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## **STRATEGIES PROMOTING SELF-REGULATION IN SCIENCE LEARNING**

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In all meaningful teaching, the teacher plans, more or less explicitly, how to teach certain contents and the student body tries to adapt, with more or less resistance, to the teacher's demands. For this confrontation to be successful there must be a continuous regulation of both the teaching and the learning process.

Regulation is understood as the adaptation of the processes used both by the teaching staff to attend to the needs and difficulties the pupil finds in his learning process. And also by the same students to overcome said difficulties. Both factors should base themselves on the evaluation and autoevaluation which permits them to identify obstacles and make decisions about the best means of reaching their learning objectives.

A key element in this process is the potentiation of the interactions that take place in the classroom, both between the teaching staff and the pupils and among the students themselves. Communication favours negotiations which allows agreement to be reached, that is pacts to be made.

The following diagram (fig.1) illustrates the fact that a pedagogic device which contemplates the continual regulation of learning processes can help each student to progress in the construction of the new knowledge as it will be continuously adapted to his needs.

# CONTINUOUS REGULATION OF THE LEARNING PROCESSES

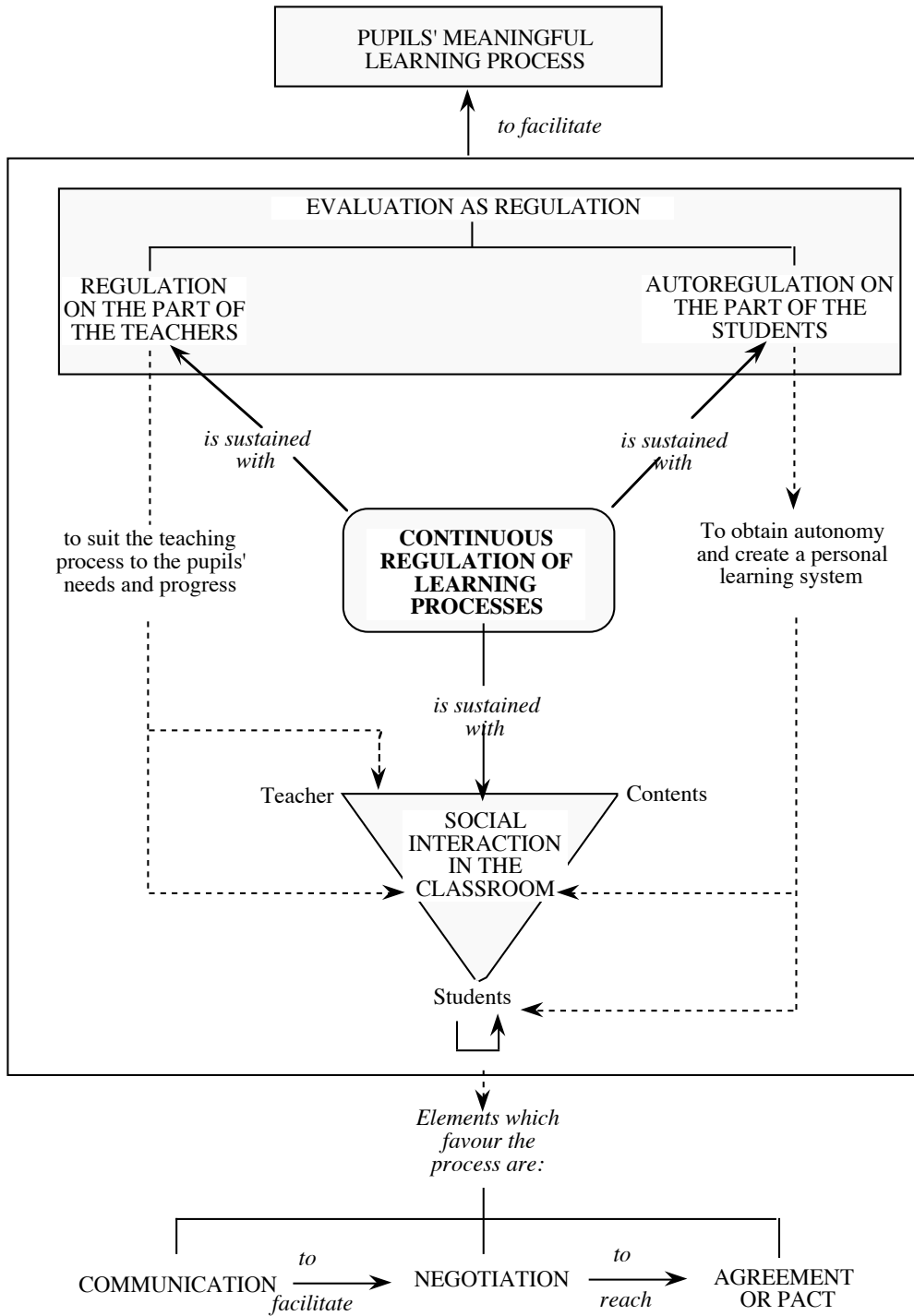


fig. 1

Foreseeing the use of instruments which favour regulation is a fundamental task in the teaching process. Generally, tests used to evaluate learning are only orientated towards examining the initial or final learning processes, whilst there are few which permit the teachers to detect the students' difficulties during the same learning process and far fewer which enable the same pupil to recognize the obstacles to be found and know where to direct his/her efforts or how to autoregulate himself/herself.

Successful students are characterized, among other aspects, by their capacity to recognize their errors and thus find ways to overcome them either by revising their own learning process or consulting teachers or companions. On the other hand, students who fail are characterized by their difficulty in identifying their problems and therefore, in contriving mechanisms to autoregulate themselves.

It is also possible to observe that successful pupils usually detect what aspect of a task prevents them from obtaining a good understanding or realisation of same. This aspect needs to be very reliable or partial. So, for example, they do not say that they cannot add fractions or calculate the density of a material, but recognize that they do not know how to find -knowing the m.c.m. of the denominators- the new numerators or how to calculate the volume of irregular solids. Whilst the students with a high degree of scholastic failure do not know where their difficulties are. Their problem is global and so it is much more difficult to overcome.

It seems then that it will be important to teach pupils how to autoregulate themselves. Throughout the years, each person has been building up autonomously his/her own personal system of learning. But, is it possible to help the students in the construction of this personal system of learning?

Among the contributions of several investigations into this field, we would underline those of the so called 'forming evaluation' (Bonniol 1981, Nunziati, 1990), and the works on autoevaluation as a representation of one's own capacity and forms of learning (Allal, 1988; Paquay et al, 1990), the works on metacognition (Laveault & Fournier, 1990) and on the use of metacognitive tools (Novak, 1989).

These works emphasize the importance of regulating learning in three basic aspects of the teaching process;

a) In the communication of the objectives and in the (auto) verifications of the representation given to them by the students.

b) In the learner's command of the operations of anticipation and planning of the action and in the autoregulation of the actions which are not well learnt.

c) In the students' application of the criteria and evaluation instruments of the teaching staff.

**a) The communication of objectives and the representation made of them by the students**

Numerous studies have shown that the pupils who learn most meaningfully are those who recognize what the teacher is trying to teach them and how he/she intends to do it. On the other hand, Edwards and Mercer (1988), through the analysis of some interactions between educators and students, confirmed that there is no coincidence between the aims fixed by the former and those which the students consider to be the object of teaching.

It would appear then that if an efficient education is to be achieved, it is important for the students to be aware of what they are going to learn and why certain activities to facilitate this learning are proposed. That means, each pupil must elaborate a representation of the end product expected in each one of the activities, of the desired results and also the reasons why the teacher has planned them.

For the pupils to know what the objectives of the tasks proposed to them are, it is not enough to enumerate them but activities must be planned to permit them and the teachers to recognize how they are formulated. This knowledge will always be approximate and it will have to be determined throughout the

learning process. In truth, to learn is to achieve a sharing of viewpoints, it is to communicate (Cardinet 1988).

In the first place, it will be necessary for the teacher to explain the objectives he/she proposes to achieve in the sequence which is initiated. In this action lies the first difficulty of the process, then, how must these objectives be formed to have the best way to present them to the pupils and to be able to recognize if they understand them and if they are achieving them throughout the learning process?

In general, the objectives are formed from the expert's logic which has not a great deal of relation to the logic of the performance of each pupil which responds to a logic of his/her own. Thus the fundamental problem from the didactic point of view is not the definition of the objectives by an expert, but the construction of the representation of these objectives by the student body. These two processes can be very disparate.

To help the students in their construction it is not enough to enumerate, at the beginning of the subject, the objectives just as the educator has formulated them, but activities must also be planned to facilitate the elaboration of a first representation of the intentions explained by the teacher by each pupil. These activities must make each student in the class-group -whatever his/her initial situation- feel involved in them.

They have a double aim, on the one hand they try to situate the student in the contents on which to initiate his/her studies and to be able to make a first representation of them. On the other hand they have to facilitate his/her autoregulation both at the beginning and throughout the learning process.

It would be a serious mistake to believe that through the first learning activities the students will have understood the teacher's intentions on providing them with certain goals to reach. In each stage of the learning process the objectives explained by the teaching staff are translated by the pupil according to previous representations and in a way that is compatible with the means he/she disposes of in that moment to achieve them.

Thus, on initiating the study of a subject, each pupil according to his/her initial situation, but also as a consequence of the interaction produced in the classroom, will give a different interpretation to the message the educator has tried to transmit to him/her. The teaching staff will have to propitiate the explanation of these representations to be able to have indications about the divergence between their representation and that of their pupils and to facilitate communication of the different representations among the students.

If we consider the teaching-learning situation as a social communication situation, the unidimensional, static nature of the objectives made and explained by the teaching staff gradually becomes multidimensional and evolutionary in the scholastic situation. Multidimensional because each student of the group perceives it in a personal way. Evolutionary because these perceptions will be modified during the learning process as new enriching elements are incorporated.

But, in the same way, on the basis of what is happening in the classroom during the teaching-learning process, the educator also modifies his/her initial representation. Thus, as a result of the interactions in the classroom, the pupil body and the teaching staff are bringing their representations closer little by little. It can be said that the way of perceiving objectives is increasingly similar.

If the learning has been successful, it is at the end of the process that the communication will have been made satisfactorily. And if not, there will only have been partial communication and the teaching staff will have to find the necessary mechanisms to cover this lack of communication, as the other regulation mechanisms have not been sufficiently effective. We observe that in this process, illustrated in figure 2, both regulation (teacher's responsibility) and autoregulation (basically the student's responsibility) play an essential role.

## DYNAMIC NATURE OF THE OBJECTIVE

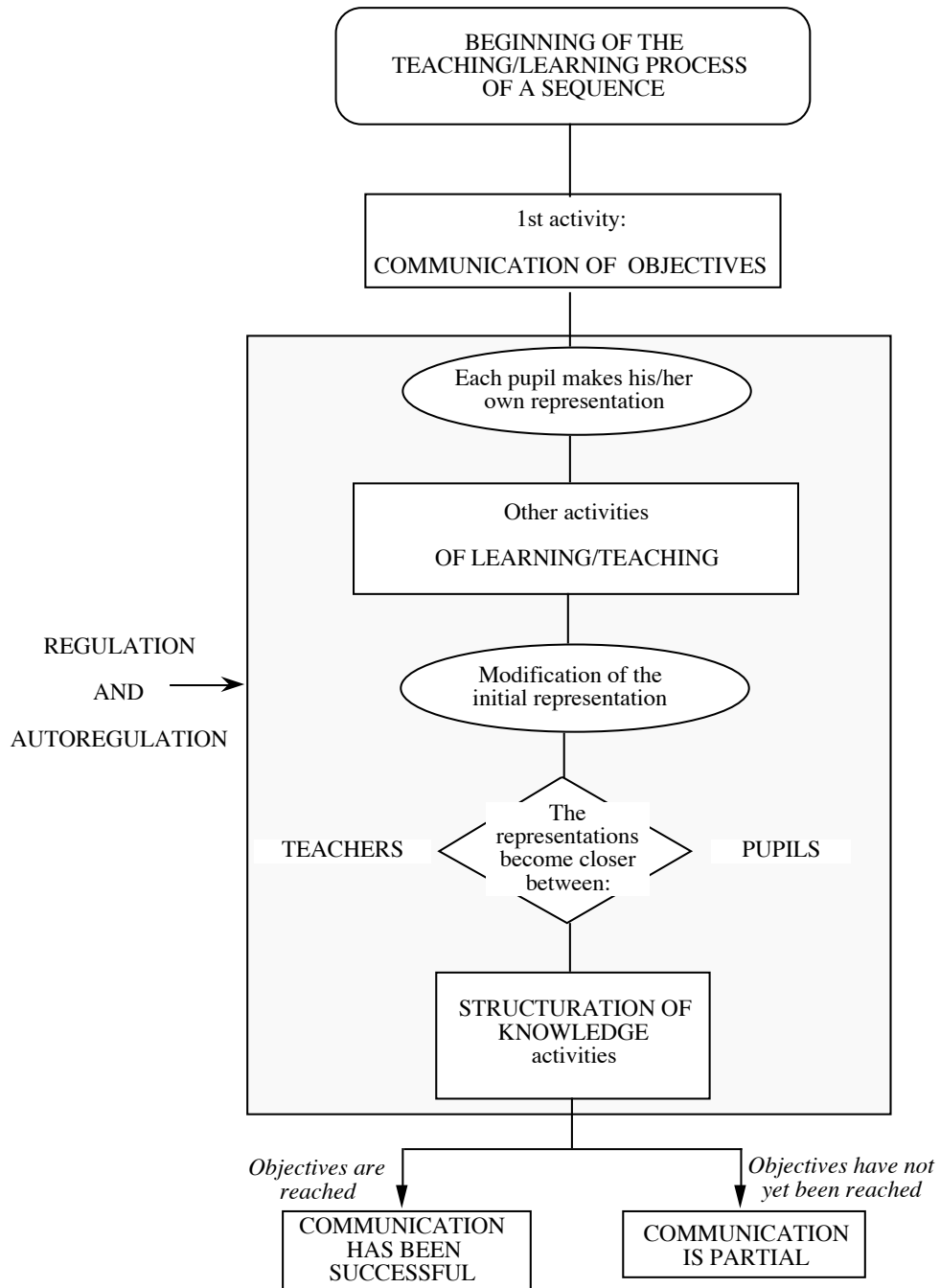


fig. 2

But, it is also worth noting that a constant, implicit or explicit, negotiation occurs between the teaching staff and the pupils. This negotiation is

propitiated basically by communication and produces agreements or pacts which pursue the improvement of the quality of teaching.

Among the instruments used to recognize the perception that the pupils have of the objectives of the activities put to them we would emphasize;

- The establishing of didactic contracts (Broseau, 1980, Burguiere & Gautier, 1990, Schubauer-Leoni, 1986). Through these teachers and pupils negotiate the contents they will work on in the classroom. These contracts can be drawn up by the teaching staff or by the same student body on the basis of their initial representation. They can be modified in the course of learning.

- Verbal communication in the classroom. For example, the pupils ask two or three classmates questions (which have been previously given by the teacher) about the subject to be studied. After the collective information, the pupils give their common points of view, either orally, through drawings or in writing. These documents are interchanged to recognize the diversity of representations and to permit the initiation of their modification.

- Analysis of other pupils' work (Nunziati, 1991, Veslin, 1991). The study of other pupils' realizations can allow the students to ask themselves what they must learn to become successful in the solution of similar tasks.

- Conceptual maps (Novak & Gowin, 1984). They permit the stating of the importance of a small number of ideas which must be the preferred object of learning. Through these, the pupils establish their initial representation in relation to the concepts that the teachers propose. By comparing with their classmates they can perceive that their representation does not coincide and begin to recognize on which aspects they should concentrate preferably.

- "KPSI" type questionnaires (Young & Tamir, 1977). On the suggestion of the teachers, the students give their opinions on their degree of knowledge of the concepts/procedures of the subject to be studied. The later combining of said initial knowledge makes the students realise not only what the object of the study is but also whether they should question their initial perception of same.

- Class diaries. The students keep a class diary in which they reply to the questions; "What have we learnt today?" "How have we learnt it?" "What have I understood well?" and "What don't I quite understand?". From the individual diaries, a group one can be made which allows different perceptions to be contrasted. If the teacher has his/her own diary, he/she can interchange with the group of pupils and, on comparing, both the students and the teaching staff can recognize their points of coincidence and differentiation.

To sum up, the adaptation by the pupils of the objectives explained by the educator constitutes a decisive stage in the process of learning. But it is also a stage which involves a high degree of difficulty.

**b) The learner's command of the operations of anticipation and planning of the action and the autoregulation of the actions which are not well learnt**

Anticipation is like a prediction, before carrying it out, about the result which would be obtained if a certain act was realised, or on the importance of following a given path to reach the objective we have set ourselves.

Planning is the choice of a fixed order of realisation, it is a work plan, which will develop and will be modified under the control of the results obtained throughout its course. It reveals knowledge of possible procedures to obtain results and previous knowledge of each chosen operation. Planning implies combining three elements; the fixed objective or aim, the pertinent operations or actions and the internal conditions of realization. (Talyzina, 1988, Nunziati 1990).

If a pupil knows how to anticipate and plan the actions, it means that he/she is capable of mentally representing the actions he/she has to take to be successful in solving the tasks set or in the application of the concepts and theories he/she has learnt. Students who reply to a question without having read all the necessary information to be able to carry out the set task, or who

begin to work without having thought of a work plan show a deficiency in their capacity to anticipate the actions they have to take and to plan them.

One of the characteristics of students who obtain scholastic success and of any expert in a subject is precisely the command of this capacity. As most of the pupils need the help of the teacher to develop this capacity, it is necessary to favour didactic situations to help the students learn how to learn.

The importance of this fact is accentuated because the logic of function of the learner is very different from the logic of the discipline and the expert's logic. A person who learns needs the presentation of the unfolded action with all the intermediate actions which are required to obtain the desired result. The expert does not have this need because he already has many of the intermediate actions instilled in his mind.

The teaching staff is normally expert in the disciplines it teaches and has forgotten the difficulties experienced at the time of learning them. It is only in recent learning such as learning to drive, using a computer or any household appliance do they realise that some instructions given by the teaching staff or in the instruction manual are not so obvious as they seem. On the other hand, once one is an expert driver, domestic appliance or computer user, the instructions seem obvious and extremely easy. This happens when the actions to be carried out have become instilled in the person. It is only necessary to renew the study if one has been a long time without practising them.

This is very often the cause of the educator, on being an expert, forgetting the need to explain very clearly the different actions required to carry out the proposed task and does not propitiate pedagogical situations which the learning of these actions needs. This may cause the students who are not capable of filling this gap to find considerable obstacles to achieving their aims.

Among the instruments used for the students to learn to anticipate and plan actions which they must put into practice to solve a task and which facilitate their autoregulation, we would emphasize:

- The basis of orientation (Nunziati, 1990). It is a system of representation of the action and of its product, of the properties of the basic material and its successive transformations, including all the indications which will be used to carry out the action

To construct them requires:

- knowledge of the diverse categories of problems which are to be undertaken.
- to imagine the expected product and the type of actions implied and the procedures to achieve them.
- to recognize the knowledge which will have to be used and the way to use it.

The same pupil must construct it from the general method provided by the teacher. The student must know how to determine:

- which category the proposed action belongs to considering it in turn as a particular case of a whole.
- the knowledge required to realise this action, before using specific resolution techniques of the kind of problems identified, if he/she wishes to ensure the transference of the strategies constructed to do a given action in all the works of the same field.

Therefore, it is necessary for the pupils to adapt the criteria of realization which are the invariant of the tasks.

- Study cards (Nunziati 1990). It is the plan of the task to be done. The student must construct it for each work. It is the exact translation, applied to a particular exercise from the orientation base.

The actions to construct it are:

- to identify the proposed action
- to identify the motive of the task
- to state the external conditions of realization: time, volume, individual work or in group, etc.

- analyse the internal conditions of realisation; implied knowledge, the role of this knowledge, etc.
- to choose and/or transform the known criteria of realisation which have already been used in this category of problems.

Among the same pedagogical means for the construction of these study cards the following are outstanding:

- regular practice of autoevaluation which obliges the pupils to be aware of the degree of divergence between their production and the expected product.
  - mutual evaluation by groups of pupils of the products of others.
  - a priori analysis of the categories of scholastic work.
- Conceptual maps (Novak & Gowin, 1984). They permit the manifestation of what has been learnt. When the pupil compiles them, he can recognize the difficulties and autoregulate them. they also favour interaction among the pupils as they permit the discussion of their productions, comparisons, recognition of similarities and differences, identification of criteria to value them, etc.
- The Gowin "V" (Novak & Gowin, 1984). They favour the analysis of experimental data, of paper and pencil problems, of written texts, etc. They permit the students to choose the theoretical settings to allow them to interpret said data and to recognize their difficulties in establishing relations between facts and theories.

### **c) the students' application of the teaching staff's criteria and evaluation instruments**

Normally teachers do not believe it to be necessary to explain the objects of the evaluation and the criteria to be used to know if the pupil has learnt a certain content or not (Cardinet. 1988). All these aspects are more or less familiarized and in the drafting of the evaluation activities the teacher acts intuitively. Then it is not surprising that in practice, contents are evaluated

which are not very important or representative of the learning promoted, or that their criteria changes according to their interpretation of the pupils' productions.

Therefore, it seems reasonable that the educator first explains the standards he/she will refer to decide, for example, if a pupil has understood a concept, if he/she has known how to do a certain work and to what degree, if he/she knows a given procedure or if his/her attitude is the expected one (Allal, 1991).

But, as with the objectives, the fundamental problem from a didactic point of view is not the formulation of objects and evaluation criteria by an expert, but the construction of the representation that the students make of them (Bonniol, 1986, Bonniol & Genthon, 1989). It has been verified that the pupils who obtain the best results are those who can intuit the teaching staff's intentions and their demand. On the other hand, there is always an important group in the class who are incapable of foreseeing either the objects or the criteria of evaluation.

At the same time it will be necessary for the pupil to be capable of correcting the errors of his /her productions. It is usual to hear the teachers say that they have to "correct" an examination or a work. In fact, it should be said that they have to identify the errors the pupils may have made, because the correction can only be made by the same person who has made the error.

For the student body to manage their errors, they have to be capable of knowing where their difficulties are and of planning actions to overcome them. In the traditional tests we know that it is difficult for the students to perceive the errors they make and even less possible for them to know what to do to control them. It seems that the pupil should be provided with means so that he himself could compare what he has projected, what he has done and what he has obtained, with the objective he had set himself. This autocontrol, very often unconscious, is a natural component of the action which is what permits autoevaluation. It leads to a reconsideration of the initial representations, or the planning, or the criteria with which to evaluate the quality of his learning.

Thus, the teaching staff should foresee learning situations which propitiate the adapting of the criteria and evaluation instruments by the students, as well as autoevaluation. In this sense the effectiveness has been shown of:

- Evaluation contracts. Through these teachers and pupils negotiate the objects and criteria of evaluation. These contracts can be written by the teaching staff or by the same student body. They permit the students to revise their own learning on the basis of negotiated criteria.

- Tests compiled by the same student body. From general criteria supplied by the teaching staff. The students -in groups- prepare tests which they have to solve and they indicate the correction criteria. This preparation is useful for them to recognize their own difficulties at the same time.

- Mutual evaluation. This is the evaluation by a pupil or group of pupils of the productions of another pupil or group. In this, the pupils who evaluate have to explain the criteria they use for correcting and they can suggest what the pupil they evaluate should do to improve results. Mutual evaluation facilitates interaction among the pupils.

Through this type of activity the pupils not only take an interest in their marks but also in the causes of their results. Likewise, it favours an interchange among the pupils about their ways of approaching a better solution of the tasks set, in their own language.

- Autoevaluation. From correction networks made by the teachers or by the same pupils, a student evaluates his/her productions and writes his/her own valuation in relation to the causes of the errors and the needs he/she detects to be able to overcome them.

- This valuation and the previous one can be complemented with coevaluation activities. Through these the teaching staff can assess the autoevaluation of a student or the evaluation has made of a classmate. Thus some of the representations the pupils have made of their productions can be completed and improved on, as well as the suggestions made to improve them.

-Improvement contracts (Przesmycki, 1991). Through these contracts each pupil or group of pupils explain their difficulties and the means they commit themselves to putting into practice to remedy them. It is necessary to bear in mind that any didactic contract is a fragile commitment which must be revised by all those who have elaborated it. It favours interactions between the pupils and between them and the teaching staff, as it clarifies many of the values and behavior involved which the teaching staff or the same students wish to promote.

### **To sum up**

For a pedagogical mechanism to incorporate the autoregulation of learning as one of the permanent components, it will be necessary to include activities and instruments which permit an adequate representation of the objectives and evaluation criteria at the same time as the anticipation operations and action planning become surer.

In this process which is illustrated in the outline of figure 3, the essential elements which stand out are the verbalization processes as they facilitate the explanation of the representations and their contrasting. which favours evolution and improvement.

## THE AUTOREGULATION OF LEARNING PROCESSES

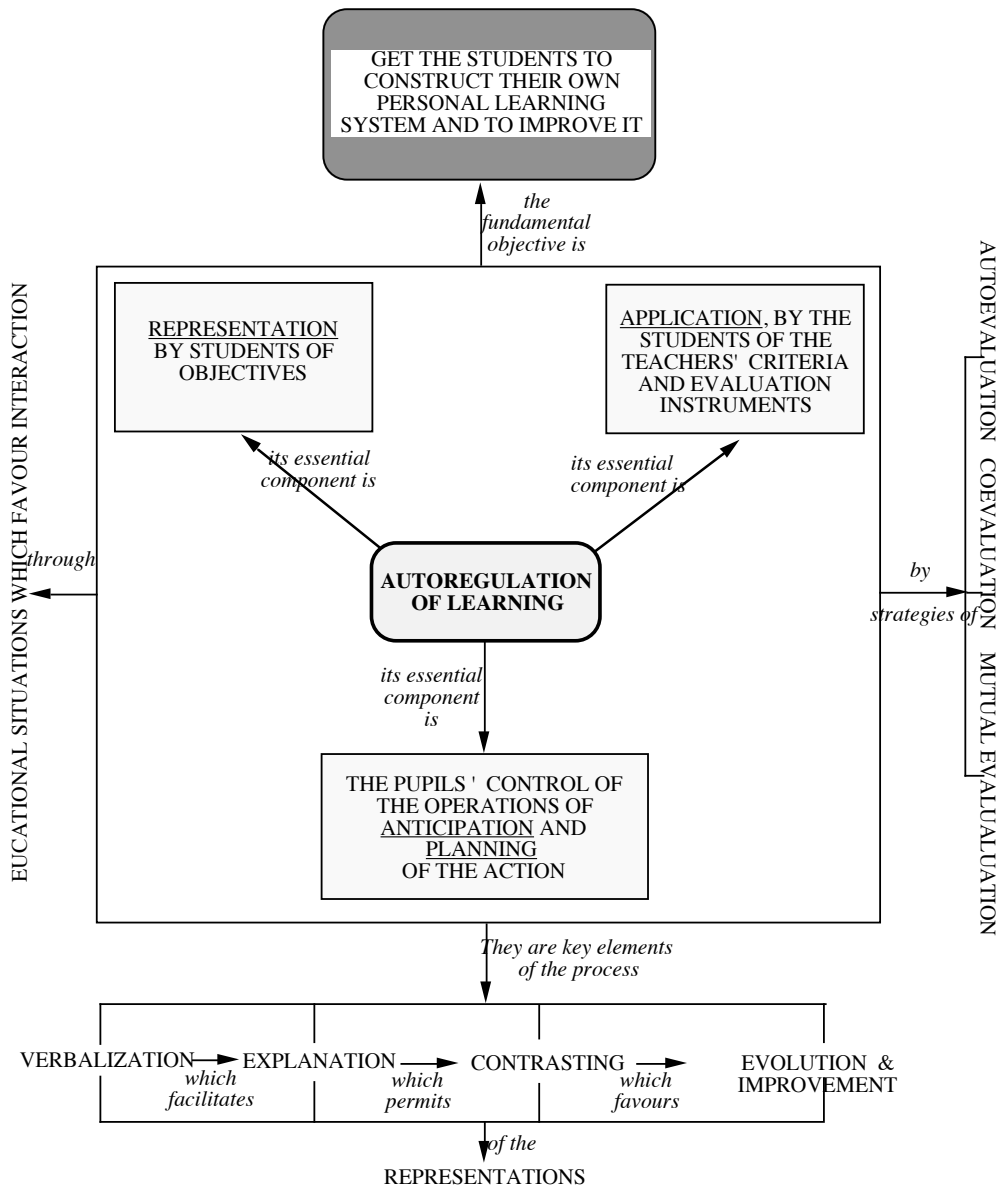


fig. 3

This learning model which underlies the previous positions is a constructivist model of learning. The teaching-learning activities and instruments which are proposed are based not only on logic of scientific disciplines, but also on the learner's logic as the one who has to construct them.

Through this type of activity, the pupil will progressively construct his/her own way of learning , which should be the priority objective of learning. Aspects such as autoregulation and autocontrol acquire a fundamental importance and through these, the pupil should be able to find his/her own way of learning and constructing a good interior system of piloting and of improving on it progressively.

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