# *Recognition and Realisation Rules in Acquiring School Science—the contribution of pedagogy and social background of students*

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ABSTRACT *This study investigates the difficulties students encounter in problem solving in the area of sciences. Contrary to usual approaches of a fundamental psychological basis, the research takes into account the sociological processes of learning and transmission in both the family and the school. The aim of the study is to see the extent to which the students have recognition and realisation rules in the micro-context of problem solving (specific coding orientation) and to find out the reasons which may underlie their difficulties. Thus the data obtained are related to social class, race and gender and also to pedagogic practices (differing in power and control relations) and school science achievement in high level cognitive competencies. They are also related to children's cognitive level. The results show a strong relation between social class and specific coding orientation to problem solving. The relation is also strong for race and weaker for gender. Specific coding orientation is also strongly related to cognitive development and science achievement. These relations differ for the variables according to realisation and recognition rules and their various indices. The study shows the positive influence of pedagogic practice, which constitutes a crucial finding to pedagogic change.*

## 1. Introduction

This study is part of a research project (Project ESSA—Sociological Studies of the Classroom) which aims at improving children's achievement in science education in both cognitive competencies and socio-affective dispositions. The whole research involves studies at the level of the school and the family. The study reported in this paper is focused on the instructional discourse in the school, in particular in the area of problem solving. It continues other studies (Domingos, 1987, 1989a, b; Peneda *et al.*, 1990, 1992) which, contrary to the research in this area mostly grounded in psychology and epistemology, are fundamentally based

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on sociology. These studies have shown that the disadvantaged children (social class, race, gender) are those who experience greater difficulty in applying knowledge to new situations, namely in problem solving.

The research is based on Bernstein's theory in the sociology of education (1977, 1990; also Domingos *et al.*, 1986) and uses as main instruments of analysis his concept of code. As expressed by Bernstein (1977), code is a regulator of the relation between contexts and as such it should generate principles which permit distinction between contexts and principles which lead to the production of texts adequate to each context. These principles are the *recognition rules* (classification—C) which create the means to distinguish between contexts and therefore to recognise the specificity which constitutes a context and the *realisation rules* (framing—F) which regulate the creation and production of the specialised relations within the context. Different values of classification and framing originate different modalities of code, i.e. different pedagogic practices.

The intention of this study was to see the extent to which students have relevant recognition and realisation rules at the micro-context of problem solving within the broader context of learning in the science classroom. In our problem-solving situation the child must distinguish between a context requiring the application of knowledge to new situations and a context requiring the showing of simple acquisition of knowledge. Having selected the relevant meanings the child then has to produce the text appropriate to the problematic question. Thus, this study is not directed to the analysis of children's general coding orientation but it is focused on a specific coding orientation at the level of the school science context.

The instruments of analysis were conceptualised taking into account the two steps for the concretisation of the code: (a) marking of the boundaries between contexts and selection of the appropriate context (recognition rules); and (b) selection of the meanings adequate to the context and production of the text adequate to the context (realisation rules).

The data obtained will be analysed taking into account crucial social indicators, some of which are more related to the family (social class, indicated by father's and mother's academic qualifications and occupations, race and gender) and some more related to the school (pedagogic practice and science achievement in high level cognitive competencies). Given the importance usually attributed, in studies of school achievement, to the children's cognitive level, the data will also be related to that level.

## 2. Sample

The sample was made up of 80 students equally distributed throughout four classes in the fifth and sixth years of schooling (age $10^{-}-12^{+}$), taught by the same teacher (female) in the subject natural sciences. The school contains a fundamentally working-class population of white and black children, and is located in a suburban area of Lisbon.

To have heterogeneous classes (social class, race, gender) was the main criterion for organising the four groups of pupils. Each one of the classes was organised to have an equal number of girls and boys. On the basis of the information available before the beginning of the fifth year (given in the child's registration form), each class contained an equal number of children of four social classes [1], from unskilled workers to professionals at the highest level. This last group was less represented (three children in each class), given the composition of the school population. Five black children were placed in each class, the parents of whom were reported to be unskilled workers. Within these criteria, which were selected for the purpose of this study, the pupils were randomly distributed to each school class.

The actual composition of the classes turned out to be slightly different from the initial set. New information obtained during the course of the research (questionnaires and interviews with families) modified to a certain extent the classes' social composition.

A sub-sample of 30 students (10 from each one of the three pedagogic practices implemented) was selected for the analyses described in this paper. The criteria for the constitution of this sub-sample were similar to those of the global sample, i.e. for each pedagogic practice, there were an equal number of boys and girls, two white children from each social class and two black children. This sub-sample was selected after the first two science tests' results in order to have, within each one of the five social groups, pupils in extreme positions according to achievement. A pilot sample of 18 students (nine lower working-class, including black and white children, and nine white middle-class children; half boys and half girls in each set) was also selected from school classes outside the research project.

Each child is coded by an ordering number and a letter indicating the pedagogic practice they received (P1-X70 . . . ; P2-Y1 . . . ; P3-Z23 . . . ).

## 3. Methodology

The pupils were taught according to three pedagogic practices (P1, P2, P3), differing in terms of power and control, from a practice (P1) characterised, in general, by weaker classifications and framings to a practice (P3) of stronger classifications and framings. Two classes received pedagogic practice P2, one pedagogic practice P1 and another pedagogic practice P3.

The three pedagogic practices were carefully defined in terms of spaces, discourses and agents in both the regulative and instructional contexts. A complete description of the practices can be found in Neves (1991) and Morais & Neves (1991a). To put the study in context, we can, however, make a brief description of some aspects of the organisational and interactional relations in the classroom. Although always strong, the classification between spaces, discourses and agents was weakened from P3 to P1. The crucial differences referred to control relations. Whereas in P3 transmission was, in general, regulated by strong framing of the discursive rules (selection, sequence, pacing, criteria of evaluation) and in the hierarchical rules, in P1 the framing of the transmission was weaker. P2 was roughly in the middle, closer to P1 in some aspects (e.g. weaker framing between students of different social background, through team work) and closer to P3 in other aspects (e.g. stronger framing between teacher and students through the explicating of the criteria of evaluation).

The above theoretical definition, which oriented the implementation of the three pedagogic practices, was followed by their characterisation in the context of the classroom. This was done at the level of both the instructional (Fontinhas, 1991; Fontinhas & Morais, 1992) and the regulative (Antunes 1991; Antunes & Morais, 1992) practices. The analysis showed that the practices were not so sharply separated as defined, particularly in some aspects. These refer to the internal framing over the pacing of transmission and to the external framing (school–community): in P3 they were weaker than had been planned and in P1 they were stronger. They also refer to the criteria of evaluation which were less explicit in P3 and P2 and less implicit in P1 when compared to the theoretical definition.

The three pedagogic practices were implemented by the same teacher (female) so that the conceptual demand could be controlled [2]. The teacher had knowledge of Bernstein's theory and had carried out a previous pilot study. She was given the theoretical guidelines for each one of the three pedagogic practices, with examples for the various aspects involved. She was monitored by two of the researchers of the project, in order to keep close to the theoretical guidelines. Such monitoring lasted for the first two terms of the fifth year. It was after this period that the pedagogic practices were characterised by two other researchers.

Students' achievement in the instructional discourse was assessed on a 0–100 scale and was determined by the results of tests (the same test for the four classes), two tests in each one of the three terms of each academic year. These two tests gave the term's achievement which was reduced to a 1–4 scale (1: 0–24%; 2: 25–49%; 3: 50–74%; 4: 75–100%). The achievement in the first term of the second year was used for the study described in this paper because it was closer in time to the empirical work (questionnaires and interviews). Some 60% of the tests' questions assessed competencies which required a low level of abstraction, i.e. acquisition of knowledge—*cognitive low level competencies (A)* and 40% assessed competencies which required a high level of abstraction, i.e. use of knowledge in new situations—*cognitive high-level competencies (U)* [3].

Four nominal indices of social class were used, father's and mother's academic qualification and occupation. A composite of these indices was used in the study described in this paper.

Data relating to the sociological characteristics were obtained through questionnaires to parents answered with the help of the researchers who, during the course of the broader study, visited the families and/or talked to them in the school. The reason for this procedure was to avoid errors when placing parents in the social groups. Given the small number of children, we had to shorten both scales (academic qualification and occupation) to six categories [4]. For both race and gender we considered two categories (1: blacks; 2: whites; 1: girls; 2: boys). Cognitive development was measured according to Piaget's stages of development on a 1–6 scale [5], and using Task II constructed by Shayer (1979, 1981). This measure and a more complete account of its relations is the object of another study (Morais *et al.*, 1991c).

Since in this study the students would have to show whether or not they were capable of recognising the difference between the two micro-contexts of *A* and *U* situations and of producing the appropriate text to the latter, a questionnaire and a structured individual interview were developed to reveal these competencies [6]. According to theoretical expectations of the three pedagogic practices, the explicating of the differences between these two contexts would be high in P3 and decrease in P2, the differences being only implicit in P1. The hypothesis was that children would be differentially prepared to recognise the two contexts and to produce the appropriate text to the *U* context.

The data obtained were related to social class, race, gender, cognitive development, pedagogic practice and school achievement in *U* competencies. Given the small number of children, the analysis was fundamentally qualitative, although a correlational analysis was made and on occasions statistical tests appropriate for small samples were also used.

Given their extent and conceptual complexity it was decided not to include in this section, dedicated to the methodology, the description and application of the instruments and the processes of evaluation of the texts produced by children. These aspects will be given in the sections which follow.

## 4. Description and Application of the Instruments

### *4.1 Identification of* A *and* U *questions*

A questionnaire was constructed to evaluate the students' ability to distinguish two types of questions. It contained 10 questions about subject matters studied in the previous year (changes of physical state, properties of bodies, etc): five *A* questions (e.g. 'In order to save money and also to avoid pollution, many countries are seriously thinking about using renewable energies. What are renewable energies?') and five *U* questions (e.g. 'When we perspire, for example after running, we feel that our skin becomes cool. Why does perspiration give this feeling of coldness?'). The length of *A* and *U* questions was similar.

The questionnaire [7] was given to the whole sample in an evaluative context of the science classroom, similar to the usual tests' context. Before answering, a short and simple explanation, using an iconic presentation [8], was given to the four classes about *A* and *U* questions. This procedure was intended to ensure that all students would have a chance to answer, even those receiving a pedagogic practice which did not make explicit the distinction.

The same questionnaire was given a second time, in the following weeks, when the interview took place, to the sub-sample of 30 children, this time in the form of a game. Cards with the same iconic representation of *A* and *U* situations were used. The students were told not to worry about their previous answers. The children were asked their idea of what *A* and *U* questions were about. The answers in the two contexts were then compared.

The data from the questionnaire in its two forms of application give a measure of the recognition rules for distinguishing between the two contexts *A* and *U*.

### *4.2 Production and Identification of* U *Answers*

In this part of the interview the child was faced with the five *U* questions of the test, one at a time. She was first asked to give an oral answer to them. After that, she had to select, among three answers for each question, the most correct, the least correct and to explain her selections. Finally she was given two alternatives of the best way to think in order to answer. Cards with the appropriate text were always used.

**Example**

*Question*

When we perspire, for example after running, we feel that our skin becomes cool. Why does perspiration give this feeling of coldness? *Explain* on the basis of the knowledge you have acquired about water's evaporation.

*Answers*

A The water of the sweat lowers the temperature of the skin because that water takes out the energy needed for its evaporation.

B The skin becomes cooler with the perspiration because of the sweat's evaporation.

C Water's evaporation is the slow vaporisation; the water passes slowly to the gaseous state as its particles are being released to the air.

*The best way of thinking*

1st I would say how the sweat is constituted and also what I know about evaporation.

2nd I would have to remember the phenomenon of evaporation and I would relate the need of energy with the cooling of the skin.

The steps of the interview were as follows:

(a) The card with the question was given to the child and she read it aloud. She was then given time to read it silently.
(b) Any doubt was clarified about the meaning of any term and also any doubts about the question.
(c) If the child could not remember the concept(s) relevant to the explanation, a definition, in very simple language, was given.
(d) The child was then asked for the explanation.
(e) The card with the three alternative answers was shown, following a procedure similar to the one indicated in steps (a), (b) and (c).
(f) The child was asked to select the most correct answer and to explain the reason of her choice.
(g) The child was asked to select the least correct answer and to explain the reason of her choice.
(h) If the child showed difficulty in verbalising her reasons, questions were asked in order to obtain any explication.
(i) The card with the two alternatives about 'the best way of thinking to solve the question' was given and the child was asked to select the one which was closer to her own thought.

It should be noted that after being asked about the best answer, many children, *before* selecting it, immediately discarded the worst answer (an answer which would be appropriate to an *A* question). Only when this was not the case were they then asked about the worst answer [9].

The data from the interview made possible the analysis of recognition and realisation rules in the *A* and *U* contexts.

## 5. Evaluation of the Texts

The evaluation of the texts produced by children was done through a scaling procedure. The scales were specific to each text and were constructed in accordance with the categories of analysis created. Conceptually these categories were determined by the type and number of items of each part of the interview, the underlying theory and the subtlety intended for each analysis. They were also determined by children's answers during the piloting. The fact that different instruments create different categories of analysis, and therefore different scales, give rise to the need for making the scales uniform, so that the data could be compared and associated. Given the small size of the students' sample, we collapsed the various scales into a new scale with a reduced number of categories (1–4).

### *5.1 Scoring the Identification of* A *and* U *Questions*

As was said above, the first text produced by children was the written identification of *A* and *U* questions in the questionnaire with 10 questions, by the whole sample of students. The second text was the same identification in the form of a game by the sub-sample of 30 students. Each correct identification (*A* or *U*) was attributed one point. The scale of 0–10 was further reduced to 1–4 [10].

The index of identification was the mean of correct identifications in the two contexts of the science class test and the interview. These values were used as an indicator of the recognition rules in the two contexts *A* and *U*.

### *5.2 Scoring Free Answers to* U *Questions*

The children were first faced with initial *U* questions and asked for a free answer. These answers were analysed using the scales presented in Table I. The categories in the scales were constructed on the basis of close reading of children's replies. There was no prompting of the children when they replied. The reliability was obtained by another researcher's checking.

Within each sub-section there were four codes, scored 0–3. The first sub-scale coded answers for the degree of common sense. The second for degrees of school knowledge, i.e. knowledge of the relevant concept. The third scaled the relevance of the application of the concept. It was possible to assess the extent to which the answer drew on common sense, the extent to which school knowledge was used and the correctness of the application. There was an overall score which gave an index of recognition and realisation rules [11].

The data obtained from this part of the interview gives a measure of recognition between two discursive contexts, the non-academic and the academic and within academic the sub-contexts *A* and *U*. It also indicates realisation of the correct text.

### *5.3 Scoring Selection of the Most Correct Answer to* U *Questions*

For each *U* question there were three alternative answers from which the child was asked to choose the best, i.e. the alternative which best explained the problem on the basis of the concept(s) indicated in the question itself. For each question the three answers always constituted alternatives of the following type (see example in paragraph 4.2): answer $U^+$—Correct explanation on the basis of the concept(s) indicated in the question; answer $U^-$—partial explanation on the basis of the concept(s) involved or explanation only on the basis of common-sense knowledge; answer *A*—no explanation, definition of the concept. The order of the three answers was not the same for the five questions.

For computing the results of this part of the interview, we constructed the

TABLE I. Scales of categorisation for the analysis of direct answers to *U* questions

| Scale of analysis for common-sense answers (CS) (degree of explanation on the basis of common knowledge) | |
|---|---|
| CS0 | Does not use common sense to explicate the problematic situation. |
| CS1 | Repeats the information contained in the question; describes only the situation without explaining; explains using non-related or inconsistent common knowledge. |
| CS2 | Points out the fundamental facts but does not explain (does not make explicit any explanation). |
| CS3 | Explains consistently but making only use of common knowledge. |

| Scale of analysis for school knowledge (*A*) (degree of selection of the knowledge needed to the explanation) | |
|---|---|
| *A*0 | Does not select school knowledge to explain. |
| *A*1 | Selects inadequate school knowledge. |
| *A*2 | Selects some school knowledge. |
| *A*3 | Selects all school knowledge needed to the explanation. |

| Scale of analysis for use of school knowledge (*U*) (degree of explanation on the basis of the school knowledge selected) | |
|---|---|
| *U*0 | Does not use the school knowledge to explain. |
| *U*1 | Tries to explain on the basis of school knowledge but is incapable of explicating its transference or it is inadequately done. |
| *U*2 | Explains using the school knowledge but that is only partially done. |
| *U*3 | Explains totally on the basis of school knowledge selected. |

following scale for each question: selection $U^+$—2; selection $U^-$—1; selection A—0. The scale for all questions was then 0–10 (this scale was further reduced to 1–4: see note 10). A frequent selection $U^+$ (maximum 10 points for the five questions), even when it was not followed by a correct explanation (see paragraph below), was considered as answers which reveal the possession of rules which permit the frequent selection of the most correct alternative (see paragraph 5.4). It was noticed that the child can select correctly quite often without being able to explain the reason for the selection. This may constitute an indicator of the presence of recognition and realisation rules which the child is unable to formalise in a correct explanation. Here the child is unable to give a correct explanation which demands greater abstract forms of thought. It may also be that the child has the thought but is unable to translate that thought in a grammatically and lexically appropriate way. The child possesses the first part of the realisation rules—selects the appropriate text—but fails the second, that is, does not put into her own words the appropriate text. This interpretation gains more support if the child answered incorrectly to the previous part of the interview, where the child gives a free answer to *U* questions.

*5.4 Scoring Explanation for the Selection of an Answer as the Most Correct*

Every time the child chose an answer as the most correct, she was asked for an explanation for that choice. We constructed a 0–7 scale to score children's explanations which is presented in Table II. This scale was further reduced to 1–4 [12]. The data obtained are an index of realisation rules. We believed that categories 5, 6 and 7, would not perhaps be reached by many children of these ages.

TABLE II. Scale for student's explanations for the selection of the most correct answer

| Coding orientation | Main characteristic of students's justification | Examples |
|---|---|---|
| Does not have realisation rules | | |
| 0 | Does not answer or answers inconsistently. | |
| 1 | Justifies by progressive exclusion of statements, excluding alternatives for not legitimate reasons. | Because: I do not agree with the statement(s); it has incorrect words; it has a confusing redaction; I do not understand well. |
| 2 | Just repeats the information contained in the alternative (textually or putting it in his/her own words). | |
| 3 | Gives personal or common-sense reasons. | Because: it has more correct words; it is as in the book [13]. |
| May or may not have realisation rules | | |
| 4 | Compares the alternatives in general terms but does not specify. | Because: it is the most complete; it is the most correct; it is the one which explains better; it is the one which answers the question better. |
| Has realisation rules | | |
| 5 | Compares and specifies the amount of different knowledge present in the alternatives. | Because besides telling about air pressure it also tells about air expansion. |
| 6 | Compares and explicates the degree of explanation of the alternatives. | Because it is not limited to telling about evaporation but also explains that this is caused by the energy obtained from the skin. |
| 7 | Compares and explicates the degree to which the alternative is adequate to the question. | Because it is not limited to explaining the phenomenon but this is done more in accordance with the question, i.e. . . . (explication is given). |

Given the fact that children's explanations were stimulated by the interviewer's probes, the child could, in each question, go through a number of the categories of the scale. Probing was done in order that the child could give the best explanation and it was this that was scored.

### *5.5 Scoring Selection and Explanation of the Least Relevant Answer*

This selection was done, in many cases when the children were asked for the best answer and, before choosing, they started by discarding the worst one. When the child selects the least correct alternative (which is in fact an answer to an *A* question) and that rejection comes with a consistent explanation (e.g. this is not the answer because it is 'saying' what it *is* rather than *explaining*), this answer is an indicator that the child recognised the two contexts *A* and *U*. The selection of the least relevant answer might be considered as an index of realisation rules since the child is faced with texts appropriate to a lesser or greater degree. However we believe we are right in considering the choice of the least relevant answer within recognition rules since during the course of the interview it was quite evident that some children distinguished between 'what it is not' (the worst alternative) and 'what could be' (the two other alternatives).

The correct selections and respective explanations were analysed according to the coding given in Table III, on a scale of 0–2 giving a maximum of 10 for the five *U* questions. The incorrect selections were scored 0. The scale was further reduced to 1–4 (see note 10).

TABLE III. Categorising scale of the explanations for the selection of the least relevant answer

| Degree of recognition | Scale | Examples of justifications given by students |
|---|---|---|
| Explicates the recognition (+) | 2 | Because: it is telling what is condensation rather than explaining the reason why the window glass is misty; it is answering the question 'what is condensation'. |
| May have recognised but does not explicate that recognition (±) | 1 | Because it does not answer well the question. |
| Does not recognise (−) | 0 | Because: it is not complete; it has a complex redaction; what it tells is not quite correct, etc. |

### *5.6 Scoring Selection of 'the Best Way of Thinking'*

The pilot study suggested that children of this age have difficulty in thinking aloud, possibly having difficulty in using the analytical process 'to think the thought'. We therefore used cards to indicate two ways of thinking about the *U* question, and asked the students to select the one which was closest to their own thought.

The children did not show any difficulty in choosing one of the two alternatives. The results obtained were combined with the choice for 'the best answer', to give an index of consistency. Let us consider the following examples:

(a) When selecting the alternative answer $U^+$ and a *U* way of thinking, the child produces the correct text and shows possession of realisation rules—score 2.

(b) When selecting the alternative $U^-$ and a *U* way of thinking, the child reveals possession of realisation rules but she has some difficulty in producing the correct text, probably related to difficulties with the knowledge involved—score 2.

(c) When selecting the alternative *A* and a *U* way of thinking this shows an inconsistency which may indicate a situation more extreme than the previous—score 1.

(d) When selecting an answer *A* or *U* and an *A* way of thinking, the child does not possess the realisation rules—score 0.

The maximum score for the five questions was 0–10. This scale was reduced to 1–4 (see note 10).

In our scoring the selection of 'the best way of thinking' takes precedence over the selection of 'the most correct answer'. Thus, if we take the extreme case of a child who chose *A* or *U* for the most correct answer but chose an *A* way of thinking, this is scored 0 because we consider that, with respect to the presence or absence of realisation rules, the explanation of thinking is more important.

Finally we would like to stress that, although it can be claimed that in some parts of the interview there was answering by chance, the consistency revealed in five or 10 situations, as was the case, can give some confidence in the data. On the other hand, the composite indices and therefore the evaluation of children's specific coding orientation (recognition and realisation rules), were a result of several measures (simple indices) which diminished the influence of answering by chance.

## 6. Recognition and Realisation Rules: results

### *6.1 Data Obtained from Simple Indices*

We now present the results together with their interpretation. This section gives first the results for recognition and second the results for realisation.

*6.1.1 Identification of* A *and* U *questions.* The degree of identification for the 30 children is given by the mean of the correct identifications in two contexts, the questionnaire and the interview. The results show that 66.6% of the students were capable of identifying more than five questions correctly (categories 3 and 4).

*6.1.2 Selection of the least correct answer and explanation.* This step of the interview gave the clearest indication of differential recognition of the *A* and *U* contexts. In rejecting in the first place an answer as simple definition (an answer to an *A* question) the child distinguishes between the two contexts. The frequent rejection of the *A* answers by some children, together with consistent explanations, makes it possible to distinguish between two groups of children, those who recognise and those who do not recognise the difference. A great percentage of children (57%) were unable to recognise the distinction between *A* and *U*.

Comparing the interview results with those obtained through the test in class, with respect to *A* questions, we can see that the percentage of children who identify correctly the *A* context is higher in the test than in the interview (66% as compared to 43%).

This may lead us to think that the recognition of the context *A* in test questions and interview answers do not share the same degree of difficulty. In the face of a question it is easier for a child to recognise if she is asked for a definition or if she is asked to use knowledge of new situations. In fact, the text of the test question shows a common format (typical grammatical structures) which the student is accustomed to recognise, whether or not he/she knows or he/she does not know the knowledge required or the correct answer. The typical formats of *A* questions, 'tell what it is . . . ', 'give examples of . . . ', 'what is meant by . . . ' are some examples. In the case of the choice of answers in the interview context the *A* answers also have typical formats. However, the *A* answer is in the context of an explanation whereas in the test the statement is only a simple question. This difference in the formats in the answers may have made the task of recognition more difficult.

So far we have argued that identification is affected by the eliciting format of test questions and interview answers. However, the children, when explaining the reason for the selection of a specific question as *A* or *U*, used expressions, considered as indicating non-recognition, for example.:

> This is *U* because one must think more to answer. [There is no explication of what a *U* question is.]
>
> This is *A* because I can tell the answer at once without having to think too much. [There is no explicit reason.]
>
> This is *U* because it tells about condensation which I do not know very well.
>
> This is *U* because I have never heard about it.

These texts show that despite the format of the question, many children do pay attention directly to the knowledge, its degree of difficulty or even to the fact that they know or do not know the situation given.

*6.1.3 Free answers to* U *questions.* Here the children were presented with the problem-solving question and asked to answer on the basis of a specific scientific concept. The results showed that: 60% of the answers were exclusively within common-sense knowledge; only 4% of the answers (6 in 150) correspond to the correct answer (CSO, *A*3 and *U*3); and 81% of the answers are *U*0, i.e. do not make use of any school knowledge in the explanation.

It was noticed that the children, in general, did not show any hesitation in answering but did it as if they had ignored the 'explain on the basis of the knowledge . . . you have acquired in science classes'. The answers sometimes consisted of descriptions of similar situations in their personal experience. They mainly consisted of repetition of the information contained in the question. Sometimes there were attempts at explanation but these were very seldom situated outside the confines of common-sense explanations. For example:

> At home, when we are shut in our breathing mists the window glasses.
>
> The window glasses get misty because it is cold and it is humid in the house.
>
> The breath hits the glass and, because it is cold, gets misty.

Even after it was pointed out that the explanation was not taking into account school knowledge, most children retained their first answers. This shows a certain stability in the explanations at the level of common sense, which act like a barrier to prevent explanation on the basis of the concept involved. On one hand, the students explained the concept in their own words but on the other they solved the problem on the basis of common-sense knowledge.

It might be that, even when reminded of the concepts, the fact that some months had passed after their learning may well have weakened their memory of the relation to which the concepts point and as a consequence no application was possible. Thus answers tended to remain at the level of common sense. However, the analysis of similar answers to test questions (problem-solving situations) selected from the tests usually given in the science classes, showed that the vast majority of children answered here also at the level of common sense. It is not possible to explain the move to common-sense thought in terms of lapse of memory as *U* questions in classroom tests always follow *A* questions about the same scientific knowledge and the pupils, in general, answer the latter easily. On the other hand, the form of presentation of questions *A* and *U* in such tests makes the boundaries between the two contexts *A* and *U* explicit.

However as we will see the children had much less difficulty in producing a correct answer when they were asked to select among three alternative answers (see below). This may mean that, within the realisation rules, the children have the first level, they can select the appropriate text but they fail to have the second level, produce the appropriate text. We can make a distinction between the child having a passive or an active realisation competence. A passive competence is where the child can only choose the correct alternative, that is where the child can decode, and an active realisation competence where the child can produce the correct text, that is the child can encode the answer. It is possible that the school does not develop efficient strategies which lead the children to encode the correct text.

*6.1.4 Selection of 'the most correct answer' and explanation.* The analysis of the selections made by the children show that in a total of 150, only 21 correspond to selections of *A* answers, i.e. definitions; 60 were $U^-$ and 79 $U^+$. The analysis of the explanations for the choice show that none of the children reached category 4 (when the scale was reduced to four categories) and that only two children (Y6 and Y13) were able to reach, for some questions, point 6 of the 0–7 scale.

The above shows that *U* answers ($U^+$ and $U^-$) were frequently selected by children. However the explanations which followed did not show possession of realisation rules. Similarly, the children showed they were unable to produce, in a free answer, the correct text for the same question. This leads us to conclude that many students can mark the boundaries, can select the context and also select the correct meanings, but because the realisation rules had not reached the degree of structuring required, they were unable to produce freely a text adequate to the context. This low level of structuring of the realisation rules is revealed in the free answers, nearly all of which are common sense and in the justifications of the selections which seldom reached the threshold of correctness. It is interesting to notice that pedagogic practice P3 leads to a relatively smaller gap between children when they had to select the best answer.

*6.1.5 Selection of the 'best way of thinking' combined with selection of the 'most correct answer'.* We have given previously the reasons for combining the selection of the best answer with the choice of the statement which was closer to the child's way of thinking. The results show that a great percentage of selections (108 out of 150) reveal consistency between the answer selected and the way of thinking and 31 reveal total inconsistency. If we consider this measure as an index of the possession of realisation rules, the results indicate that a high percentage of the children possessed such rules.

### 6.2 Results Obtained with Composite Indices

In this section we will combine the simple indices to form composite indices of recognition and realisation rules. Fig. 1 shows all the simple indices and how they were combined to form the composite indices. The indices of recognition and realisation taken together give what we shall term the specific coding orientation in $A/U$ contexts in science class. For the construction of the composite indices we used the reduced scales of four points [14]. Further in constructing the composite indices we did not score the free answers to $U$ questions since virtually all children were unable to give correct answers.

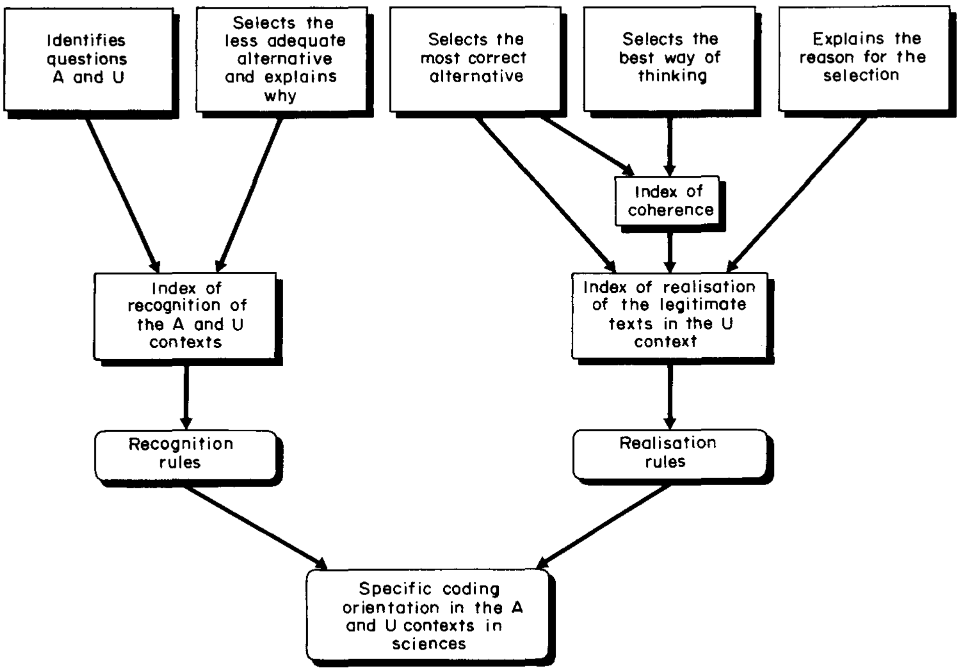


FIG. 1. Relations between the indices of recognition and realisation to determine the specific coding orientation to the $A/U$ contexts.

Table IV shows the data for all students grouped according to pedagogic practice. The composite indices (recognition, realisation) are rounded up means of the simple indices and the global indices (specific coding orientation) are rounded up means of the five simple indices of recognition and realisation. The specific coding orientation shows differences between the children in the acquisition of recognition and realisation. It is the data in Table IV which provide the basis for the sociological analysis of the relation between recognition and realisation rules and school, gender, race and social class.

TABLE IV. Values for the 30 students of the sub-sample in the texts produced and in the composite indices—recognition rules, realisation rules and specific coding orientation (students are grouped according to pedagogic practices P1, P2, P3. *R*—recognise or realise; *NR*—do not recognise or do not realise)

| Students | Identifies questions *A* and *U* in 2 contexts (mean) | Selects the worst answer (answer for a question A) | Recognition rules | Selects the best answer | Explains why | Selects best way of thinking/ selects the best answer | Realisation rules | Specific coding orientation |
|---|---|---|---|---|---|---|---|---|
| | A | B | | C | D | E | | |
| X70 | 4 | 1 | 3 R | 2 | 2 | 3 | 2 NR | 2 |
| X72 | 3 | 4 | 4 R | 3 | 3 | 4 | 3 R | 3 |
| X73 | 2 | 3 | 3 R | 3 | 2 | 4 | 3 R | 3 |
| X75 | 3 | 2 | 3 R | 3 | 3 | 3 | 3 R | 3 |
| X79 | 2 | 2 | 2 NR | 3 | 3 | 2 | 3 R | 2 |
| X81 | 3 | 1 | 2 NR | 2 | 2 | 4 | 3 R | 2 |
| X82 | 2 | 1 | 2 NR | 2 | 2 | 2 | 2 NR | 2 |
| X84 | 3 | 4 | 4 R | 3 | 3 | 4 | 3 R | 3 |
| X88 | 3 | 3 | 3 R | 4 | 3 | 4 | 4 R | 3 |
| X90 | 2 | 1 | 2 NR | 2 | 2 | 2 | 2 NR | 2 |
| Y1 | 3 | 1 | 2 NR | 2 | 2 | 1 | 2 NR | 2 |
| Y4 | 3 | 1 | 2 NR | 3 | 3 | 3 | 3 R | 3 |
| Y6 | 4 | 4 | 4 R | 4 | 3 | 4 | 4 R | 4 |
| Y8 | 2 | 1 | 2 NR | 1 | 2 | 2 | 2 NR | 2 |
| Y10 | 3 | 1 | 2 NR | 3 | 2 | 3 | 3 R | 2 |
| Y13 | 2 | 3 | 3 R | 4 | 3 | 3 | 3 R | 3 |
| Y15 | 3 | 3 | 3 R | 4 | 2 | 3 | 3 R | 3 |
| Y17 | 2 | 2 | 2 NR | 3 | 2 | 3 | 3 R | 2 |
| Y18 | 3 | 4 | 4 R | 3 | 3 | 4 | 3 R | 3 |
| Y19 | 2 | 1 | 2 NR | 2 | 1 | 3 | 2 NR | 2 |
| Z23 | 3 | 2 | 3 R | 4 | 3 | 3 | 3 R | 3 |
| Z27 | 3 | 3 | 3 R | 3 | 2 | 4 | 3 R | 3 |
| Z29 | 3 | 4 | 4 R | 3 | 3 | 4 | 3 R | 3 |
| Z32 | 3 | 3 | 3 R | 3 | 3 | 3 | 3 R | 3 |
| Z34 | 2 | 1 | 2 NR | 2 | 2 | 1 | 2 NR | 2 |
| Z36 | 3 | 3 | 3 R | 4 | 3 | 4 | 4 R | 3 |
| Z38 | 3 | 2 | 3 R | 2 | 3 | 3 | 3 R | 3 |
| Z40 | 4 | 4 | 4 R | 3 | 2 | 3 | 3 R | 3 |
| Z43 | 2 | 1 | 2 NR | 3 | 2 | 4 | 3 R | 2 |
| Z45 | 3 | 1 | 2 NR | 3 | 2 | 3 | 3 R | 2 |

## 7. Relation between Recognition and Realisation Rules and Characteristics of the Students and School

### *7.1 Data*

We measured the degree of recognition and realisation of children, i.e. their coding orientation, in the *A* and *U* contexts and the data obtained show that there is differential recognition and realisation. We now want to find out reasons for this differential competence, and we shall examine the relations between the findings and specific characteristics of the children, with respect to both the family and the school (social class, race, gender, cognitive development, and pedagogic practice and school achievement in *U* competencies).

In order to simplify the analysis, we reduced the four point scale to two points, for both recognition and for realisation rules: 1—'does not recognise' or 'does not realise' (*NR*); 2—'recognises' or 'realises' (*R*). The 30 children were then grouped according to the following four categories of the specific coding orientation: R/R: recognise and realise; R/NR: recognise and do not realise; NR/R: do not recognise but realise; and NR/NR: do not recognise and do not realise. Table V shows the distribution of the children in the above four groups, with respect to social class, race, gender, level of cognitive development, pedagogic practice and achievement in *U* competencies in the school science tests.

TABLE V. Distribution of students (and their characteristics) according to four levels of recognition and realisation of *A* and *U* contexts. (*R*—recognise or realise; NR—do not recognise or do not realise)

| Coding orientation | Students | Social class | Race | Gender | Cognitive development | Pedagogic practice | Achievement (*U* competencies) (means) |
|---|---|---|---|---|---|---|---|
| Recognise and realise (R/R) | Y6 | 3 | 2 | 1 | 4 | P2 | 3 |
| | Y13 | 3 | 2 | 2 | 4 | P2 | 2 |
| | Y15 | 2 | 2 | 2 | 3 | P2 | 3 |
| | Y18 | 6 | 2 | 2 | 3 | P2 | 2 |
| | Z23 | 4 | 2 | 2 | 2 | P3 | 2 |
| | Z27 | 3 | 2 | 2 | 2 | P3 | 2 |
| | Z29 | 5 | 2 | 1 | 4 | P3 | 2 |
| | Z32 | 3 | 2 | 1 | 2 | P3 | 2 |
| | Z36 | 2 | 2 | 2 | 4 | P3 | 3 |
| | Z38 | 4 | 2 | 2 | 4 | P3 | 3 |
| | Z40 | 3 | 2 | 1 | 4 | P3 | 4 |
| | X72 | 5 | 2 | 2 | 5 | P1 | 2 |
| | X73 | 5 | 2 | 1 | 3 | P1 | 1 |
| | X75 | 1 | 1 | 1 | 2 | P1 | 2 |
| | X84 | 5 | 2 | 1 | 3 | P1 | 2 |
| | X88 | 2 | 2 | 1 | 6 | P1 | 3 |
| R/NR | X70 | 6 | 2 | 1 | 4 | P1 | 2 |
| Do not recognise but realise (NR/R) | Y4 | 4 | 2 | 1 | 3 | P2 | 2 |
| | Y10 | 2 | 2 | 1 | 3 | P2 | 1 |
| | Y17 | 1 | 1 | 2 | 4 | P2 | 2 |
| | Z43 | 1 | 1 | 1 | 2 | P3 | 2 |
| | Z45 | 2 | 2 | 2 | 2 | P3 | 2 |
| | X79 | 2 | 2 | 2 | 5 | P1 | 2 |
| | Z81 | 1 | 1 | 2 | 2 | P1 | 2 |
| Do not recognise nor realise | Y1 | 2 | 2 | 1 | 3 | P2 | 2 |
| | Y8 | 5 | 2 | 1 | 3 | P2 | 2 |
| | Y19 | 1 | 1 | 2 | 4 | P2 | 2 |
| | Z34 | 1 | 1 | 2 | 1 | P3 | 1 |
| | X82 | 2 | 2 | 2 | 2 | P1 | 2 |
| | X90 | 2 | 2 | 1 | 3 | P1 | 2 |

We also supplemented our data base by a correlation analysis (Spearman correlation) which shows the relation between the variables and the various indices, simple and composite. The simple indices are indicated by letters, the explanation for which are at the bottom of the table. The composite indices were calculated using the 1–4 scale rather than the reduced one (1–2) referred to before. The table of correlations is presented in Table VI. One should remember that the rounding up in calculating the composite indices is responsible for some discrepancies between the correlations referring to the composite and simple indices.

Table VI. Correlations between students' characteristics and specific coding orientation (simple and composite indices). Significant correlation $\geq 0.306 (p \leq 0.05)$

| Students' characteristics | Recognition | | | Realisation | | | | Specific coding orientation |
|---|---|---|---|---|---|---|---|---|
| | A | B | Recognition | C | D | E | Realisation | |
| Social class | 0.33 | 0.38 | 0.51 | 0.16 | 0.41 | 0.25 | 0.22 | 0.41 |
| Race | 0.50 | 0.61 | 0.59 | 0.58 | 0.59 | 0.42 | 0.61 | 0.62 |
| Gender | 0.04 | 0.16 | 0.09 | 0.25 | 0.21 | 0.15 | 0.29 | 0.16 |
| Cognitive development | 0.27 | 0.46 | 0.41 | 0.32 | 0.40 | 0.27 | 0.43 | 0.34 |
| Pedagogic practice | 0.29 | 0.16 | 0.18 | 0.28 | 0.17 | 0.13 | 0.33 | 0.30 |
| Achievement (*U* competencies) | 0.63 | 0.53 | 0.55 | 0.52 | 0.49 | 0.40 | 0.64 | 0.61 |

*Note*: A identifies question *A* and *U* in two contexts; B selects the least correct answer; C selects the best answer; D explains the selection of the best answer; and E selects the best way of thinking/selects the best answer.

### *7.2 Discussion*

The interpretation of the relations is going to be made essentially using the data as expressed in Tables V and VI. The correlation table (Table VI) on its own is likely to be misleading and therefore the discussion will take into account the raw data as these are given in Table V. The discussion will start by looking at the relations of each one of the variables with the specific coding orientation and will proceed with a more comprehensive discussion of all the variables, that is the background of the child (social class, race, gender), cognitive development, pedagogic practice. The relation between the specific coding orientation and the school achievement in *U* competencies will also be discussed. The data and their interpretation should be viewed within the limitations of the study (size of the sample, methodology). However, the use of several measures for specific coding orientation and also the rigour and care put into the processes of interviewing and analysing give a high degree of reliability to the study.

The correlations show that social class is highly correlated with recognition (0.51), especially with the measure obtained through 'the least correct answer'. Social class is less correlated with realisation (0.22), but when we only consider the more complex task of realisation ('explain the reasons for the selection of the best answer') the correlation is much higher (0.41). If we consider the group of children who can recognise and realise and the group who cannot recognise but can realise (Table V), that is those who differ in recognition rules, we find

(Mann–Whitney *U* test) that there is a significant difference between these two groups in terms of social class. This gives more strength to the findings from the correlations which indicate recognition as the fundamental reason for the failure of the lower social levels. There is a very strong relation (0.41) between the specific coding orientation and social class. This can also be read from Table V. We conclude that children of lower social levels have more difficulty in recognising the difference between the *A* and *U* contexts and in producing orally the correct text for the *U* context except when the task of realisation is limited to the selection between alternatives (passive competence of realisation). This difficulty appears to correspond to a lack of the active competence of realisation. If this is true we may suggest that children of lower social classes are unable to produce by themselves the appropriate text to high level competencies (*U* context), although they can choose between a set of given texts.

Race is highly positively correlated with all the indices of recognition and realisation and therefore with the specific coding orientation (0.62). We should not forget that all black children were part of social class 1, that is this variable is interfering in that relation. Thus, when we compare the two races we are comparing *also* the lowest social class with the other social groups. When we consider the total pattern of correlations between social class and recognition and realisation on one hand and race and recognition and realisation on the other, the crucial difference in the pattern occurs with the index of selecting the best answer (0.16 and 0.58). This indicates that black children of low social class have great difficulty in selecting an appropriate *U* answer. A more detailed analysis done through the data of Table V shows that only one black child is placed in the group of children who both recognise and realise. In the interviews black children were incapable of recognising differences between the *A* and *U* contexts when they had to 'choose the least relevant answer', whereas half of them were capable of recognition when this was measured through the 'identification of *A* and *U* questions' on the questionnaire. Although we must be cautious in interpreting these results, since black children are all part of the lowest social class, the evidence seems to suggest that these children not only lack the active competence of realisation but also lack the passive competence. Further they also fail in the more complex tasks of recognition.

Although the correlation between gender and index of realisation rules falls just below the level of acceptable significance there is clearly a trend favouring boys in being able to 'select the best answer' and 'explain the reason'. From Table V we can see that there is no gender difference in any of the categories of the specific coding orientation. However, from the same figure it is interesting to note that most girls of P1 (4 out of 5) are in the group which can recognise and realise. This may indicate that P1 is particularly favourable to girls independently of the social group and cognitive development score. On the whole, there is no difference between boys and girls when they have to recognise the *A* and *U* contexts. However, at the level of realisation, girls when compared to boys appear to have a lower passive and active competence whenever they have to produce the correct text in the *U* context.

The relations found between the variables social class, race, gender and children's specific coding orientation are a consequence of children's primary socialisation. It is in the family/community that disadvantaged children tend to develop a restricted coding orientation and to acquire a low positioning. There are many studies to support this view, namely those carried out with the sample used in this study (Fontinhas, 1991; Neves, 1991, 1992; Neves & Morais, 1991). However, the relations found in this study also point to the influence of the school (see later discussion).

The specific coding orientation is positively correlated with pedagogic practice (0.30); this is a consequence of the relation with the simpler tasks of recognition ('identifies the *A* and *U* questions') and realisation ('selects the best answer'). A detailed anslysis of the data in Table V shows that seven children out of 10 of pedagogic practice P3 can recognise and realise. For P1 and P2 the numbers are significantly lower. We have also seen that P3 is the practice which led to a smaller gap between children in the 'choice of the best answer'. This shows a *clear relation with pedagogic practice*. However, we cannot conclude that P3 is the best practice, since other studies (Morais *et al.*, 1991b; Neves *et al.*, 1992; Fontinhas, 1991) show that P2 improves achievement of children with unfavourable characteristics (low children's positioning in the family, parent's restricted coding orientation, etc.) who are more represented in P2 classes. These studies also show that P2 produced a higher improvement of the children's general coding orientation. In spite of the ambiguities to which these data can give rise, we can see that the relation between pedagogic practice and specific coding orientation holds only for the simpler tasks of recognition and realisation; in the most complex tasks, the pedagogic practice did not have any influence. This may be a consequence of the fact, already pointed out, that the three pedagogic practices were not so sharply separated as planned, namely in the explicating of the criteria of evaluation.

Of great interest, perhaps validating our analysis, there is a very high correlation between school achievement in *U* competencies and the specific coding orientation (0.61) through all its indices. Achievement in *U* competencies is, in general, low for all children (Table V). This may explain why nearly all the children were unable to give answers to *U* questions in their own words. However, we have evidence that although they lack the active competence they possess the passive realisation competence.

There is also a positive correlation between the specific coding orientation of the children and the cognitive development (0.34); this relation is also evident in Table 5. Children who can recognise and realise have the highest scores on the science reasoning task and those who cannot do both operations have the lowest. From this data we could conclude that children with a lower cognitive level have more difficulties in recognising between the *A* and *U* contexts, and in realising the appropriate text to the *U* context. However, this relation seems to be very complex as shown by the study referred to before and related to the analysis of the general coding orientation (Morais *et al.*, 1991c). In this study, the causal relation appears to be the opposite, i.e. it is the coding orientation which influences the level of cognitive development. A better understanding of this relation might be reached if our work is articulated with the more recent work done by Shayer & Adey (1991) and Adey *et al.* (1989), in which they show the influence of cognitive acceleration, through pedagogic intervention, in scientific school achievement.

Summarising, we can say that social class and race are the most important variables in recognising the distinction between *A* and *U* contexts and in realising the appropriate text to *U* situations. It can be seen that cognitive development of the child also has some importance. We have also seen that pedagogic practice is an important factor. The gender relation seems to be mediated by pedagogic practice, at least for girls.

It is of interest to find the reasons for 'discrepant' cases. If, for example, social class and race are factors influencing the coding orientation, i.e. the possession of recognition and realisation rules, what is the reason why some working-class and black children (Y15, Z36, X75, X88) have these rules and some middle class (Y4, Y8) do not? There are clearly other factors intervening. For reasons of space we cannot enter into a detailed discussion of these aspects although data provided in other studies (for example Antunes, 1991; Fontinhas, 1991; Morais *et al.*, 1991b, c; Neves, 1991), give some basis for grounded explanatory hypotheses. As an example, we will briefly refer to one case.

Let us consider student Z36 who was subjected to a very detailed analysis (Neves, 1991) and who is placed in social class 2. His father is employed in a good restaurant having close contact with high middle-class people, he did a middle level course in hotel service, he can speak English, he learned Latin when he was young (his parents wanted him to be a priest), he is interested in academic subjects especially in the area of sciences, he likes classical music, data showed that he had an elaborated orientation. It is not surprising that this child has acquired in the family an elaborated orientation, and sensitivity to the pedagogic code of the school.

Finally, it is important to point out that students who have the better achievement in *U* competencies are those who can both recognise the two contexts and produce the appropriate text in the *U* context. These are likely to be of high social class, white, with higher cognitive development and receiving a pedagogic practice where, among other characteristics (Fontinhas, 1991), explicit criteria for *A* and *U* contexts had been given.

## 8. Conclusion

The aim of this study was to see the extent to which the students have recognition and realisation rules at the micro-context of problem solving and to find out the reasons which may underlie their difficulties.

The study shows that social class is an important variable in determining the specific coding orientation in the *A* and *U* micro-context of the science classroom. Social class is most strongly correlated with recognition rules and it is also strongly related to the most complex task of realisation, i.e. encoding the explanation. Children of lower social classes fail in recognition and lack the active competence of realisation. The study also showed that black children (mainly part of social group 1) have, in general, a lower degree of recognition and realisation.

The finding about gender is also interesting because it shows that girls, irrespective of social class, cognitive development and perhaps race, develop better recognition and realisation competences within the pedagogic practice P1. This supports other conclusions of the project (e.g. Morais *et al.*, 1991b, c).

Perhaps the crucial finding for pedagogic change is the finding which shows the positive influence of pedagogic practice on children's specific coding orientation. The pedagogic practice P3, where the distinction between *A* and *U* situations was made explicit and also the appropriate text, was the practice where a higher percentage of children were shown to possess recognition and realisation rules. We have evidence from other studies in the project that P2 is a relatively very successful practice in the acquiring of *U* competencies by children who as a group come from the least favourable backgrounds of all the three pedagogic practices, whereas the children of P3 are coming from the most favourable. It is clear from the research findings that, irrespective of the social background of the children and their cognitive development, the school does make a difference.

Our findings show the mutual influence of the family and the school in developing the specific coding orientation required by science classes. Not surprisingly, school achivement in *U* competencies is significantly correlated with the specific coding orientation through all its indices. These findings are extremely important because they show that although family socialisation is crucial in developing the elaborated orientation, institutionalised in the school and required for developing *U* competencies, the school is also effective if its pedagogic practice is appropriate through a change in the modality of the pedagogic code. The explicating of criteria (strong framing), for *A* and *U* contexts seems to be a crucial factor [15], although other factors absent in pedagogic practice P3 such as weak framing of the social relations of conduct, weak framing between groups of students in terms of social class, race, gender may be of great importance. If these are simultaneously present in the same pedagogic practice, as, to a certain extent, happens in P2, the students' achievement in the fundamental competence of problem solving should be higher. It is important to add here that there was some mismatch between the theoretical guidelines for P3 (Neves, 1991) and the actual pedagogic practice of the teacher (Fontinhas, 1991; Antunes, 1991) and as a consequence certain features (pacing of transmission, school–family relations) of the framing were weaker than they should have been and this may have contributed to the achievement of the children. Thus P3 was nearer to P2 than expected; as a consequence, as we have seen, P2 was also effective for disadvantaged groups.

The results obtained in this paper lead us to think that lower social groups have special difficulty in distinguishing the context of problem solving from other contexts, that is they seem not to have the recognition rules at this level. Once these are given they can realise the correct text, although they again show difficulty in explicating this realisation. It is important to remember that virtually all students were incapable of producing a free correct *U* answer. They have a passive realisation competence but not an active realisation competence.

The general difficulty in producing a free *U* answer should not lead us to conclude that children of this age are unable to perform at that level. Our observations of the classroom lead us to believe that *U* situations were not created by the teacher as often as planned nor were the criteria made sufficiently explicit (even in pedagogic practices P2 and P3 where this was supposed to be done). This may explain the general difficulty students encountered and the further difficulties felt by disadvantaged children.

In all classes the outstanding fact is that the mean score for *U* achievement in school science formal tests is very low, although scores correlate with social class. This should provide great motivation for evaluating pedagogic practices and implementing more effective modalities, namely in the area of problem solving which constitutes a crucial competence to attain a high level of scientific development.

We would like to stress the importance which was given in this study to all children's knowledge and competencies through the weakening of the external framing between school/family-community. To evaluate the influence of this variable we made it vary across the three pedagogic practices although, as we have seen, differences were not as sharp as it was planned. Our concern was to value all children's knowledge without leaving *some* children deprived of the scientific knowledge needed to go up in the educational system, acquiring the discourses of power to reach higher positions in society.

Thus, in a problem-solving situation, as was the case in this study, the common-sense explanation was devalued because the scientific knowledge was not being applied in a context which required such knowledge. The problems given to children were based upon everyday situations to weaken the boundaries between academic and non-academic knowledge (crucial relation for scientific competence). This may not be easy for children, especially the disadvantaged, given the strong classification, present in their primary socialisation, between those two types of knowledge. However, new strategies (modalities of pedagogic practices) should be implemented to alter these difficulties.

We are aware how the above assumptions may be viewed as an acceptance of social reproduction. However, if we introduce changes in the school, following a procedure similar to that of the project which includes this study (see paragraph 3), we are giving students instruments to challenge and criticise. In other words, the possession of scientific knowledge *together* with socialisation in new forms of social relations may ultimately contribute to social change.

Our research contributes to implementing more effective modalities of pedagogic practice and thus opening up a space for pedagogic change. It is clear that such change can only go forward on the basis of sensitive sociological description and analysis of the processes such change entails. There is a theoretical point which can be made. Variations in the internal and external values of classification and framing of pedagogic practices ($C_{ie}^{\pm}$ $F_{ie}^{\pm}$) act selectively upon the recognition and realisation rules which construct classroom interaction and communication of both teacher and taught and which in turn regulate the contexts in which the specific coding orientation to various specialisations of school knowledge is acquired. Thus the sociological base of the classroom is fundamental to both differential acquisition *and* more equitable distribution of school knowledge.

**Acknowledgments**

We are most grateful to Professor Basil Bernstein, consultant of the Project ESSA where this study is included, for many valuable suggestions and constructive criticisms. We are also indebted to the JNICT—*Junta Nacional de Investigação Científica e Tecnológica* and to the *Fundação Gulbenkian* for making this research possible.

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## NOTES

[1] The term social class is used, in this paper, as a nominal concept.

[2] Previous studies (Domingos, 1987, 1989a, b) have shown the influence of the teacher's conceptual demand on the relation between social factors and students' achievement.

[3] The detailed meaning of these two groups of competencies can be seen, for example, in Domingos (1987) and Morais *et al.* (1991b).

[4] A detailed description of the scales for academic qualification and occupation, and of their construction, can be seen in Neves (1991). A short version is the following:

*Scale for academic qualifications*: Number of years of schooling was the main criterion for the scale of academic qualifications: 1—cannot read or write: 2—completed primary school or attended a part of preparatory school; 3—completed preparatory school (fifth and sixth grades) or attended some years of secondary school (middle section seventh to ninth grades); 4—took the ninth grade exams or completed a medium-level course after sixth grade; 5—took the eleventh grade exams (completed secondary school) or completed a medium-level course after ninth grade; 6—completed a medium-level course after eleventh grade or did some years of a university or obtained a university degree.

*Scale for occupations*: The socio-economic status was the main criterion for the construction of this scale: 1—unskilled workers with no supervisory functions; 2—unskilled workers with supervisory functions, skilled workers with or without supervisory functions, self-employed unskilled workers; 3—self-employed skilled workers, small proprietors; 4—non-manual employees in administration, commerce and other services without supervisory functions; 5—non-manual employees in administration, commerce and other services with supervisory functions; 6—self-employed or salaried professionals, administrators, managers.

[5] The scale for cognitive development was the following: 1—Pre-operational; 2A—early concrete; $2A^+$—mid-concrete; 2B—mature concrete; $2B^+$—concrete generalisation; 3A—early formal; $3A^+$—mid-formal; 3B—late formal. The highest stage reached by the children in this study was 3A; the scale was then reduced to 1–6.

[6] For reasons of space we are only giving some examples of the questions and steps of the questionnaire and of the interview. The complete versions can be seen in Fontinhas, 1991.

[7] The test was piloted with a greater number of questions from which selections were made, retaining those where students showed a better knowledge of the concepts. The language was also simplified.

[8] Two heads were drawn on different cards. One head had a chest of drawers inside and the other had a light bulb. The researcher explained that *A* questions were like the drawers in the head—retrieving information—whereas the *U* questions were like the light bulb that is illuminating a new area, i.e. throwing light.

[9] The interview was first piloted with some pupils of the pilot sample, 4 middle-class and 3 lower working-class children. The immediate recognition of the least correct answer by the four middle-class children gave some indication of the discriminatory power of this part of the interview. Some aspects of the former interview guide were discarded and they were not included in the final version above. Thus, for example, the indication 'think aloud when you compare the alternatives' was taken out, since the majority of the children showed difficulty in verbalising their thought. The tape recording of the interviews was also excluded because, given the conditions of the school, the interviews could not take place in a totally silent locale and the noise of the playground interfered with the recordings. A grid with the 'typical answers', obtained from the pilot study, was constructed to record the children's answers. Although this procedure led to some loss of information and some 'interviewer's interpretations', the grid facilitated the conceptualisation of the interviewees' answers.

[10] Reduction of 0–10 scale to 1–4; 1 (0, 1, 2); 2 (3, 4, 5); 3 (6, 7, 8); 4 (9–10).

[11] This scaling intrument was also used to analyse the answers to *U* questions given by the students in their formal science tests.

[12] Reduction of 0–7; scale (0–35) to 1–4: 1 (0–8); 2 (9–17); 3 (18–26); 4 (27–35).

[13] Common-sense examples are not given in the table because they are too long.

[14] It should be pointed out that the two simple indices for recognition are each based upon two scores and one of the three simple indices for realisation is a combination of two scores.

[15] A suggestion of the influence of this factor had been given by the study carried out by Domingos 1987, 1989b).

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