be said. The interplay of words is what Pêcheux called **metaphorical relation**, and meaning-effect is called **metaphorical effect**. Pêcheux defines a theory of meaning as an effect of metaphorical relationships (selection and replacement) that are specific to (the conditions of production) a verbalization or to a text.

The essence of this theory of his own de Saussure and Pêcheux is to see language as a system³. Saussure makes an important distinction between language (language, or English language) and speech (speech).

Language is a collective social institution allows us to speak, while the single talk is something we do with a degree of personal freedom [8]. The difference is similar between code and message.

2.5 Imaginary Formations

Pêcheux [15] models the discursive process from a set of imaginary formations (called positions). Within any communication of two subjects the process is configured by designating the positions which A and B ascribe to themselves and to one another.

As we previously mentioned, the model distinguishes both the situations (defined objectively) and positions (representations of situations), and their correspondence is not biunique.

The place that a subject ascribe to himself, to another and to the referent is described by expressions which denote different imaginary formations (see Table 2).

The manner in which A represents B' representation at any given moment of discourse is expressed as: $I_A(I_B(A))$, $I_A(I_B(B))$, $I_A(I_B(R))$. Similarly B represents A' representation as: $I_B(I_A(B))$, $I_B(I_A(A))$, $I_B(I_A(R))$. It follows that the state n conditions of production of a specific discourse D_x addressed by A to B on the referent R, written as $\Gamma_x^n(A, B)$ can be represented by the schema of Table 3.

The elements of Γ_x^n do not all have the same efficacy, and that one element may become dominant within

³language is a system that is shared by a community (a nation or a culture) [5]

a given state of conditions [15]. Pecheux gives an example of the case within a therapeutic discourse: in which the patient's self-image that is at stake in discourse.

Pêcheux defines the following rules in [15]:

- **Rule 1:** The process of production of discourse D_x (with a determinate state n) results in composition of the conditions of production of discourse D_x (with a determinate state n) with linguistic system L . Notation: $\Gamma_x^n \circ L \rightarrow \Delta_x^n$

This rule can be interpreted as the following: Γ_x^n is used as selection and combination principle from the elements of the L language, which are used to build a link of semantic system representing the discourse matrix D_x within the state n , in other words, it sets the *semantic domain* and *domain dependencies*.

- **Rule 2:** The compounding of any process of production Δ_y^i with a determinate state n of the conditions of production of discourse D_x results in a transformation of that state: $\Gamma_x^n * \Delta_y^i \rightarrow \Gamma_x^{n+1}$ where $*$ represents the operation of compounding.

This rule shows the transformational effect on the state of conditions of production from the presence of a particular process within the discursive field. A discourse addressed by A to B modifies the state of B insofar as B can compare with his anticipations. In the same way, any orator is potentially his own listener, and that implies that what is said by A also transform his or her conditions of production.

Table 3. Schema of production of discourse D_x addressed by A to B on the referent R

$\Gamma_x^n(A, B)$	$I_A^n(A)$
	$I_A^n(B)$
	$I_A^n(R)$
	$I_A^n(I_B^n(R))$
	$I_A^n(I_B^n(R))$
	$I_A^n(I_B^n(R))$

3 Pedagogic Discourse

In this section we present the main contribution of the paper based on related work described in section 2.

Education is often thought of as a teaching-learning process, and this process is communicative, discursive.

It is therefore important in this instance, after analyzing the discursive process' components and their conditions of production, to trace the first steps towards a model of the pedagogical discourse.

Papert [14] clearly describes how the number of elements of a trans-discursive paradigm of modern pedagogy (family-school partnership, construction of childhood, etc.) are in direct transformation of a new social contract, and a new social capital [16], [7], [21] in educational matters. This series of transdiscursivos elements of modern pedagogy, corpus visible comeniano paradigm [2] - are being modified, giving a new meaning, readjusting, as elements of a new device trans-discursive.

If there was a logical shift of speeches based on law to those rule-based and gradual rise in the emergence of a new discourse of diversity, technological devices have undergone a major transformation. Although the creation of technological devices for operational purposes is widely oriented to communication and are commonly incorporated in educative tasks, expanding our perception, the paradigm enclosing them is not clear.

3.1 Formalization of the Pedagogic Discourse

When Pêcheux gives an example of the displacement of the dominant element in the conditions of production of discourse, he talks about the pedagogic discourse. In this section we will use this short example to model a pedagogic model using a constructivist approach. The short example of Pêcheux said: 'in the pedagogic discourse, it is the students' image of what their teacher is telling them, $I_B(I_A(R))$, that dominates discourse (in relation to $I_A(R)$)'.

However, this pedagogical discourse is more typical of a teaching role that has a unique view of R (an encyclopedic vision of R). Today the teacher has a role closest to a tutor, in some aspect of power relations have changed. In constructivist learning, teachers consider what is know by the subject about the discourse' referent of $I_B(R)$ and taking into account this component as dominant in the production scheme n of the subject (ie Γ_y^n) make use of it to select and combine those elements of language L most significant (rule 1): $\Gamma_x^n \circ L \rightarrow \Delta_x^n$ ⁴ to obtain the most accurate transformation in their students (Rule 2): $\Gamma_y^n * \Delta_x^n \rightarrow \Gamma_y^{n+1}$.

It is through the new state (Γ_y^{n+1}) and through the selection that students do from the language (rule 1) for the production of a new discursive process,

⁴In the diagram Γ_x^n must be dominant imaginary representation of teaching students about $I_A(I_B(R))$

$\Gamma_y^{n+1} \circ L \rightarrow \Delta_y^{n+1}$, that the teacher has a return of that transformation has been obtained.

So as argued by Pêcheux [15] that is impossible to define the origin of the production conditions of a speech, as this could involve infinite regress, in the same way is impossible to know all previous knowledge of the subjects. The professor has only a imaginary representation of the previous knowledge.

Pêcheux indicates that it is possible to investigate the conditions of production on the basis of a given state of conditions, therefore defines a correspondence rule between production conditions and the discursive process (rule 1) and the transformation of the conditions of production from a process of discourse (rule 2).

3.2 Outline of Vygotsky ZPD

Vygotsky theory proposes a social cognition learning that emphasizes social interaction in the development of cognition [19]. Within this theory the Zone of Proximal Development (ZPD) is the distance between a student's ability to perform a task under adult guidance and / or with peer collaboration and the student's ability solving problem independently. According to Vygotsky, learning occurred in this zone.

We will not make a detailed description of the ZPD of Vygotsky (we refer the reader to [17]). Within the ZPD, the imaginary formations are significant components of the intersubjective space of a person. What the subject is capable of doing, what the subject is able to learn determine different states in a transformation of learning.

An encounter between the learner and others more capable (commonly know as MKO -More Knowledgeable Other-) is done within that zone, allowing the subject to learn through support. The MKO refers to anyone who has a better understanding or a higher ability than the learner, with respect to a particular task, process, or concept. The MKO is normally thought of as being a teacher, older adult, but the MKO could also be peers, a younger person or even computers. Within the learning process the support is sometimes called scaffolding (*scaffolds*), it involves the use of means by which the teacher provides assistance or performs its help. However, the ability of a person also expands from interaction with the use of computers, technological objects or resources (technological resources can also be considered as MKOS).

A text is a vehicle of communication, in fact the text itself can be thought a representation of a discourse [9]. From the point of view of the fundamentals of computer science, language are handled by comput-

ers [10], [5], and may consider a computer program as a type of speech [3].

In any teaching-learning process it is natural the use of technology resources (computers, text, etc..) and associated materials (software, images, etc..). In the case of using a number of resources in the process of discourse Δ_x^n we consider each resource associated with its own language, represented by the function $f : R_i \rightarrow L_i$. We define the following rules taking into account the use of technologic resources:

- **Rule 3:** The process of discourse production D_x (with a determinate state n) results from the composition of the conditions of production of Discourse D_x (in the state n) with a system L_i associated with the resource R_i . Notation: $\Gamma_x^n \circ L_i \rightarrow \Delta_x^n$.
- **Rule 4:** The transformation of materials, results from the composition of the production conditions of discourse D_x (in state n) with a system L_i associated with the resource R_i^n . Notation: $\Gamma_x^n \circ L_i \rightarrow R_i^{n+1}$. This rule denotes the selection and composition in the production of materials.
- These rules are combined with rules 1 and 2 (defined by Pêcheux) listed above, which are still valid.

We should clarify two important considerations from the previous rules:

1. We must broaden the vision of the discourses or speeches, we will consider not only verbal speeches but also the text or the program such as a speech.
2. Rule 3 is read in a manner similar to Rule 1. The construction of semantic domains and their relationships are based on the languages associated with the technological resources applied in the pedagogic task⁵. The resources do not generate discursive processes, but the languages associated with resources do.

Having expanded the set of rules, we give a representation in our model of the Zone of Proximal Development.

- The ZPD is represented by a transitive closure, $(\Gamma_x^n * \Delta_y^i)^+ : \Gamma_x^n * \Delta_y^i \rightarrow \Gamma_x^{n+1} * \Delta_y^{i+1} \rightarrow \Gamma_x^{n+2} * \Delta_y^{i+2} \rightarrow \dots \rightarrow \Gamma_x^k * \Delta_y^{i+k}$. Where Δ_y^j with

⁵This rule is based on one Foucault [4] premise: the language itself goes beyond its verbal form and there are many things who speak, there are languages that are articulated in a non-verbal form.

$j = i, i+1, \dots, i+k$ describes a chain of production processes of discourse, the scaffolding used. That is, the ZPD is a sequence (chain of transformations) resulting from repeated application of rule 2 defined previously. Such that, if Γ_x^k represents the final state (k) of the closure, verifies that:

- $I_A^k(R) \approx I_B^k(R)$, i.e. the educator and the learner have an imaginary formation equivalent of the Referent R, or
- $I_B^k(R) \approx I_A^k(I_B^k(R))$ i.e. *The image of B' view of R is equivalent to the image formation of B' view of R for the subject placed at A.*

4. Conclusions

The pedagogic production is inherently associated with the discourse, communication and education.

The task of modern pedagogy is not only important to understand the place we want to go but also the use of individual operators that guide, direct, discipline pedagogical production [13].

In this guide is important the schedule and plan, the accreditation and evaluation as well as the selection and combination of materials and the discourse we produce ⁶

In this paper we used as a basis the formalization of the discourse analysis of Pêcheux (which in turn is based on Jakobson's model) to reason and to define a set of rules for a new pedagogic discourse. These rules (rules 3 and 4) were in turn used to model the ZPD from the initial proposal. These formalizations can be used in the construction of computer tools modelling the teacher-student interaction, tools automated speech analysis, and analyzing the execution of protocols of the learning process.

As future work, we intend to formalize the process (teaching and non-teaching) of common constructs from a social aspect. The formalization of a model encompassing a broader spectrum will be more in keeping with the *learning and thinking in a net* and the collaborative construction.

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⁶In fact Papert points out that two of the functions of digital technology are material and communication channel [14].

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