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ELABORATION OF INSTRUMENTS TO ASSIST DIALOGUE BETWEEN THE TEACHER AND THE PUPIL

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1. INTRODUCTION

In this paper we present the results obtained in extensive research which was carried out in our department during the years 1989-92. The didactic setting in which it was made is characterized by the importance given to the progressive construction of a language which permits the communication of the teachers' and the pupils' ideas, and which results in the negotiation of the meanings of the new concept they are learning. This requires instruments which permit the representation of knowledge in formation, so that the pupil may reflect on it, discuss the problems with the teacher and progressively increase his own autonomy with regard to learning.

Our research was centred on the construction of these new instruments. Open questions, redactions, Gowin Vee and conceptual maps were designed for it. Each one of these proposals was doubly characterized: for its conceptual content and for its procedural contents. The pupils' replies were analysed by networks and conceptual maps. **The original proposal together with the results of the analysis gave rise to our "instruments".**

We have successfully applied these instruments in science classes. The representation of the overall knowledge of the class, as expressed through the analysis of the written language or of the diverse graphs and diagrams we used, permits more precise questions from the pupil and guides the teacher's thoughts towards the complex problem of the relation between the pupil's thoughts and the discourses which will finally be used in the class.

2. FOCUS OF THE RESEARCH

The research was established from a constructivist conception of teaching/ learning and for the purposes of introducing data analysis instruments into the classroom which are used in science education research. This responds to the following requirements:

1. The need for suitable instruments to analyse not only the concepts, but also the procedures that science pupils have to learn to use, particularly suitable for the evaluation of learning related to experimentation.
2. The need for suitable instruments to analyse the pupils' evolution.
3. The need to back up the teacher's contribution towards a significant learning of these sciences, by providing the use of current techniques for detecting the pupils' knowledge.
4. Finally, the need for instruments which support thepupils with regard to their own learning.

Because of this, our "diagnostic evaluation instruments" must have the following characteristics:

* It must be possible to characterise them for their procedural and conceptual dimensions.
*Their use in the classroom should facilitate communication between teachers and pupils.
* They have to facilitate didactic research in the classroom.
* They have to facilitate didactic performance in the classroom.

Our work has been inspired by the English APU (Assessment Performance Unit) with regard to the procedural characterization of the questions. As in the APU, we consider that science subjects in non-university teaching must be experimental and be considered as "problem solving" which are authentically relevant and significant for the pupils.

2.1. Theoretical setting

The constructivist paradigm in which the teaching of science and mathematics is currently situated has plainly shown that there are great differences between the teachers' thoughts and those of the pupils, especially when the pupils apply their knowledge to the interpretation of the phenomena of everyday life. Teaching is conceived as "conceptual, methodological and attitudinal change" and learning models have been assimilated to the "models of scientific change" (evolutional for some, revolutionary for others) or to the cognitive readaptation which the Philosophy of Science and Cognitive Science is currently proposing (Gil, 1983) (Hodson, 1985, 1988).

This new orientation presents aspects of "scientific and technological revolution"; therefore, its consolidation in the classroom requires new institutional frameworks, new interventions, new instruments, new interactions and, above all, **a new conception of the evaluation**, considering that the pupil has to know that the teacher demands much more from him than before; that he

has to be the protagonist and maker of his own education. The investigation into the "pupils' thought", which has been very important in recent years, now allows us to advance in this path, to elaborate successive platforms from which to plan the different stages of educative intervention.(Johnson, 1985)

Finally, an interactive and communicative conception of teaching which suggets that every question the pupil is asked can be an agent for change. To characterize discourse in the classroom, simultaneous consideration of the question asked and the answer given will be necessary.

2.2. The thesis of our research

All work is based on the following assumptions:
1. The thoughts of pupils belonging to a same culture and scholastic level show sufficient common chracteristics to enable us to use the results obtained from researching a sample of pupils to design instruments for diagnosing other pupils.

2. Current knowledge in Science education permits the designing of instruments for the specific purpose of promoting a certain discussion in the classroom.

2.3. Methodology

The research methodology is qualitative and is based on the use of systemic networks to analyse and systematize the pupils' replies to the questions they are asked, following the lines established in King's College (London University) few years ago.

The systemic networks (Bliss and Ogborn, 1979, 1983) have been used for some time to organise and analyse qualitative data obtained from the questionnaires, interviews and/or observations made in the class. In our research we have used this technique mainly to analyse the replies to he questions posed or to those obtained in interviews.

The analyst tries to codify the ideas expressed and thus determine an "artificial" description of the whole discourse (i.e. of all the pupils' replies in relation to the initial question). The systemic networks made from the results of the analyst are structures which show the interpretation of the data by the analyst. No system of analysis can disregard the fact that the

relation between the perception of data and the analysis is problematic, but this system allows the relation to become more explicit and therefore, more accessible to discussion.

Once the systemic network is designed, a great number of new interconnections can be made and thus "categories" can be established according to: kinds of explanations, language, models used, etc. The categories established can be correlated and thus detect "interactions" and, consequently, models of replies which can be tested.

2.4. Characteristics of the questions and the sample

The testswe have designed have generally been written ones, but in some of the research projects interviews have also been carried out. The contents of those have been chosen according to the bibliography on "objectives- obstacle" (Martinand, 1982)

Since it is a qualitative research, the samples analysed have been reduced, in some of the research projects, to one sole class group; nevertheless, in most of them the samples are very extensive (150 to 200 pupils).

2.5. Stages of the research

Our research is made in two clearly differentiated stages.
1st. Elaboration of the instruments, which include:
a. Designing the question or action proposed to the pupils.
b. Selection of the sample of pupils and the obtaining of replies.
c. Analysis of the replies by systemic network and determination of the categories of the detected explanations.
d. Preparation of the "pattern network" and other indicators, which will be supplied to the teacher together with the initial question.
In this stage the research was qualitative.

2nd. Use of the instrument in the classroom, which include:
a. The design of teaching activity
b. The use of the instrument
c. The analysis of the replies obtained and the modification of pattern network if applicable.

3. RESULTS. A. CHARACTERISTICS OF THE INSTRUMENTS OF DIAGNOSTIC EVALUATION OBTAINED

3.1. Types of instruments

Instruments of diagnostic evaluation have been elaborated from:

- Conceptual maps (Marquez & Izquierdo, 1991) (Novak & Gowin, 1989)
- Gowin Vee (Solsona & Izquierdo, 1991)(Izquierdo & Marquez, 1993)
- Semi-open questionnaires (adding to each question the above mentioned "give reasons for your choice") (Sanmartí, 1991) (Morato & Izquierdo, 1991)
- Open questionnaires (Sanmartí, 1991) (Sanchez J. & Casadellà, 1991) (Rayo & Casadellà, 1991)
- Likert type scale questionnaires (Sanmartí, 1991)
- Interpretation of graphs (Correig & Izquierdo, 1993)
- Networks for the analysis of the processes for solving problems (Sánchez M, & Izquierdo, 1991)
- Essays (Solsona & Izquierdo, 1991).

As a consequence of our research we have:

A. A "Question Bank" (150) available to all teachers who wish to carry out a "constructivist education". Each question is identified by a code which refers to the subject, procedure, scholastic level, didactic function and the research work it corresponds to. It is accompanied by the classification of replies obtained from the pupils.

B. A pattern for interpreting the concepts of each question (the pattern network)

C. A pattern for the use of each instrument, which emphasizes:
-the question-reply relation, for the questionnaires;
- the relation between the methodological and theoretical aspects, in the Gowin Vee;
- the variables to be be considered in the conceptual maps;
- the relation between the symbols and their meaning, in the graphs.

3.2. Characterization of the instruments

As we have already said, the instruments we have made are combinations of a question and of systemic networks through which we have analysed the pupils' replies, together with instructions which allow the teacher to use them.

The questions obtained from our research oblige the pupils to make use of their scientific knowledge and therefore they cannot reply in a meaningless way but are "made to think". The questions are about experimental situations which must be solved or outlined, problems which require a qualitative treatment, texts which must be interpreted, etc. Each one of the instruments obtained is doubly characterized: by the scientific concept and by the scientific activity involved in the reply and they can be classified according to a double entry- conceptual and procedural. Each one of the categories and subcategories is defined through describers. Our intention is that they be applied afterwards and also to stimulate the redaction of new questions by the teachers.

We have tried not to disperse the subjects and procedures being worked on and for this reason we have not yet covered a large enough number of concepts and procedures to be able to reach any conclusions about the relationship between them.

Specific instruments have been elaborated to analyse 'attitudes". Nevertheless, because this is a difficult field, we have limited ourselves to considering it as a section in itself, without establishing relations with specific concepts and processes.

Herewith, we present a general table of the questions which have been analysed.

	Conserv.mass	Geolo.	Mixtures	Evolution	Sound	Gravity.	Angles	Chem. Eq.
comunication								
instruments								
observation								
Concept appl.								

Interpretation

_____

Planning

_____

Problems

_____

4. RESULTS. B. GENERALISATION OF THE DESIGNED INSTRUMENTS

4.1. Application of the pattern networks: an example

We present an example of the application of our instruments below. Three questions were formed about combustion and they were passed to a group of pupils. The replies were analysed and on the basis of their systemic networks the pattern networks were elaborated, with the result that they were suitable for analysing diverse samples of pupils. These networks allowed us to detect the epistemological obstacles and to determine the suitable didactic objectives for them, as well as the design of other schemes to present these objectives to the pupils (Morató, 1991)

We present one sole question as an example, together with is network, the pattern network, the results obtained with two very different groups of pupils and the scheme for the derived didactic intervention, the latter from the errors detected in the replies to the three quesions (see the questions, networks and schemes in the annex)

4.2. Formation of the same profession

The teaching performance described in the above points tries to organize an interactive system: Teacher- pupil. We have ascertained that it constitutes a "program of formation of the same profession" which promotes a change of attitude in the teaching staff centred on systematic reflection and criticism regarding their professional practice. We believe that the use of networks has been decisive in this.

On the basis of the research made some conclusions may be reached about the usefulness of the instruments for the formation of the professorate. These are as follows:

a. The systemic networks which accompany the question provide the teachers with a great deal of information and in many cases, allow them to discover a richness of thought in their pupils unkown to them.

It has been discovered that over-detailed systemic networks are not useful to the teachers. On the other hand, the pattern networks are.

b. These instruments identify the difficulties and intuitions of the pupils which go beyond the simple classification of "correct" or "incorrect".

The function of the instrument is to show the richness of points of view with regard to the initial question more than to decide on the degree of accuracy and this is the message the teacher has received. The experiments made show that this aspect is particularly important in relation to the change in the teacher's attitudes as a consequence of using instruments of diagnostic evaluation.

c. The systemic networks faciliate the adapting of the programme to the needs of the class-group (the individual diagnosis of each pupil and the pronosis of the class- group). Based on these, an analysis can easily be made of each pupil's situation with regard to the different items which have been identified and the overall situation of the class- group.

d. The systemic networks permit the analysis of each pupil's evolution as well as the class-group's. It has been proved that it is positive to pose the same question in the initial diagnosis and in the diagnoses which may be made at different moments of learning. Through these the teachers and the same pupils may recognize their progress and their difficulties.

e. The instruments are applicable in different class-groups and thus facilitate communication between the teachers.

As we have stated, their use permits the teachers not only to diagnose their pupils' situation but also to recognize which aspects are significant in the learning of a concept or a procedure, by permitting the interchange of teachers' opinions with regard to the differences which may appear in the networks applied to different groups. The comparison of the results obtained from the analysis with systemic networks in many cases enables the separation of valuations of learning from the valuations related to attitudes and behaviour.

5. CONCLUSIONS

We can affirm that the applications of our instruments to date confirms our thesis and is proving to be very efficient. But we do not wish to be hasty in this sense. On the other hand, in the different research made to obtain the "instruments" we have obtained specific results, too long to be explained here.

We can summarize the results obtained under the following points:

Regarding the instruments

1. The pupils' response has been very rich confirming the validity of the questions which had been designed for this purpose. This confirms the need for questions which are suitable for research into the conceptual setting that the pupil uses in non-academic questions as well as for the follow-up of its evolution.

2. The "instruments of diagnosis" elaborated as a result of the research are 150 questions and their pattern- networks. All the questions refer to one concept and one procedure.

The concepts are: angle; geological change; evolution; chemical change (combustion); mixture and compound; speed; gravitation; mass and weight; conservation of the mass in the chemical change.

The procedures have been: communication (use of symbolic representations, written communication); use of observations and of measuring instruments; interpretation and application of the information (interpretation, application of the concepts); research planning and problem solving (solving of problems, experimenting)

A test is been made to evaluate attitudes in science.

3. "Standards" have been elaborated to make some of the instruments useful for the representation of the processes of giving explanations on the pupils' part.

Regarding a new way of considering learning, centred on evaluation

4. These instruments have made the process of teaching- learning more transparent (communication between teacher and pupils increased) and have facilitated the pupils' reflexion on their own learning process (their metacognition processes).

5. The teachers who have carried out this research or have collaborated with it have gone on to consider evaluation as an integrated activity in the educational process, thanks to which investigation is being made into what is happening in the classroom, with the aim of improving the teaching performance.

6. The elaborated instruments have proved themselves to be useful as a support to the pupils' metacognitive processes with regard to the follow-up of their own learning. We believe it to be very necessary to continue working in this sense, to pass on to the so called "forming evaluation" (Sanmarti and Jorba, in this Seminar) in which the pupils take on their responsibility, together with the teacher, of their own evaluation.

With regard to methodology in research

7. The network technique as an instrument of analysis of the meanings which appear in the pupils' replies has proved very valuable for our qualitative research. Not only has it allowed us to obtain nuances of the pupils' thought, but also to proceed to a certain typifying of same which offers us a first systemization of the results and a better understanding of what is happening in the classroom. The networks which have been elaborated can be used from now on by teachers who wish to initiate this style of diagnostic evaluation.

8. An interesting relationship has been established between our Department and the Schools whose teachers have collaborated in this research. We can even affirm that we are jointly undertaking small reforms in the way of conducting the class which increase communication between teachers and pupils and the significance of the apprenticeships.

Regarding the teacher

9. The diagnostic instruments have proved to be very useful too in the formation of educators as the discussion about them and interchange permit an acknowledgement of new ideas on the teaching and learning of science.

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ANNEX

Questions

1. Burn a little alcohol until none is left. Say which of the following statements you agree with most and why:

a. Alcohol disappears when it is burnt. It only gives heat.

b. When burnt, alcohol is transformed into other substance(s) which are gas(es) and at the same time produce heat.

c. On lighting the alcohol, heat is produced which provokes the evaporation of the alcohol and its transformation into alcohol steam.

d. Another explanation.

2. Surely, on more than one occasion you will have found that on covering a lit candle with a glass, it immediately goes out due to the lack of oxigen. Explain why oxygen is necessary for combustion.

3. If you leave a plate containing a little alcohol on the radiator, it will have disappeared after a few minutes. What do you think has happened? Justify the option you choose.

a. The alcohol has turned to a gaseous state.

b. The alcohol has disappeared, without being transformed into any other substance.

c. The alcohol has been converted into another gaseous substance.

d. Another explanation.