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Teacher and Technology: The Computer In Education

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Abstract

This article is results of the research carried out between the years 2000 and 2001 in a Chilean high school, with the objective of studying the role of the computer in teaching. The focus was to understand and to describe the technologies used for teaching in high school, identifying them and seeing how they operate, their possibilities and limitations and the contradictions that may emerge as part of the natural development of the activity.

The approach used for the methodological design was the cultural-historical Activity Theory, this being the reason why the investigation was structured in two phases: (a) the cultural-historical reconstruction of the teaching activity and (b) the empirical description of pedagogical practice in a specific context.

Keywords: Teaching, cultural-historical Activity Theory, Technology, Design

Introduction

The educational field in Latin America during the decade of the 90's was marked by the adjustment of educational systems to the new social and economic conditions that the region faced (Cepal, 2000). These processes of updating included the introduction of new information and communications technologies (ICT) as a way of facing the challenges that globalization and the technological revolution had imposed on the educational system. With this perspective, the introduction of the ICT in Latin America must be understood within the broader framework of the transformation of education, and therefore as a part of the general changes taking place in education, as a response to the historical, social, political and economic conditions that mark the present-day development of the region.

The introduction of new technologies during the last 15 years in Latin American schools reflects policy makers' desire to attain the goals of equality, productive transformation and competitiveness, as well as the consolidation of modern democratic systems based on the public participation of citizens.

The introduction of computers into educational systems can help to solve the problem of equality as that it allows advances in the equality of access to sources of information and the communication for all young people. This equality in access will surely represent a difference in

the short term between those who have such forms of communication, information and social exchange at their disposal, and those who remain marginalized from these processes.

Cepal (2000), at the start of the present decade, indicated that a better distribution of symbolic assets, i.e. knowledge and useful skills, contributes to a better distribution of material assets in the future. In this way the introduction of computers to a teaching environment aims to address an equality issue: it promotes educational quality to which young people from less-advantaged economic strata may gain access. From this perspective, the inclusion of new media is also relevant to the development of the competitiveness of the Latin American countries on the global economic scene.

In Chile the incorporation of ICTs on a mass scale within the educational system it is a recent process that began in 1993 with the incorporation of the ICTs simply as one new component of that country's educational reforms. By means of the national network ENLACES, 100% of the country's high schools and 50% of the primary schools have already been equipped with computers and access to the national network.

Nevertheless, this systematic process of incorporation should be considered in the historical context of Chile in the 90's, when the country entered into a process of reintegration into the international arena and began to establish new strategic alliances with other countries of the southern part of South America.

Chile needed to reposition itself in competitive terms within a global economy that demanded new skills and knowledge among its labor force. It also had to take a new role in the international community, as a democratic nation consolidating a strong and responsible citizenship. This demanded that the government find solutions to direct the course of the country towards these goals. It is in this political and economic framework that computers emerged as desirable element in Chilean education. It was hoped computers would trigger changes within schools, seeing them not only as a tool for efficiency, but also as an engine for transformation. Reports on the ENLACES project in 1996 (Potashnik, 1996) made clear that the expectations of the project related directly to the economic, social and educational needs present in Chilean society, They were centered basically on: 1) generating changes within schools, and 2) improving the social and economic conditions of the users of the school system, and therefore of the country as a whole (Potashnik, 1996). Therefore, the basis of the argument was that the introduction of computers would generate important changes in school organization and in the type of learning they give, while simultaneously offering better opportunities for young people in the modern world.

These hopes are not new ones. The process of the incorporation of computers is not new in the world; even in the decades of the 60s and 70s there were cases of using computers as a form of support for learning. Nevertheless, it was not until the decade of the 80s that the systematic introduction of computers into education became a reality, both in European and American countries, particularly Britain and the United States. Olson (1988) indicates that no other technology has generated more expectations in education than the arrival of the computers.

However the promise of computers has not been fulfilled. Although the results are favorable with respect to the need to incorporate these technologies into education; the ideological, historical and social development aspects of incorporating computers are unclear. These aspects need to be uncovered if we are to be able to understand the problems involved with the incorporation of computers in the world of education, and understand why the expectations about the development of qualitatively different conditions in schools has not materialized.

The introduction of the computers, as described, does not depend on the development of the field of computing, but rather on political and technocratic interests that seek to improve the

conditions influencing production. Thus it is not surprising to find that there are contradictions and resistance arising within the education community, which are a product of these processes of incorporation. They reflect the conflict and contradictions between the different fields, where the cultural values of the technocrats are superimposed on the cultural values of the world of education, which is symbolically threatened. So, the potential benefits that this technology can provide for learning processes in schools is unclear for the teacher, and this becomes more serious where the computer becomes a self-contained machine which fails to impact upon the educational system.

Computers in education. A problem unsolved.

Although the use of the computers is seen as a need according to the demands of the context; and despite the general consensus that they are tools that can aid the learning process, its incorporation into pedagogical practices as a tool that could make new forms of education possible still seems to be marginal.

But what problems have there been? In the literature it is usual to consider the teachers to be the critical element. It has been common for teachers to have been qualified as "traditionalists" or as "obstinate to change" when talking about the little success of the introduction of computers to schools. Amarel (quoted in Olson) "describes teachers as anxious, resistant to change, and afraid of losing their jobs" (Olson, 1988, p.9).

The argument of control ties in closely with this assumption in two ways: 1) the loss of control regarding content - as computers can provide more information on a given subject, teachers feel worried that they will lose control of educational content and that the students will therefore obtain data by themselves; 2) the loss of control of the classroom environment - the use of the computer concentrates the students' attention, and thus it is suggested that teachers fear to lose control of what goes on in the classroom (Vizacarra and Leon, 1998). This loss of control with respect to the work-space, in both senses, is strongly associated with teachers' low expertise in computer applications and the technical problems that may occur. The loss of control that may occur if the computer fails, for example, is a factor that naturally generates anxiety among teachers (Crook, 1996).

The evidence shows that the computer as a tool in education practice is still not available to teachers. Time, workload, lack of technical knowledge, and the loss of control that upsets the old system of classroom organization and forms of training are the most recurrent arguments to explain teachers' resistance to incorporate new technologies into their education practices (Hannafin and Saveney, in: Moonen, 1995; Crook, 1996, Vizacarra and Leon, 1998).

However, it is necessary to explore these critically important points and the resistance to the incorporation of new technologies, as indicated by different authors, from the point of view of the nature of human behavior itself. The explanations reviewed tend to simplify the complexity of the human behavior in general and behavior in education in particular; regarding these tools as independent elements, to be adopted and used or not by rational and conscious decisions of the agents.

It is necessary to consider that the use of these tools conditions the relation between the people and the intentions of their actions, therefore its availability in the activity is influenced by its role in the user's purposes and its value is related to that purpose. The tools become available as part of a cognitive network that forms a dominion of social action.

Practices and habitus

In the incorporated rationalist perspective to the prevailing common sense, practices are understood to be the execution of procedures previously stored in the mind. Thus, human activity and human cognition are to be understood as two separate aspects, the first - human activity - being the objective manifestation of mental schemes and outlines that are expressed as procedures and pre-defined rules, and the second - human cognition - the information processing that is acquired, manipulated and stored in people's heads. This understanding of practices as the repetition of routines or scripts that are applied from a "rational brain", has led to the development of innovation processes that are essentially focused on technical aspects, oriented to norms and rules as well as to the establishment of fixed criteria in each stage of the process (Diaz and Santos, 1998). From this perspective, it does not seem strange that the predominant ways of focusing the process are understood to be instructive mechanisms, implying the explicit transmission of prescriptions for activating or using a given tool. This supposes that, if the practices consist of a list of procedures to be followed, if we replace the procedure in people's minds, then the practices will change. Following this logic, the breaks that appear during the implementation processes are interpreted as a problem of the agents, which must be solved and be corrected by means of new expert procedures (Diaz and Santos, 1998).

However, drawing on explanatory frameworks regarding human behavior and research into non-traditional cognitive science, which explain human cognition as a complex process that is closely related to the context in which human beings live and work, it has been shown that people develop cognitive orientations that influence their actions in the interaction that recurrently takes place in their fields of behavior, and which simultaneously are validated in those same actions.

Human behavior, from this perspective, is not only the action taken, but is the way of acting and the knowledge constructed within the framework of complex systems of activity which involve people, spaces and devices in a network of interactions that constitute understandings and practices. As Wenger indicates, behavior "includes the explicit and the tacit, which is what is said and what it not said, that which is represented and that which is assumed. This includes language, tools, documents, images, symbols, specific definitions of roles, specific criteria, codified procedures" (Wenger, 1998, p.47).

In this web of interactions, we form understandings and perceptions of the world, which orient our behavior, and which at the same time are constructed within them. This is what Bourdieu calls *habitus*, a second skin, which contains the willingness to act, and at the same time including mechanisms to exclude any action that is not compatible with the objective conditions in which the action is carried out (Bourdieu, 1990). The actions in our behavior, in this sense, cannot be completely objective, and are not totally conscious – there is a background that is transparent to our understanding, but non-accessible to the conscious mind, and this orients and defines our actions. The behavior constituted in habitus forms a closed cognitive unit, incorporating the person's sense of his/her own being, which expresses itself in the person's forms of acting, speaking, thinking and feeling. Habitus, seen as a principle that generates behavior - individual and collective - organizes the person's actions in the world. It generates forms of thought, actions and speech, and these are only possible within the limits of what thought, actions and speech the habitus itself produces. Habitus is a product of the person's history, constructed in the objective conditions in which behavior takes place. It contains the willingness to act in the future and to reproduce the conditions that make its existence possible. Thus, our behavior develops in a non-material environment – the habitus - which contains our willingness for action in the world, actions which reaffirm the perceptions, ideas and willingness that the habitus itself generates, creating a closed system. In this sense, behavior conforms to a state of being that is relatively impermeable to external modifications.

This characteristic of behavior, formed within the habitus, shows us that to simply put in place a list of procedures is not enough to generate changes in behavior, which has habitually been made from the rationalist perspective.

The technologies of the practice

As we have indicated, practice is constituted as dominions of action that involve different devices which mediate the activity. The tools used are not isolated things, but are part of the network of meanings and interactions that has been formed by the practice itself and the habitus of that practice. Therefore, if we consider practice as a set of relatively impermeable cognitive units which involve technologies as a part of these cognitive units; the inclusion of a new technology cannot only be made by giving instructions on how to use a certain tool; nor can it be centered solely on stressing the necessity of incorporating it. The introduction of technology in social practice is a complex issue, which involves how people are involved in the daily events in which they use the instruments and tools, but which also involves the social history of the subject's practice.

As we have indicated, human practice is made up of a web of historical and cultural influences, which develop against a background that is transparent to those who are engaged in the practice. So, any new information that is introduced into the system of the behavior will be reassigned significance according to the understandings generated within that system. The introduction of a technology that is not part of the cognitive network of the practice will be unclear in terms of the natural development of the activity, and in regard of this, it will tend not to be used or to have only a marginal use. So, the rationalist models for the introduction of technology are not efficient, relying on a centered linear incorporation of information about how the tools are to be used. Learning how to use such tools in this framework of incorporation: 1) tends to limit the use of the tool to those ways of using it which were learned, thereby restricting its use, 2) the use in certain specific tasks tends to be unclear, and therefore its use may be rejected from that context of action, and 3) those responsible for integrating the new technology tend to become subordinated to those with expert knowledge of the technology.

Therefore it is necessary to think of the incorporation of technology in the field of education from a viewpoint that is more understanding of the complexity of human practice; with analytical frameworks that allow us to understand, as far as possible, the limits of the habitus through which the behavior sets its course. The discussion on how computers can insert into the cognitive system of pedagogical practices, from this viewpoint, means viewing it in terms of the transformation of practice via the configuration of a new habitus. This reconfiguration of habitus means modifying the objective conditions in which the activity takes place, from a process of designing new models for the action; in which the mediators of the activity (tools, rules and division of the work) are the object of specific designs in relation to the intention of the activity. The development of new models of action means that those involved in the different actions must consciously reflect on the contradictions arising within the activity system. For this reason, where there is an attempt to transform an activity system, it is first necessary to recognize the characteristics of the activity and its latent contradictions, and then it will be possible to orient the transformation process, "one must learn to know and to understand what wants to transcend" (Engeström, 1999).

Aims and objectives of the research

The aim of this research is to take stock of the technologies in use in education, recognizing what they are and how they operate, as well as their possibilities and limitations, and the contradictions that arise as part of the natural transformation of the activity. This view means analyzing the cultural-historical evolution of the machinery involved, exploring the changes in the conception of knowledge that is associated with this technology, and to make projections regarding the possibilities for the application of technology in the field of pedagogical practices. This last aspect stands out, and is central to establishing the potential and the limits with respect to the incorporation of the new information and communication technologies into current educational practices. Recognizing how the practice of education is organized, and the tools that are used for this purpose, will allow us to open up new avenues to explore more effective ways of incorporating technology.

Within this framework of discussion, the objectives of this investigation are:

- To identify and to characterize the type of devices used by the teachers of a specific school community in their pedagogical practices.
- To describe how the devices work in the context of education.
- To identify whether the teachers incorporate the use of ICTs in their pedagogical practices, and what the problematic aspects are for their incorporation.

Methodology

As has been stated, the complexity of introducing computers into the activity of education is a result of interplay of different aspects: Firstly, its introduction stems from an attempt to encourage innovation in educational practices – its use will be centered on teaching, which is a new context for its use. Secondly, the historical background of present-day education is that of a shared social behavior which has barely changed over the last 200 years, a point which shows the strength and generative ability of the habitus in which it is carried out, and which makes that community very conservative. Thirdly, the transformation of an activity system by way of incorporating new technologies does not happen simply by being incorporated on an individual level.

This brings us back to the problems of introducing technologies, something that is not easy to solve or to analyze. The contradictions involved affect the whole activity system. Examining an activity and the practices associated with it means analyzing the actions of the people and the technologies that mediate these actions within socially and culturally organized spaces. This examination requires an analytical framework that allows us to observe the actions of a subject in the historical, social and cultural context where those actions operate, in such a way that the depth, complexity and uniqueness that characterize human activity can be taken into account.

At present, the Theory of Activity seems to be an explanatory framework that allows us to work with an analysis unit that includes the context of the activity. The notion of mediated activity which was developed in the works of Soviet investigators, in particular Vygotsky, to explain the formation of the higher mental functions, and the later development of the notion of activity by Leontiev, offer us a historical social perspective on the development of the human mind. They have opened up a very interesting field to explore - the consequences of the use of the technologies in the transformation of human life. This viewpoint, which gives a central role to the notion of mediation as an explanatory principle of the theory, has the advantage that it allows us to view the role of the instruments as part of the cognitive system of the human action, and also

to explore its relation with the behavior from a perspective that encompasses all its complexity. Within this analytical framework, the technology is viewed as a part of the cognitive operation which is formed when the activity is carried out. Thus, the technological devices that are integrated into an activity system are not merely isolated and self-contained, but are defined according to their use, according to the purpose of the action, and within the framework of an activity oriented to a particular aim. So, analysis of technologies always is explained as something that is incorporated into the cognitive system of the behavior.

As Engeström (1999) points out, human activities have their own cycles of expansion, and to analyze this process requires that we distinguish between different moments in the analysis, whose process cannot be reduced to a simple technique (Engeström, 1999). Different authors (Engeström, 1997, 1999; Davydov, 1999) understand the complexity of the analysis in terms of the socio-historical processes that lead to the formation of the activity (ontogenic process) as far as the activity in situ. That is to say, both a social and historical analysis of the activity and an empirical analysis are necessary (Engeström, 1999). However, this is not all. The analysis of an expansive cycle of the activity has different phases: (1) Questioning, which involves the historical analysis of the activity and the empirical analysis; (2) the projection of a new model; (3) its revision; (4) its implementation; (5) reflection on the process and; (6) the consolidation of a new practice (Engeström, 1999).

The present research is basically centered on the first aspect of the analysis of the cycle, that of establishing the social and historical evolution of the activity and its empirical analysis, later considering the viability of participatory design that would allow for the introduction of the technology. The first aspect that is analyzed is the social and historical reconstruction of the teaching activity, defining the intentions and reasons behind it. Later an empirical analysis is made, and the actions that make up the activity are identified. From this point we can look at the tools, operations and procedures that mediate the action. This analysis serve to recognize the nature of the tools - primary, secondary, tertiary devices - and how they tie in with the activity according to the aims of the actions for which are used.

Finally, an analysis is made regarding the contradictions within the activity. This approach has been used to observe practices in an educational establishment in order to offer a description taking into account both the activity and the devices that mediate it. The research, from this viewpoint, involved observing educational practices in the subjects of physics, mathematics, natural sciences and social sciences; centering on the observation of events in terms of actions, procedures, operations and tools.

Interviews were used as a way of bringing together the data originating from the observation. The development of education as an activity is the first analysis made, and later an analysis of education as a local activity in a real scenario will allow us to establish potential areas for changes in the present activity, based on the contradictions can be detected.

The social and historic background of teaching

As we have indicated above, human activity is distinguished by purpose (Leontiev, 1984), the reasons for the activity are what allow us to differentiate one activity from another. For example, education has the goal of inserting society's youngest into its culture, a reason that is bound to the need, shared by different human groups, to transmit and reproduce its culture. This activity manifests itself in the form of different actions, which form a complex and interrelated system, involving people, devices and spaces. Education can be defined as activity as soon there is a clear link established between the person that teaches, the tools s/he uses, and its target (Sepúlveda, 2000). In this same sense, education can be defined as an *ecology of information* (Nardi and ÓDay, 1999) which involves a community made up of teachers, students, parents, networks of support, spaces and technologies that mediate the action between people and

objects. In this way, the activity of education, which we understand to be a complex system of activity or as an ecology of information, involves different elements, which in their different interrelations combine to form a set of ideas and beliefs - a particular way of understanding their domain - and which are created via a process of historical accumulation. As mentioned, the notion of activity allows us to explain human cognition, not as a physical reality of actions, but rather as a phenomenon related to behavior. So, recognition of the relations that establish the different components of an activity - subject, object, tools - allows us to become aware of particular forms of understanding in specific field of behavior. From this viewpoint, analysis of the social and historical make-up of the activity is a crucial aspect for interpreting the specific actions of the subjects, in a dimension that goes beyond particular historical conditions of the context and allows us to recognize that people's behavior patterns are the product of a gradual process of accumulation over time. However, the product of their subtle form is an aspect that seems to develop naturally. In this same sense, the tools and devices are part of this accumulation, and they embody ideas and beliefs pertaining to the behavior. They therefore have a role in structuring a particular way of their being used, and will be used within the limits set by people's understanding of them.

It is possible to track the development in time of the teaching activity as we now know it from the 16th century, when it was established as a "means of discipline and inculcation" (Sepúlveda, 2001). Let us examine this. Education was, until the 16th century, monopolized by the Catholic Church, whose intention was centered on the Christianization of the mankind. The protestant ideologies that arose during the Renaissance established their intention as being the salvation of mankind by means of character-forming and morality. Discipline of the spirit must be forged by submitting to the rules and by discipline of conduct: these same intentions also became central to the non-religious teaching practices of the 18th XVIII, centered on the "guidance for the child" who is seen from a psychological perspective as "capricious being" who needs to be "set on the right tracks". Meanwhile, the illustrated speeches about the "moralizing of the masses" sought to civilize the people's rules in one way or another. This way the social ideal of education was created from different objectives and historical conditions as a mechanism of "moral" and social regulation, which is traceable to the present day in the internal structures of the educational systems. Not only was education as we know it formed during this process of moralizing and the creation of norms, but the transmission of contents also went hand-in-hand with this process. The central idea of an infallible method for education – instruction in the different contents, mainly education of the language, a present and critical aspect in modern schools – was already established in the 16th century, arising from the Comenius's *Didactica Magna*. The idea of a method that allows us to solve the problems of education is not a new idea, and its development has represented a way of understanding what teaching is. The method arises in Comenius's *Didactica* as a tool for organizing effective instruction, basically in the languages, and supposes that its correct use ensures the success of the learning, a learning centered basically on the memorization of certain cultural contents. This understanding with respect to education materialized with greater clarity with the appearance of the traditional school, associated with the training needs arising from the new forms of production of the industrial revolution. This also sought to legitimize the new bourgeois ideology of the accumulation of the capital, related to hard work, and to justify social differences by means of evaluation systems of individual capacities within a structure that provides formal equalities (Contreras, 1994). The modern ideal that underlies education is that of using education to save individuals from moral threats, something that, as we have seen is not new, and to socialize them in the customs and the ideals of the family. This guiding process must necessarily be carried out rigorously, so mass schooling is characterized by discipline of the individual by means of diverse technologies (Foucault, 1995): the organization of time, the school routine with its schedules that indicate every moment, the organization of the space which establishes the place assigned to each member of the community, and the position of the teacher in the classroom, which allows him/her to check that each individual performs their task. In this way, gradually, discipline in school seeks to transform the external monitoring into internal discipline. Again the idea that underlies it is the

taming of the body and mind by means of discipline, punishment and the structuring of time. These diverse mechanisms of school socialization go together with the notion of passing on the necessary knowledge by means of effective methods: rules, norms, contents of the culture, which the students must know so that they can live in society. The rationalist society of the time conceives knowledge as a self-contained substance that can be transferred as an item of information item to be stored and used at the necessary moments. This conception of knowledge relates to the necessity to civilize to the masses, sets in place a scenario for education in which the transmission of contents and discipline are possible. These overlapping aims of the transfer of information, through methods, and socialization, through rules, make education strongly instructive in character and prescriptive with respect to the carrying out of its charges. This situation continues to the present day, providing correct transmission of the cultural items within a context of rules and norms that guarantee the correct socialization of the students. This way, the formation of the conscience within this system of activity is carried out within a framework of monitoring, control and the application of method, issues that are also reflected in the technologies that mediate the action: the rules, the spaces, the texts and the punishments; and whose deep roots are visible in present-day educational systems and in the tools/devices that are used.

As we have seen, education has, as a constituent part, the aspect of the transmission of information through effective methods. In the transition to the modern school it has already been established fundamental aspects for a good education are defined as: Firstly, the teaching of one thing at a time and the central role of a method – which is considered a critical aspect for transformation at present. The method in education only offers estimations with respect to the content to be taught, and its main role is to establish a specific sequence, oriented towards the memorization of information and the development of reading and writing skills.

The notion of a method began with Comenius's ideas on how to organize the instruction process, and later tied in well with the rationalist and positivist perspective on how the human being knows and learns. Within this framework of method and instruction, the tools that teachers use basically have one primary characteristic, that of the reproduction and representation of the information available. School texts are the only mediators of the teaching. This is considered to be the transfer of the information necessary for the youngest groups of society.

Education in this perspective is based on three fundamental aspects: the disciplining of the body and the mind for purposes of civilizing, the method as the basic nucleus of pedagogical knowledge, and the texts as devices that mediate the activity. So, it is no surprise that now the transformation of education being brought about by the introduction of new tools is generating tensions within the an activity strongly built upon norms and on the transmission of information.

The logic of teaching practice. An empirical analysis of the activity and its structure

The social and historical background of education, outlined in the previous section, allows us to understand the internal nature of the teaching activity, and to understand its actions as a constituent part of a unit of consciousness that generates and orients understandings that are contained in its practice. In other words, the action of teaching, on the part of the teacher, contains forms of understanding with respect to its practices that have been constructed socially and historically, and which can be analyzed by way of the forms in which this is expressed, i.e. operations, procedures and tools.

The first analysis of the practices observed makes use of the basic triangle developed by Leontiev (1984) to explain human activity: subject-tool-object.

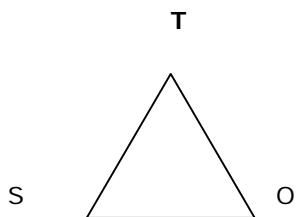


Figure 1. The activity

In parallel, we will analyze them using the basic structure indicated, also by Leontiev (1984) in relation to activity - action - operation, procedure and tools

Activity	Object
Action	Aim
Operate	Procedure and tool

Table 1 the structure of the activity

Firstly, we recognize the tools that are used in the pedagogical practices and how they are used. Let us remember that the tools that mediate the activity bring together the understanding of all elements (the activity as a unit of consciousness) and its use on an operational level.

Table 2 (Frequently-used tools) indicates the different tools that teachers frequently use in their practices.

Teaching of:	Frequently-used tools ¹	
Social Science	<ul style="list-style-type: none"> • Guides for student work • Text • Blackboard • Video 	Conceptual maps Dictation Questions
Math	<ul style="list-style-type: none"> • Verbal explanations • Blackboard • Exercise books 	Mathematical formulas Diagrams
Physics	<ul style="list-style-type: none"> • Blackboard • Guides • Diagrams 	Experiments Formulas

Table 2 Frequently-used tools

¹ The computers were not used during the months of observation, although the professors indicated in interviews and conversations them to have used in some opportunity.

Table 3 (Use of the tools) shows the uses that teachers assign to these tools; How they use them - the operations - and the work that the students do with them.

Teaching of Physics and Mathematics

Tools	Use of the tool by the Teacher (operation)	Student's work
Mathematical exercise books	<ul style="list-style-type: none"> Exercise of procedures 	<ul style="list-style-type: none"> Do the exercises Follow guidance Give answers
Diagram	<ul style="list-style-type: none"> Represents structures Represents figures 	<ul style="list-style-type: none"> Copy into notebook Questions / discussion
Experiment	<ul style="list-style-type: none"> Shows processes 	<ul style="list-style-type: none"> Work with tools Follow procedures Verify hypotheses
Blackboard	<ul style="list-style-type: none"> Present information 	<ul style="list-style-type: none"> Copy into notebook
Formulas and procedures	<ul style="list-style-type: none"> Apply for solving exercises 	<ul style="list-style-type: none"> Answer, solve exercises

Table 3

Taking the use of the formulas and mathematical procedures as an example, we can note that what the students learn is a type of procedure, a series of steps to reach a result. Nevertheless, they do not learn that procedure as a tool to solve the problem, but rather as a problem to be learned. If we analyze an exercise of mathematics, we will be able to recognize that its process of resolution has at least three parts:

- Understanding of the exercise – knowing why it is to be solved
- Operation of the exercise - knowing how it is solved
- Result of the exercise – knowing what was solved.

In the practices observed, the main focus of attention tended to be the aspect of the operation, where the result of the exercise is given in the form of numerically correct answers, and not by its applicability. So, the mathematical procedure or formula ceases to be a tool and becomes transformed into the purpose. Thus, it seems logical to say that the tool is a technique of frequent repetition of exercises. A device that clearly embodies this condition in the learning of mathematics is the exercise book, which in some extreme cases is only a long listing of numerical problems $((2x + 3x) (3 + 4x))$, without even establishing the reason for solving the exercises. This condition of the tool, as we shall see, has consequences for the type of learning the students acquire and for their possibilities of extending the repertoires of technologies used in education by teachers.

Teaching of Social Science

Tools	Use of the tool by the teacher (operation)	Student's work
Map	<ul style="list-style-type: none"> Presents information 	<ul style="list-style-type: none"> Copy information Recall information
Text	<ul style="list-style-type: none"> Give information 	<ul style="list-style-type: none"> Write information
Dictation	<ul style="list-style-type: none"> Give information 	<ul style="list-style-type: none"> Copy
Video	<ul style="list-style-type: none"> Give information 	<ul style="list-style-type: none"> Copy
Diagrams	<ul style="list-style-type: none"> Recall information 	<ul style="list-style-type: none"> Copy

Questions	<ul style="list-style-type: none"> Recall information Check retention of information 	<ul style="list-style-type: none"> Repeat information
Work guides	<ul style="list-style-type: none"> Organize different information Classify information Summarize 	<ul style="list-style-type: none"> Answer questions Summarize text

Table 3

Table 4 (Table 4 Procedures and operations) shows the procedures linked to the use.

Teaching of Physics and Mathematics

Tool	Operation	Procedures	Organization of the students' work
Mathematical exercise book	Use of a procedure to solve exercises	<ol style="list-style-type: none"> Show how to solve the exercise. For example binomials. Give a book with different excursions. Review the excursions on the blackboard 	Individual
Blackboard	Present information	<ol style="list-style-type: none"> The teacher copies information onto the blackboard. 	Individual
Outlines and tables	Recall information	<ol style="list-style-type: none"> Give each student an outline/table with key words. The student must complete the outline/table with the correct contents. 	Individual
Diagram	Presents and describes structure.	<ol style="list-style-type: none"> Teacher draws a diagram on the blackboard Teacher describes different components of the diagram. The student listens and copies 	Individual
Formulas and procedures	Store and recall of procedures or formulas by students Solution of exercises.	<ol style="list-style-type: none"> Teacher shows procedures Students apply procedures. Students solve exercises on board. 	Individual

		4. Students solve exercises in exercise book.	
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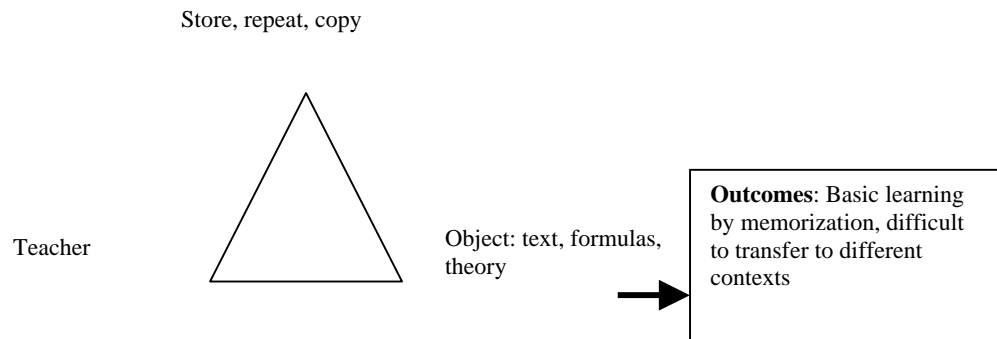
Teaching of Social Science

Tool	Operation	Procedures	Organization of the students' work
Outlines	Transfer information	Each student has empty gap-fill exercise. They use the book's representation and copy the information onto their outlines.	Individual or team
Text	Transfer information	Answer questionnaires	Individual or team
Dictation	Transfer information	Teacher reads out the content for the students to copy.	Individual
Video	Transfer information	Answer questions on video	Individual
Questions	Recall information Check learning	Ask the students questions	Individual

Table 4 Procedures and operations

The tools used in the practices described, as has been shown, are used basically as tools for presenting information, in the form of outlines, texts, formulas or diagrams. Their use basically makes it possible for the students to memorize and repeat the information provided. In other words, way in which the tools are used is mainly to achieve the passing on of information, which is to be retained and used as a self-contained thing, which is confined to the context of education, with little applicability to situations of everyday life. The tool's mode of use turns the tool itself into the object of the learning, and therefore it is not used as an instrument in the education activity, but is transformed into the aim of the activity.

So, while learned contents – such as mathematical language or social theories – take on the character of secondary instruments outside the world of the school, in formal education this is not so, in so much that the students manipulate them like objects, and the instruments that lend themselves to this use have more to do with certain techniques for adapting contents - copying, repeating, memorization techniques and routines.



In this type of practices, the students' learning can be defined as basic learning by repetition, the aim of the action being set mainly in terms of their memorizing the different contents provided in class. The way of using the tools defines their character (primary, secondary or tertiary) and, as indicated above, the devices that mediate the activity, i.e. the relation between the subject and the object, also mediate the subject's mental processes. So, the type of tools used, and how they are used are important. The direction of the mediation, according to this viewpoint, defines the development of one kind of learning or another. In the work of Vygotsky, the role of the mediation in the development of the individual is of fundamental importance, as human learning is mediated by the world in which it lives. The tools that mediate the relation with learning can be said to be mainly techniques of memorization, procedures of repetition and copying, and techniques for organizing information. In this way, what is learned is within the boundaries of the school's structures, and its usefulness is defined mainly in terms of getting marks or grades, and not in terms of the capacity to solve problems or to create new things. Rather, we can say that, with this manner of using the tools, they basically allow for transmission of information, individuality and self-containment.

The second element that needs to be analyzed is the object of the activity. As has already been mentioned, all activity has a purpose, and it is this purpose that gives a sense of system to the actions that involved in a given activity. The purpose of pedagogical activity is that young people learn. According to the points specified by the teachers in conversations with them, the reasons for their educational projects are the following: to train the young people to have critical thought, act cooperatively, independently and selflessly, with commitment to the values of respect for others and for the environment in which they find themselves - people who are able to adapt to change and who have a sense of ongoing improvement. So, the activity is oriented towards allowing the students to obtain the necessary skills to develop critical thought, independence, solidarity, respect and flexibility.

Activity	Object
Teaching	People prepared for life, with critical faculties, flexible in the face of changes.

However, the activity is a unit of consciousness, a cognitive unit that orients understandings and which manifests itself in the world as a set of actions. The actions relating to the activity of teaching can be graphically expressed as follows:

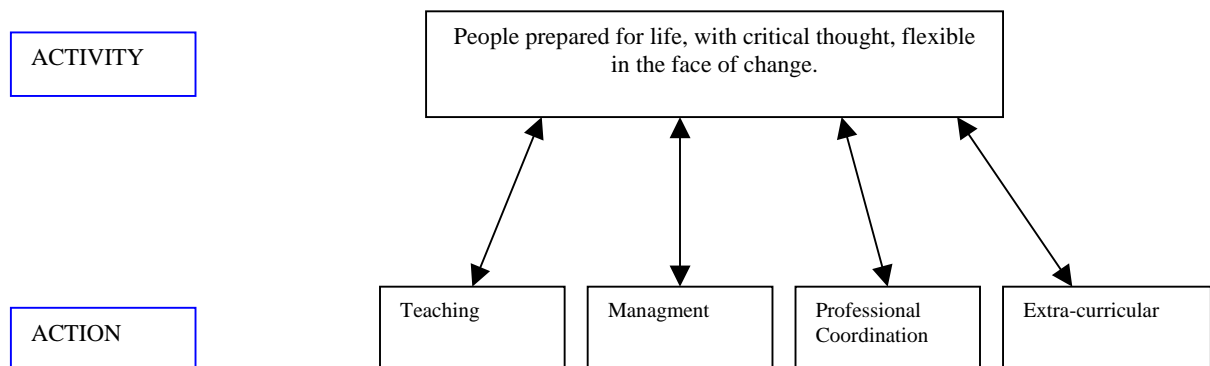
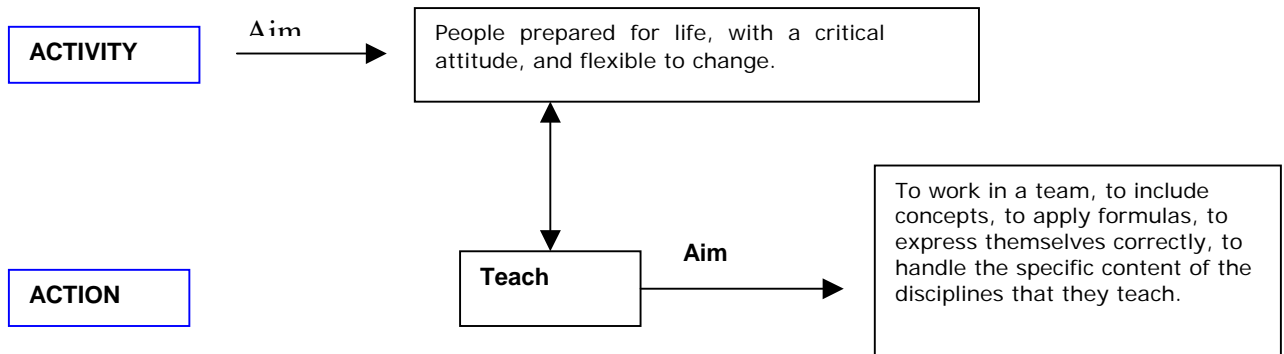


Figure 1 Actions in the teaching activity

Each of these actions has goals that need to be analyzed according to the purpose of the activity.

In terms of hierarchy, the most relevant action of the education is that of teaching. This action, as expressed by the different teachers consulted, has conscious goals that are reflected in the type of learning that the teachers propose for their students.



The most important goal of educational action, according to teachers, is the students' learning of their subject's contents. As expressed in one of the interviews: "the objective for the average 3rd or 4th-Year student is basically that of being able to handle the content", soon, talking about to the average students between 7th grade lower and 2nd grade higher, the teacher said: " for them too it is the subject matter [which is most important], but in addition to this they learn to do research, to look for their material, and also to comprehensive reading". However, the teacher noted that it is only now that research and reading have become explicit and evaluated as learning goals. The teachers indicated that an important goal of their practice is that of achieving learning would lead to good exam results in national tests (particularly the one for gaining access to tertiary education).

Action	Aim
Teach	Handling of subject matter, leading to good exam results in national tests.

Now the learning of subject matter has the characteristics explained above, i.e. learning basically consisting of repetition and memorization of representations that can be remembered and repeated.

Analysis of contradictions

Our analysis of the contradictions will be explained by contrasting an educational activity that incorporates the new tools of computer science technology in an ideal scenario with the education activity in this study. The example will be used to show a transformed education activity, considering the different elements that compose that activity, in contrast to the activity in the study, which presents a number of contradictions, which are the product of the changes that are taking place outside the system and which are having an impact on it.

Figure 2 Ideal System Activity

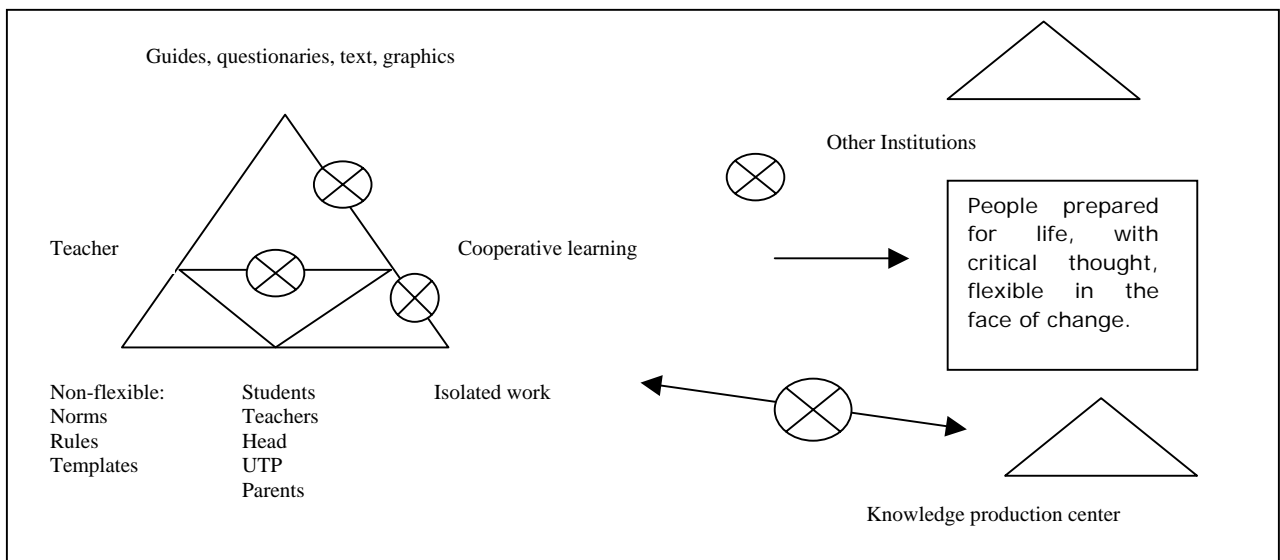
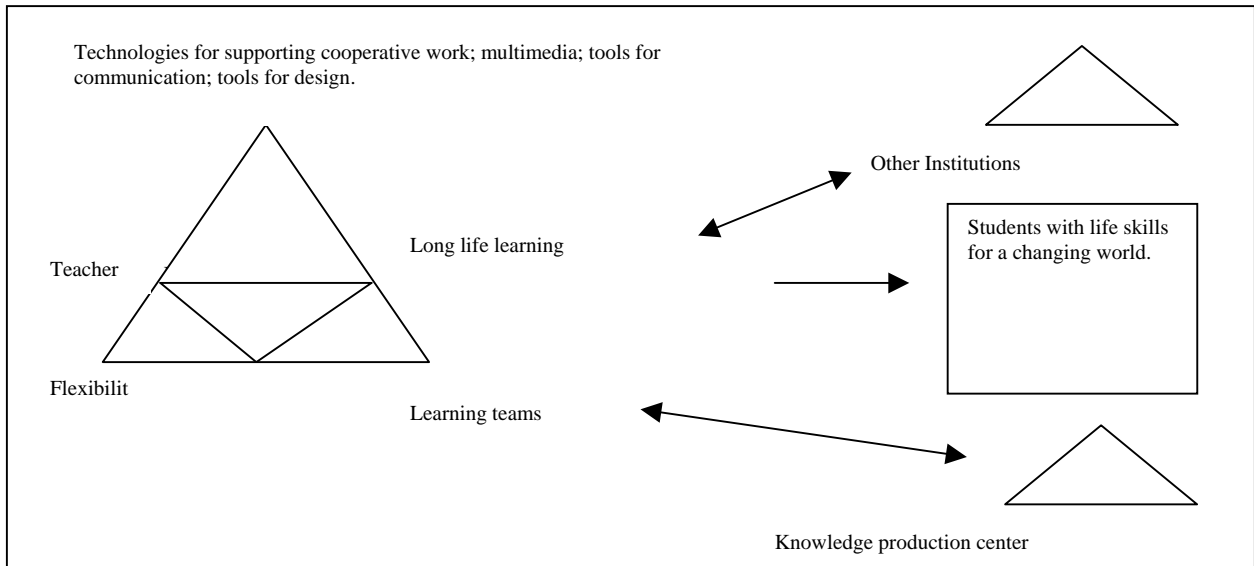


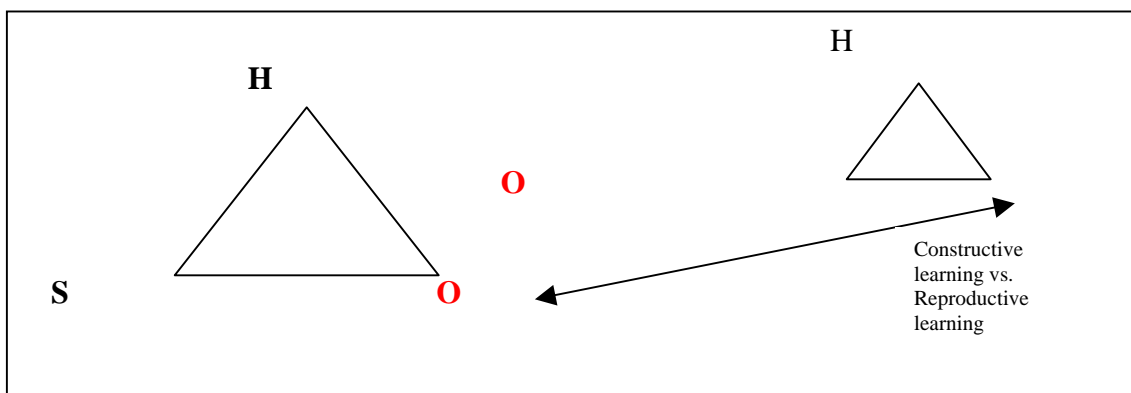
Figure 3. Studied System Activity

In the ideal example, the tools and the rest of the elements of the activity system integrate around the intention of the system, generating stability. However, in the analysis of the studied case, the object is in contradiction with the tools available and with the way of organizing the work that the community organizes. These contradictions make it impossible for the interior of the system to produce results that approach its proposed ideals. These contradictions, as explained below, arise from the disturbances that are currently affecting the traditional objects of this activity system.

At present, as a result of the processes of Educational Reform, which tries to match school learning to society's knowledge needs, the object of the education activity, has been redefined from outside the educational community – from political orientations and policy. This has been

incorporated gradually form, although not without contradictions, over the last 10 years. This generates what we call a contradiction of tertiary order. The classic objective, as we saw in the process of forming the social and historical background of education, was based on the conception of knowledge and technologies as "things", and of learning as a process of instilling information by means of its transmission. However, the redefinition of the objective in terms of training for life within the framework of a philosophy that considers knowledge and technology to be tools, and learning to be a constructive process, generates tensions that can be seen in the disturbances shown in the figure above.

In the study we could note that declared purpose of the activity is expressed as an education that promotes solidarity, independence and the critical thought. But the tools that mediate this activity, and ways of dividing up the work that are organized by the school community do not match that expressed purpose. The central contradiction between the old objective and the new objective of the activity is hidden in the discussion, and it is only possible to access it through the analysis of the actions that are involved with the activity.



In this way, the introduction of a new objective also implies the introduction of new tools to mediate the activity. These new mediators, which are appropriate to a purpose different from that of the reproduction of knowledge, generate tensions in each of the elements that make up the activity. Again let us take the example of an ideal activity, contrast the different elements of the activity in both cases, and we will then see in what areas of the system a contradiction is occurring. From a general perspective, the tensions that are arising in each of the elements of the system can be expressed of the following way:

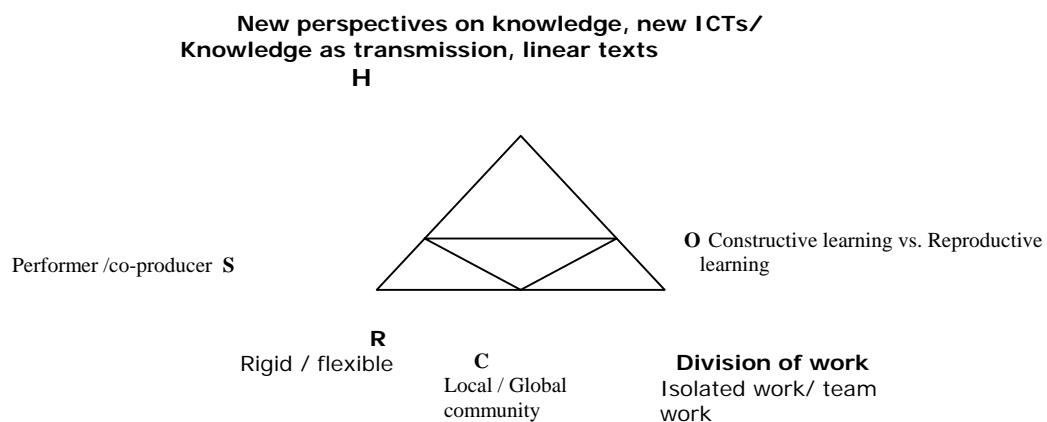


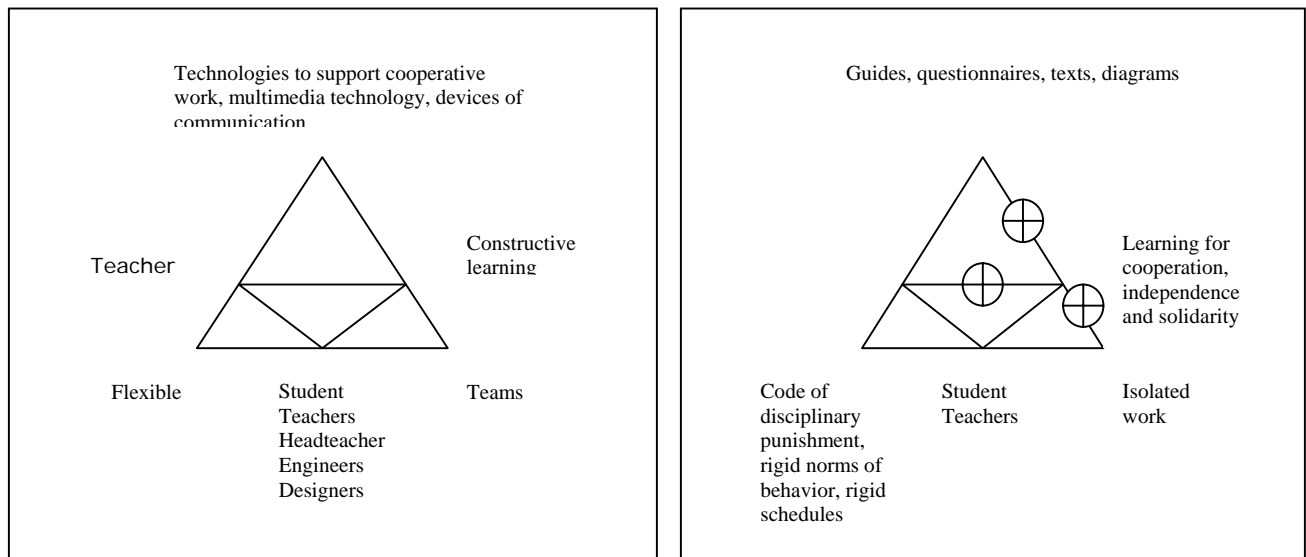
Figure 4. Contradictions in the teaching activity system

The secondary contradictions.

As mentioned, the secondary contradictions are those that arise between the different elements of the system. In the activity of our study, the secondary contradictions occur, as we explain below, for two reasons (1) the general unsuitability of elements of the system with respect to a new objective, and (2) the unsuitability of new mediators of the activity with the traditional objective that operates in the carrying out of the educational actions.

(1) The contradictions between the elements of the activity system and the new objective.

Figure 5. Comparison between the ideal activity and the studied activity with the new objective.



In the activity in the study, the secondary contradictions occur as a result of the new objective of the activity. The first contradiction that appears occurs between the tools and the new objective (as we have seen previously). As has been analyzed, the way of using the tools in education mainly allows learning by repetition and memorization of the information to take place. A critical analysis of the potential of the tools currently in use for learning purposes is necessary in order to re-orientate and expand current teaching practices. Teachers often complain that their students "have little capacity for criticism or for developing independent thought". This is very important, as it shows that the teachers' "conscious purposes" are, to a great extent, oriented to goals that are different from those memorizing and repetitive learning. However, their professional knowledge and the tools they use not allow them to develop educational forms that promote a different type of learning. Unlike this system, the system of the ideal activity uses the tools of computer science associated with cooperative ways of working, and this creates a high degree of consistency to the interior of that system. The contradiction that arises between the way that the work is organized, which mediates relations within the community, and the object, is also an important contradiction. Unlike the activity in ideal conditions, in the study activity the division of the work is organized mainly as a way of regulating and ordering the system, and not as teams for the production and handling of knowledge. Indeed, the teachers said that there were different types of regulation in their institutional structure, but they noted a lack of a structure that led them pedagogically. The departments worked randomly "my department has been headless for some time, and to tell the truth everyone worked on their own" a language teacher pointed out. The lack of understanding of the new objective also generated tensions among the teachers in the system of the studied

activity. The teachers recognized that all the educationalists did not share a common vision with respect to the mission of the establishment.

Contradictions between new tools and traditional objectives

If we analyze the activity of the study, considering the objectives that have formed socio-historically in the education, and which are manifested in the form of educational actions, and then incorporated the new tools that have become available to teachers for the development of new practices, we can see that these tools generate three basic types of contradiction. (1) Computer science tools, both as technologies for handling knowledge and as tools for organizing the students' work, enter into contradiction with an objective centered on the memorization of information and the handling of information as closed units that must mainly be learned individually. The use of these new tools becomes difficult and problematic, as the teachers recognize when they allude to their difficulties of working with computer science or to the organization of cooperative ways of working within the courses. (2) Teachers' understanding of the technology and their training for its use also generates tensions where computer science tools are used (3) The use of these tools also generates tensions with respect to the rules that mediate the teachers' relationship with the community, disciplinary rules, timetabling. They become "stiff shirts" in the face of tools that promote more independent forms of working and which also demand different working timescale. In this respect, the more effective use of tools such as the new ICTs will imply thinking about how certain aspects of the curricular structure will have to be transformed in order to make their use viable.

Figure 6. The ideal activity system and the study activity system with new tools.

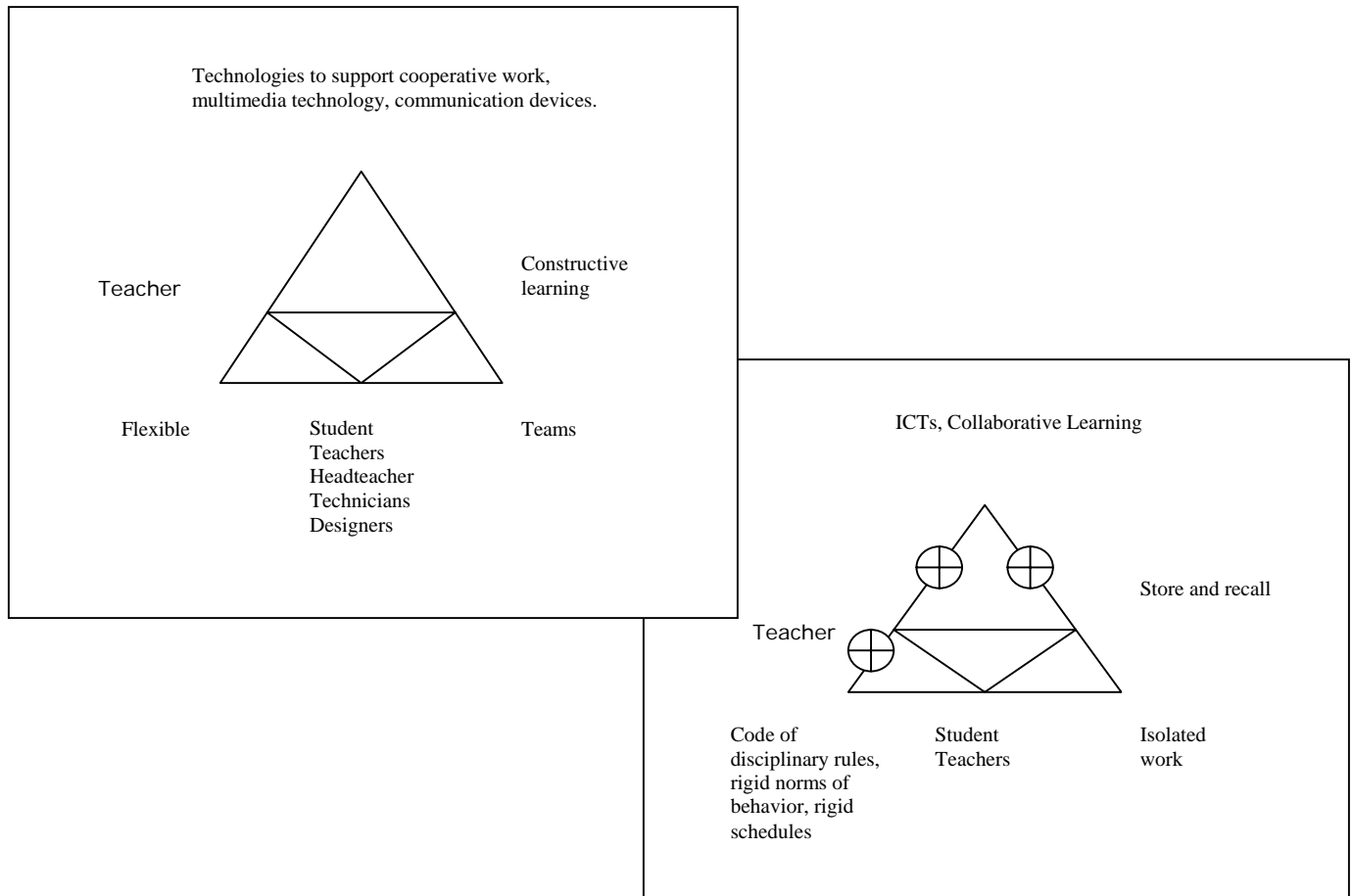


Figure 7. System of the activity in the study

Final Discussion

This research points to several aspects regarding the problems of incorporating computers into education.

- (1) The marginal use of the ICTs in educational practice can be explained the contradiction that is created within the system of the activity by the incorporation of a tool that, due to its technological nature - used for the handling and processing of information - becomes unclear in a practice in where knowledge is seen to be the reproduction of subject matter. So, one way of dealing with this is to reject it. This is understandable, given the social and historical background of the teaching practices, in a context where of knowledge is reproduced rather than produced or handled.
- (2) Educational devices have, essentially, a primary nature. The devices with a secondary nature are mainly techniques for repeating, storing and remembering information.
- (3) In the logic of instructive practices, the use of tools such as the computer is seen as unclear, difficult to incorporate and even unnecessary. The traditional tools are better mediators for the purposes of memorization, in a situation here there are many students and few machines. A type of learning that allows different skills to be developed means thinking again about the type of tools that are being used, in terms of their possibilities and their restrictions. Here, three aspects or principles should be present in learning environments to allow this development: Cooperation, i.e. the type of relationship that requires mutual aid in order to carry out certain tasks - which without that aid would be impossible; Constructiveness, i.e. the creation of devices; and Authenticity, which is that the activities have a functional and relevant character, and where the devices that mediates them allow for the development of meaningful activities. (Bellamy, 1997) The way of using the tools in the practices described neither allows constructiveness nor authenticity, and barely allows cooperation, (as in the organization of the education of the Social Sciences classes in the first levels) - three basic criteria for the development of a higher order of learning.
- (4) Design as an alternative for the introduction of the ICTs, which allows a redefinition of the objective. The tools mediate and make certain things possible. In this perspective, tools designed to allow cooperation, constructiveness and authenticity will mediate practices that allow this. A new objective tool that allows new objective conditions will lead to the construction of a new awareness, leading to a redefinition of the object.
- (5) Instructive methods of including computers do not have an impact on the teachers' views on education, and reinforces forms of use oriented to the presentation of information, transforming to the computer into a tool of primary nature, connected to the same logic of use, and limiting its potential for other uses.

Perspectives and limitations of the study.

An important projection of this investigation would be to advance from a position where the difficulties of incorporating technology into education are seen as centering on individual teachers who "refuse" by their own rational decision to use the new technologies, to an interpretation that analyzes the problem of the incorporation of the technology in terms of the contradictions within an activity system – a system that, with the knowledge available to it, seeks points of equilibrium which allow it to continue to function. This perspective allows the designers of educative technologies to look at the critical aspects of the incorporation of computers, taking the nature of the activity as a point of reference, not as an obstacle but as door leading to the transformation of the system; seeing the use of computers in the perspective of a new knowledge that will help to stabilize the imbalances that have arisen. This research also promotes the view of computers as a device to be used within a complex social network of

activity, and not just as an isolated instrument. The understanding and analysis of the technology must encompass the complete system of activity and the interaction and change that is produced - both the technology in the system and the structures of the system where the technology is used. If the purpose of the activity is not understood, it will hardly be possible to understand the ways in which the devices will be used within it.

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