

# **Biology, Health and Environmental Education for better Citizenship: teachers' conceptions and textbook analysis in 19 countries**

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The European Biohead-Citizen research project has started in October 2004 and is now in its last year of implementation. It aims to understand how Biology, Health and Environmental Education can promote a better citizenship, by analysing potential differences in 19 countries (13 European countries and 6 non European countries) and associating them to controlled parameters. Six topics were defined by the consortium for the research (“Human Brain”, “Human Genetics”, “Human Origin”, “Human Reproduction and Sex Education”, “Health Education” and “Ecology and Environmental Education”). Specific grids were constructed and validated for application to primary to secondary school textbooks (5/6 to 17/18 years old students) of all 19 countries. A questionnaire was constructed and after validation in a pilot test, the final questionnaire was applied to a total of 6379 teachers of primary school and of secondary school (biology and of national language), and also to corresponding pre-service teachers. We describe the successive steps of both instruments (grids and questionnaire) collective construction process, their validation and application and also present general results to exemplify the diversity found in different countries textbooks and in teachers and future teachers' conceptions. Teachers' and future teachers' conceptions are contrasted in relation to creationism, sexism views and awareness of some environmental issues. Some of these differences are correlated with the controlled parameters as religion, degree of religious practices, political positions, academic level and training type. Challenges of this interaction between the taught scientific knowledge, values and socio-cultural contexts will be discussed.

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## **A - GOALS AND THEORETICAL BACKGROUND**

Our goal is to explore the multiculturalism related to the teaching of important topics as sex education, health education and environmental education as well as evolution (and mainly the sensitive question of the human origins) and the biological epigenesis linked to the socio-cultural determinism of human behaviour and performances (by a critical analysis of the reductionism in teaching the human genetics and the human brain).

A priori, we could suppose that the scientific contents are universal, in reference to the same scientific publications, and in consequence they could be the same in the school syllabuses and textbooks, as well as in teachers' conceptions.

Nevertheless, we will show that it is not the case, at least for the selected topics which are related to "questions vives" often articulated to social and scientific debates (Albe & Simonneaux 2002).

Our goal is to analyse the differences existing among countries, selecting several European countries to analyse differences linked to contrasted geographical, historical, socio-cultural and political issues in Europe, but also non European countries, chosen in Africa and Middle East, to analyse an eventual European unity in contrast with these non European countries, as well as to analyse the context of the frequent collaborations (for research and teaching) between these countries and the European ones.

A first step is to define our theoretical background.

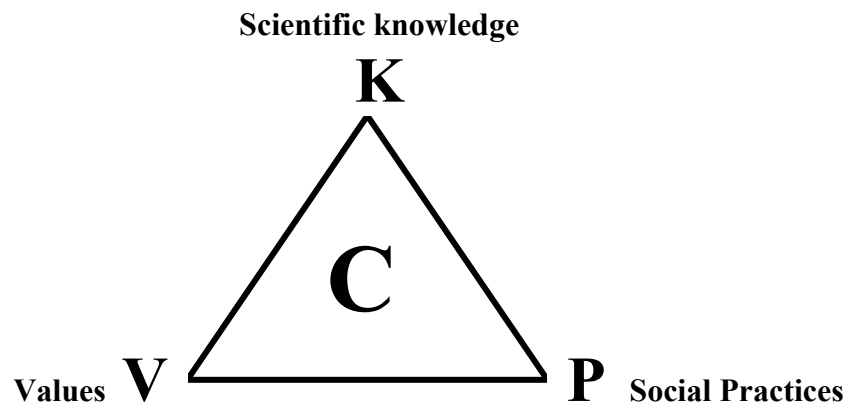
### **1 - Analysis of conceptions; the KVP Model**

We are mainly working on the conceptions of teachers and of authors and publishers of school textbooks. Our work is anchored in didactics of sciences (science education) but is also linked to social psychology with the concept of social representations (Moscovici 1984).

The conceptions are classically studied in the research in didactics of sciences (Astolfi et al 1997), the word "conceptions" being chosen to be more adapted than the word "representations" (Clément 1994). The list of works done in this perspective was listed in Pfundt and Duits (1994) and this list is then regularly up-dated on the web site of Reinder Duits (with thousands of references of published research on conceptions of learners and teachers).

In the present work, the conceptions of some actors of the educational system are analysed as being the emergences from interactions between the 3 poles K, V and P, as proposed by the model KVP (Clément 1998, 2004, 2006). The 3 poles are: the scientific knowledge (K), the systems of values (V) and the social practices (P). Any conception can also be analysed with other theoretical background. Nevertheless, the KVP model is useful to analyse important features of the taught knowledge: the epistemological one, to try to understand what is related to science or to values in a scientific presentation, for instance in a textbook; and also its interaction with social practices (e.g. some images come from medical practices, some other from lab of research, some others are strongly modified just for aesthetical aspects, some others are created for a pedagogical goal, ...). The scientific knowledge (K) is referred to the publications coming from the scientific community. The social practices (P) are those of the actors of the educational system: the practice of teaching in their country for the teachers, the practice of the authors and publishers of school textbooks, but also their conceptions related to the actual and future social practice of their students (their future professional job but also their present and future responsibility as a citizen). The values (V) are defined in a large sense, including opinions, beliefs and ideologies. For instance sexism, racism, westernism will be considered as values, as well as the research of truth by the science and the "scientific ideologies" defined by the epistemologist Cangulihem (1977) to characterise some trends inside the biological science as for examples reductionism or vitalism or anatomism, or explications only by the genetic determinism.

We will illustrate the pertinence of the KVP model with examples coming from our analyses of school science textbooks in 18 countries and from comparisons of the conceptions of in-service and pre-service teachers in these countries.



*Figure 1 - The KVP Model. The conceptions (C) can be analysed as interactions between the 3 poles K, V and P*

## **2 - The didactic transposition**

The anthropological approach defined in didactics of mathematics by Chevallard (1989), using the work of the sociologist Verret (1975), proposed three steps for the didactic transposition: at the top are the scientific references, then transformed into the knowledge to teach and then to the taught knowledge. This schema is now completed in three ways (Clément 1998, 2006, figure 2):

- (1) There are more than 3 steps, the school textbooks being one of the steps;
- (2) The transposition is not linear: it involves retroactions at any level;
- (3) At each step, there is not only the scientific knowledge, but also values and social practices, as proposed by the KVP Model (figures 1 and 2).
- (4) The anthropological approach of Chevallard is against the analysis of conceptions. A contrario, we think useful to clarify conceptions (as KVP interactions) of the main actors of the didactic transposition, at each level of the transposition (figure 2).

# DIDACTIC TRANSPOSITION

# CONCEPTIONS of

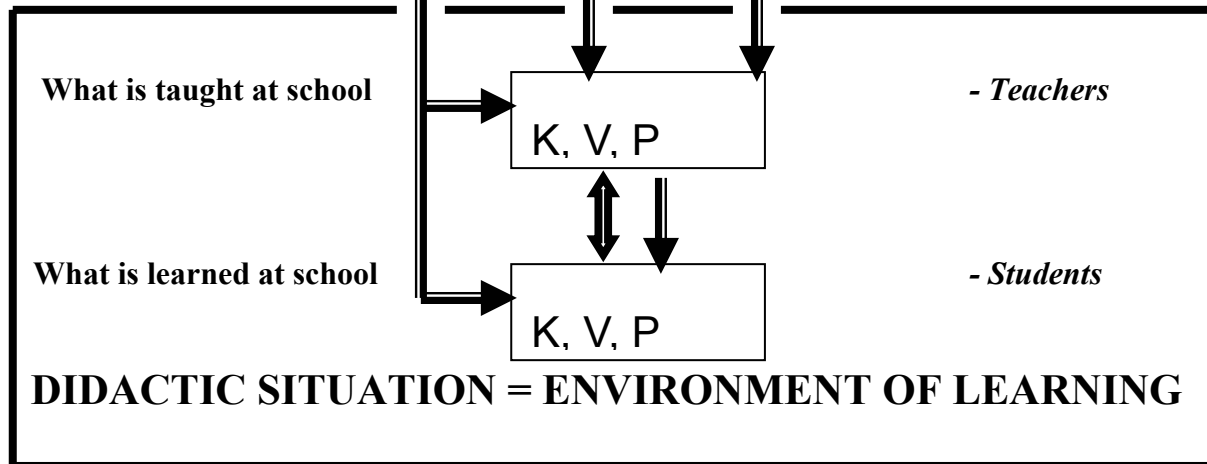
## REFERENCES

- Science publications
- Social practices
- Dominant values

Different levels of  
science popularisation

Curricula and syllabuses

School textbooks  
and other tools



- science researchers
- socio-economic groups
- leaders (politics, medias, religion, etc.)

- scientists, authors
- editors, actors of TV radio, media, ...

- main actors of the school  
system, Ministry of  
Education, ...

- Authors and editors of  
textbooks and other tools

- Teachers

- Students

**DIDACTIC SITUATION = ENVIRONMENT OF LEARNING**

*Figure 2 - A new schema of the didactic transposition, linked to the analysis of the conceptions of the main actors of the transposition (modified from Clément 2006).*

## B - CRITICAL ANALYSIS OF SYLLABUSES AND SCHOOL TEXTBOOKS IN 19 COUNTRIES - Examples of results

The challenge was to define, for the critical analysis of science school textbooks, a methodology which is specific to the didactics of science. Other approaches are possible, coming from linguistic,

semiotic, psychology, sociology, economy, politics, etc. The specificity of didactics of science is to be focused on the scientific content of a precise scientific domain. Each method will be also specific to this precise content through specific parts of the grids of analysis (some other parts of the grids being transversal to several topics).

A good way to analyse the KVP interactions is to compare the contents of different textbooks, with several possibilities:

- (1) Today, in one country, comparing the content of textbooks from different publishers (for the same topic, and the same level of teaching).
- (2) In the same country, comparing the same topic at different historical periods. It is varying with the evolution of the scientific knowledge, but introduced with a delay (that we called DTD = Didactic Transposition Delay: Quessada & Clément 2006) which is significant of the poles V and P.
- (3) Today, in different countries which are contrasted by their culture, their history, their geographical situation, their economical level. We develop this methodology in the European project of research Biohead-Citizen (Carvalho et al 2004, Clément et al 2005, Bernard et al 2006).

A first example can be evocated just to introduce the model KVP when it is applied to science school textbooks (Clément 2006b): in some old French science textbooks (published by Hachette in 1959), for the same age of student (11-12 years old), there is one book for boys and another for girls. Half of the scientific content (K) is different, with different scientific and technical contents. For example there are several chapters for mechanics and motors for boys but not for girls, and several chapters for the new cleaning methods for girls but not for boys. This choice was linked to rural social practices (P) at this period and is judged today as sexist (V), illustrating clear KVP interactions in the content of these science textbooks.

Let us just list now some examples of results coming from our collective work to analyse textbooks for the precise six topics of the BIOHEAD-CITIZEN project, in the 19 concerned countries.

We started to publish our first results related to the chosen six topics where the interactions between the three poles K, V and P are maximal, and linked to citizenship challenges:

- (1) Environmental Education and Ecology: Caravita et al 2007.
- (2) Health Education: Carvalho et al 2007.
- (3) Human Reproduction and Sexuality: Bernard et al 2007.
- (4) Evolution and Human Origins: Quessada et al 2007a.
- (5) Human Genetics: Castéra et al 2007.
- (6) Human Brain and cerebral epigenesis: Clément et al 2007.

For each of these topics, we have collectively created, tested and then used specific grids (each grid is specific to each topic and is more than 10 pages), each one focused on the specific contents and values linked to the precise topic.

We will briefly take some examples of questions used in these grids for two topics:

***The human central nervous system.*** We compared 55 textbooks coming from 15 countries (Clément et al 2006, 2007), showing for example that the images of neuronal pathways are mainly limited to reflexes in most of the countries, as behaviourist illustrations: Stimulus (S) → Response (R). Between S and R, the spinal chord is more often present than the brain. These pathways are linear: only 19% of them show feedbacks (mainly the neuro-hormonal regulation of the reproduction). The gamma innervation, which is involved in any human movement, is (briefly) present only in 3 countries (Romania, Lebanon and Tunisia). In most of the countries, the brain is giving orders but is not structured by the human behaviour: the cerebral epigenesis is generally not present in the textbooks, and the paragraphs related to the cerebral supports of learning, language, etc. are very short or absent. Behind this choice of the scientific contents to be taught (K) are some values (V): dualism (with the division between brain and body as a continuation of the division between soul and body), behaviourism, innate ideas, lack of constructivism. Nevertheless, in some

countries as in France, the cerebral basis of learning and constructivism started to be present in the last syllabuses and textbooks (mainly for the non scientific students). This difference between the scientific contents to be taught to scientific or literacy students, is an example of the influence of social practices (P), suspected to be different for the future job and life of scientific or literacy students.

**The human evolution.** The image of *Homo sapiens* at the top of line (or tree or bush) of evolution is quasi-always a white man (not a woman), often nude (figure 3).

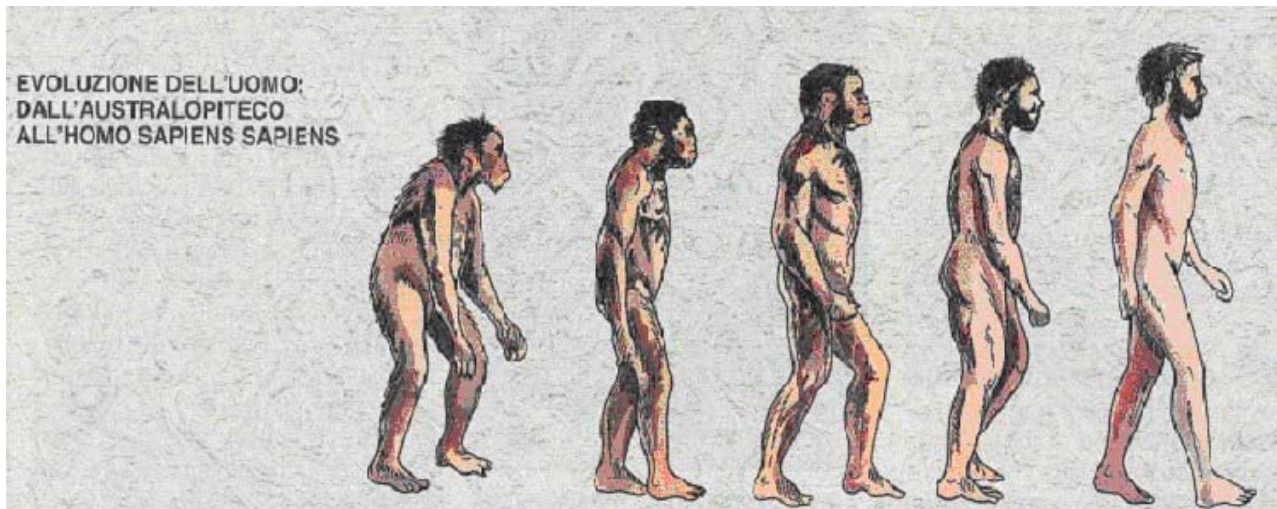


Figure 3 - "Evolution of the humankind: from the Australopithecus to Homo sapiens sapiens". (From an Italian school textbook: Il Capitello, senior high school, 2001, p.277)

Quessada et al (2007a) found only 3 images, in the textbooks from 15 countries, with also a woman near a man, but never a woman alone. We found only one image (in Germany) with 3 human beings from several continents and colour of skin (one female and two males). In all the other textbooks, even in Senegal, the top of the evolution is an occidental white male: an interesting illustration of the possible results coming from the KVP model. This kind of images is coming from the (western) scientific publications or from the occidental popularisation of science.

## C - CONSTRUCTION AND VALIDATION OF THE QUESTIONNAIRE

To construct a questionnaire, to test it and to validate the questions, are not easy steps. The complexity is greater when the same questionnaire is to be applied in different countries. We shortly present here the difficulties to do it, through the methodology collectively decided and then applied in the European project of research BIOHEAD-CITIZEN.

### **The first step: a clear definition of the research goals and of the theoretical background.**

The goal is to analyse the conceptions of teachers on topics related to biology, health and environment, and to the difficulties to teach them. We first had to reduce the field to six more precise topics: (1) Environmental Education and Ecology, (2) Health Education, (3) Human reproduction and sexuality, (4) Evolution, mainly human origins, (5) Human genetics, (6) Human brain and its epigenesis.

The theoretical background is the KVP Model (see above).

We also decided to work on contrasted countries, with precise hypotheses for their choice: 6 countries outside Europe (Muslim or not, Arabic or not) to evaluate a possible homogeneity of conceptions inside the different European countries, and 13 European countries to identify possible differences between more or less developed ones, Northern or Southern European countries, Eastern and Western Europe, catholic, protestant, orthodox traditions, etc.

All this was done before the official starting of the project (in October 2004, except the selection of the 6 more precise topics, done collectively during the 6 first months).

### **The second step: gathering questions related to our goals.**

The 3 fields (biology, health and environmental education) had already been worked by the 3 coordinators of the project and their teams. For instance, Environmental Education in Germany and in France (with a comparison between France, Germany and Portugal); Health education and sexual education is the speciality of Carvalho; and the other topics more linked to biology were worked by Clément and his team since more than 10 years (with several theses and other works, in particular done with non European countries to-day associated in the Biohead-Citizen project). All these works used questionnaires, and we selected the questions most related to our project. We also used some questions coming from other works of research, and some new ones decided collectively during the 6 first months of the project implementation (e.g. questions on Environment coming from Italy and Estonia).

From this collective work, emerged our first questionnaire divided in 5 parts: T (transversal, with 84 questions dealing with biology, health and environment), E (environment: 38 questions), H (health: 35 questions), B (biology: 26 questions) and P (19 personal questions: gender, age, matter, diploma, religion, political position). Each question was discussed collectively to be sure that it was meaningful (and in the same way) throughout the 19 countries of the project. This was a difficult but exciting issue due to the countries cultural diversity.

### **The third step: questionnaire translation, and validation of the translations.**

Two alternative methods were used: (a) two parallel independent translations in the national language from the original English, then comparison by a third person; (b) back-translation where the national version is translated back to English by an independent person and compared to the original English version. For the 4 Arabic countries, a more specific translation procedure was carried out. At the end there were three Questionnaires of reference: in English, in French and in Literary Arabic.

### **Interviews to identify difficulties related to some questions.**

Each team had to interview some persons after they had filled the questionnaire, to identify the most problematic questions, and to suppress or to change them in the final questionnaire. The problems came sometimes from the translation, and sometimes from the questions themselves.

### **Analyse the reliability of each question**

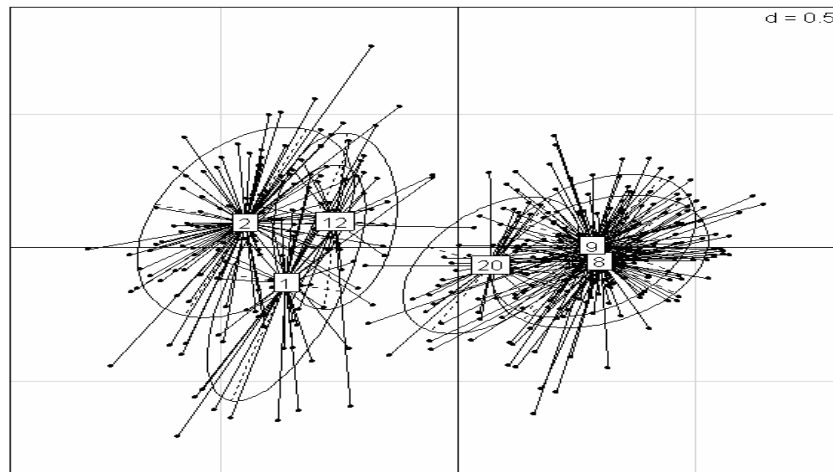
In 4 countries, the same questionnaire was proposed twice to the same students, with more than one month between the two tests. The questions with a low rate of reliability had then been suppressed. It was the case of all the open questions, and some closed questions.

### **Using a pilot test to choose the most discriminating questions, and the most pertinent ways to analyse data.**

We did it with limited samples of students / pre-service teachers from 13 countries. The personal questions (P) were filled in all the countries, but were not used for the MCA (Multiple Components Analysis). They are only used to interpret the results of the MCA.

*(1) The pilot test in six countries*, all the questionnaires were submitted: T, E, H, B, P. The total sample for this pilot test was 411 students: Portugal (42), France (100), Hungary (24), Lebanon

(113), Tunisia (108), Senegal (24). The results of the MCA can be drawn to differentiate the 6 countries (figure 4)



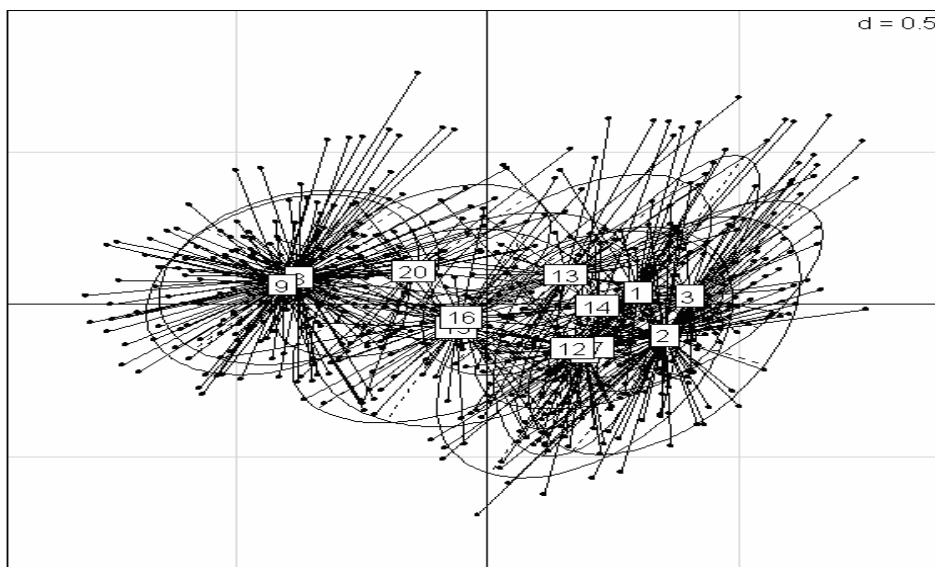
**Figure 4: Representations of MCA individuals, grouped by country (plane F1-F2).**  
 1:Portugal; 2:France; 8:Lebanon; 9:Tunisia; 12:Hungaria; 20:Senegal.

Each point in figure 4 corresponds to a student, each ellipse is surrounding 2/3 of the students from the same country (identified by a number in the centre of the ellipse). The horizontal axis F1 is the most important one. Its meaning is given by the place, along it, of the modalities of answers to several questions (not drawn in the figure 4):

- Evolutionist answers are at F1 left side and creationist answers at F1 right side.
- Higher sexual freedom are at F1 left side, and their opposite at F1 right side.
- At F1 left side there is more reaction to protect the Environment than at right side.

Then, the strong opposition in the conceptions of European and non-European pre-service teachers can be linked to some of the controlled personal variables, which the most important ones are the belief in God (very important at right of the F1 axis; nearly all the atheist and agnostic are located at left). Muslims are mostly at right whereas Christians are located all along the F1 axis.

**(2) The pilot test in 13 countries**, from only questionnaires T, E and P. The total sample for this pilot test is 654 students: the precedent sample (figure 4) added by Germany (49), Italy (40), Estonia (21), Lithuania (44), Malta (17), Poland (32) and Romania (40) samples. The results differentiating these 13 countries can be seen on figure 5.





**Figure 5: Representations of MCA individuals, grouped by country (F1-F2). 1:Portugal; 2:France; 3:Germany; 5:Italy; 7:Estonia; 8:Lebanon; 9:Tunisie; 12:Hungaria; 13:Lithuania; 14:Malta; 15:Poland; 16:Romania; 20:Senegal.**  
*Italy (5) is underneath Hungary (12) with also Estonia (7); Poland (15) under Romania (16).*

The results of this MCA are quite similar to the precedent one (with just the inversion of the F1 axis: that was at left is here at right and reciprocally). The meaning of the axis F1 is the same : the evolutionist answers are at F1 right side and creationist answers at F1 left side; higher sexual freedom are at F1 right side, and their opposite at F1 left side.

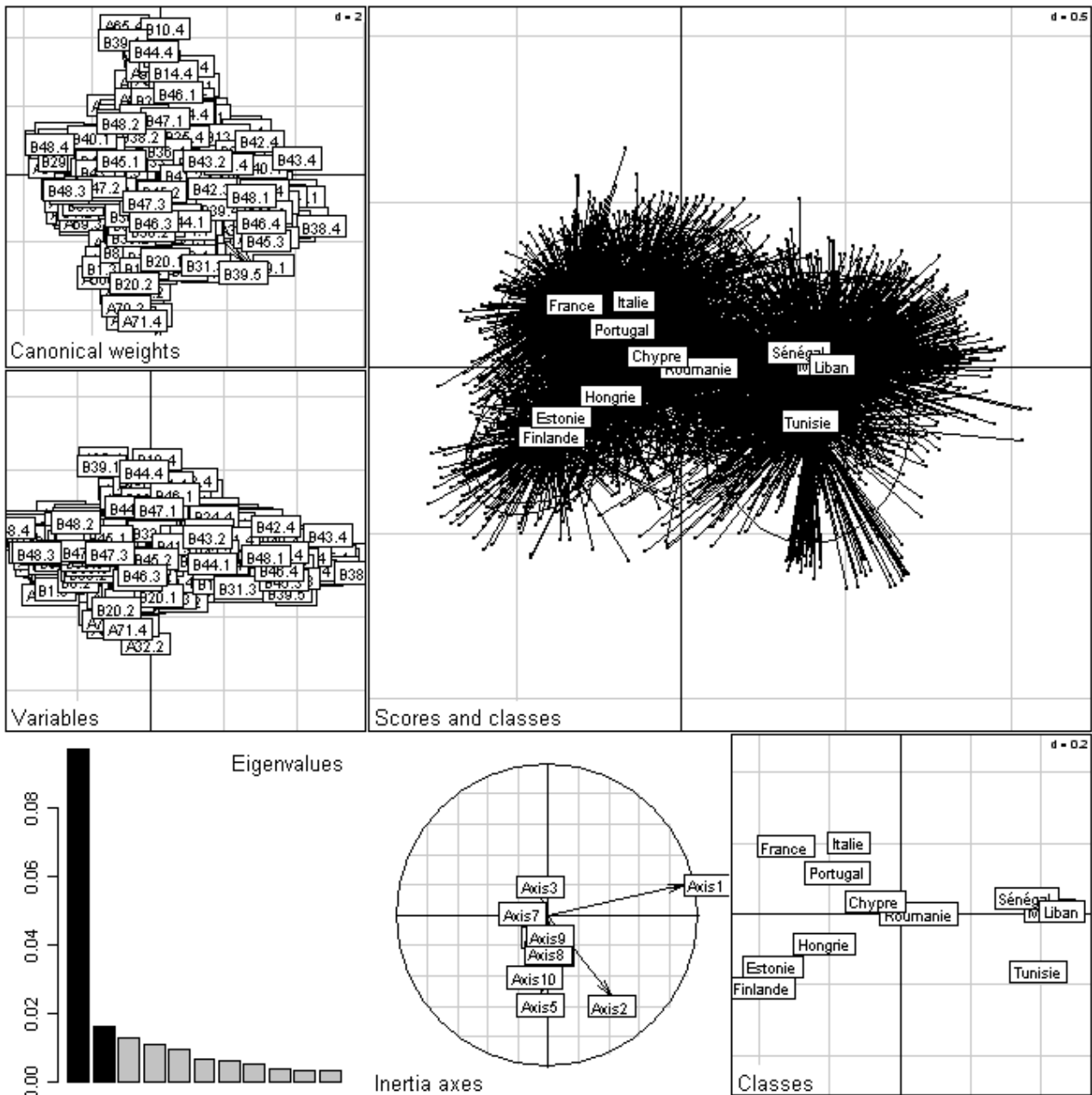
The new information is the position of some countries (Poland and Romania) in the middle between the European countries (at right) and the non European ones (at left).

### **Consequences on the construction of the final questionnaire.**

The final questionnaire was reduced to half length of the original questionnaire used for the pilot tests. We suppressed all the questions where everybody answered more or less in the same way in the pilot tests (this information is acquired from the pilot test: no need to test it again with the final questionnaire). We also suppressed all the non reliable questions (including all the open questions which were very difficult to analyse in the same way due to the great number of different languages. We maintained the questions that were discriminating and meaningful (in relation to our precise hypotheses) in the multivariate analyses (MCA: figure 1 & 2, but also PCA and other analyses not shown here). We also defined six precise samples: three of in-service and three pre-service teachers; primary schools and secondary schools (Biology and national language) and finally we chose the precise contexts and ways to apply the questionnaires: the same procedure in each country, with a total guaranty of being anonymous.

## **D - SOME RESULTS COMING FROM THE ANSWERS TO THE FINAL QUESTIONNAIRE**

When working from the 12 countries that used all the questionnaires (5189 filled questionnaires), we find results more complete and precise than those discussed above from less important samples (figures 4 & 5). The figure 6 is illustrating a between analysis done to differentiate the 12 countries (5189 persons) which filled all the questionnaires. The main differences of conceptions are linked to the horizontal axis F1, with an opposition along this axis between the non European countries (Lebanon, Morocco, Tunisia, Senegal) at right, and at left the European countries as France, Estonia and Finland, then Italia, Portugal and Hungary, with Cyprus and Romania in the middle between these European countries and the non European countries. The axis F1 is defined by the answers to questions related to several topics, mainly Evolution and Sex Education.

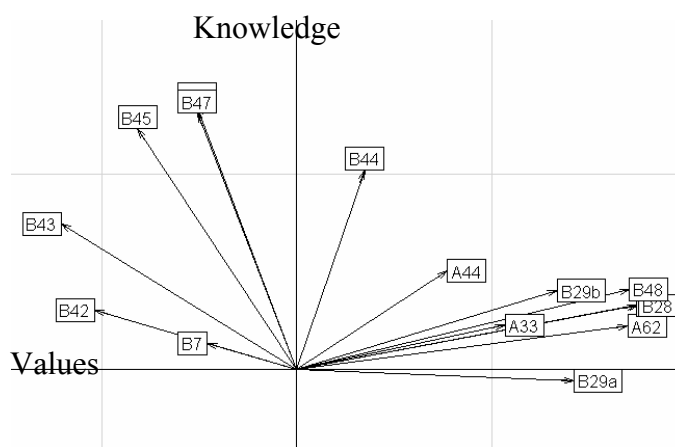


**Figure 6 - PCA between analysis to differentiate the countries (5189 pre-service and in-service teachers from 12 countries):** 5189 points on the graph above right, linked to the centre of gravity of their respective country; each ellipse surrounding 2/3 of the persons of each country). It is a between analysis to differentiate the different countries. The horizontal axis F1 is the most important (see the histogram): its signification is given by the location of each variable (question: see the two graphs at left: impossible to read, but we have the tables !)

To better describe our results, let us take an example: the conceptions related to Evolution. These conceptions are emerging from the answers to 15 questions. If we do a PCA from only these 15 questions, and still the 5189 responders in 12 countries (figures 7 and 8), we observe that their answers differ in respect with two orthogonal axes (figure 7): the main one is related to values, with the questions on creationism vs evolutionism and on finalism in Evolution (at right of the horizontal axis 1, figures 7 and 8, are the creationist and finalist answers, and at left the evolutionist ones; the second axis, vertical, is dealing with questions related to knowledge (questions on the importance of environment - B45 -, transposons - B46 - and virus - B47 - in Evolution of species. The figure 7 is also showing that some questions are in the same time related to knowledge and to values: B44 on

intelligent design is linked to the vertical axis and to the creationist part of the horizontal axis; the answers related to the function of chance (B42) and of natural selection (B43) are partly linked to the vertical axis (knowledge) but mainly to the evolutionist part of the horizontal axis (Figure 7).

**Figure 7:** PCA from the 15 questions dealing with Evolution. The questions defining the axis 1 (horizontal) are related with values (see the text), and those defining the axis 2 (vertical) are related to knowledge (see the text; the number B47 is hiding the number B46).

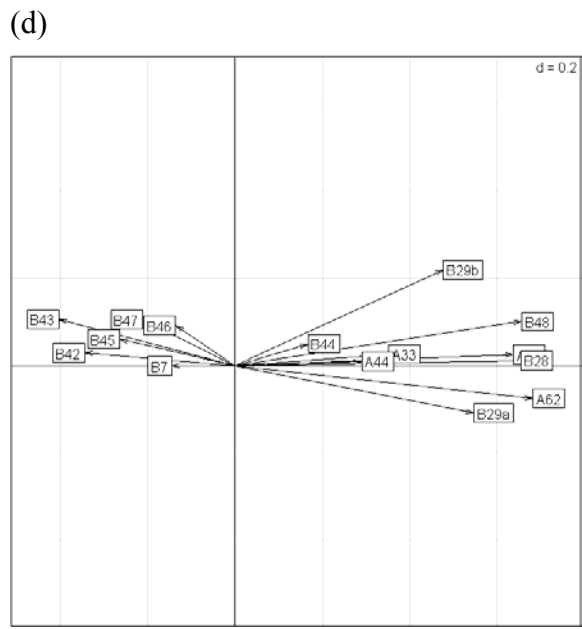
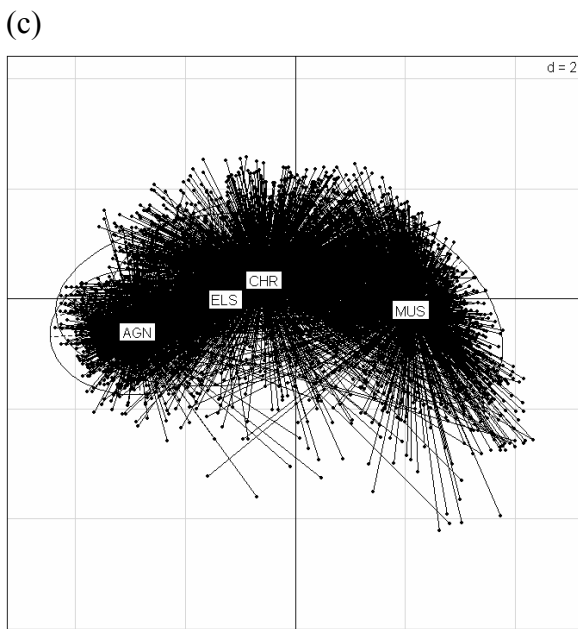
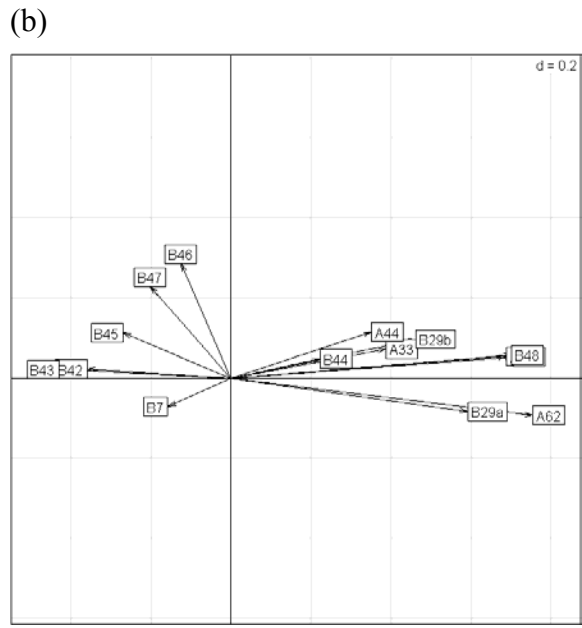
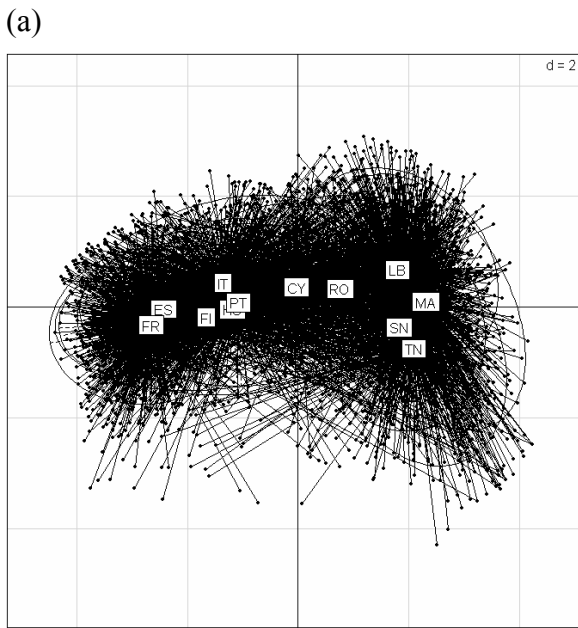


If we do a between PCA to differentiate no more the 5189 persons (as in figure 7) but groups of persons, as countries (figure 8 a & b) or religions (figure 8 c & d), we can add some interesting observations:

- From the initial PCA, the personal conceptions differ from values (axis 1) and from knowledge (axis 2: questions B45, B46, B47, and partly B44 and B43). This variation, due to knowledge mainly, differentiates the biologists from the other (future) teachers.
- The PCA between countries shows (figure 8 a & b) the same two axes, horizontal for the values (still here with the strong opposition between the creationist positions and the evolutionist ones), and vertical for the knowledge (mainly the questions B46 and B47, partly B45: figure 8c). These differences characterize here the countries (with the same amount of biologists and no-biologists in each country).
- The PCA between religions shows (figure 8 c & d) the same horizontal axis, for the values and also including all the questions related to knowledge. There is no more a vertical axis for the answers related to the knowledge.

In conclusion, the differences among religions are only dealing with values, whereas the differences among countries are dealing with values and knowledge. There is a very strong correlation between the values which differentiate the countries and the religions (figure 8e). There is also an interaction between values and knowledge related to teachers' conceptions on some topics (as the role of chance, natural selection, and intelligent design in the evolution of species: figure 7). Nevertheless, the independence of some knowledge from the values, differentiating teachers among themselves (figure 7) as well as groups of teachers by countries (figure 8a & 8b) show a possible acquisition of knowledge related to evolution independently from religions.

We have presented and discussed these results with more details in Munoz et al (2007) and we go further in another work (Quessada et al 2007) showing that, even independently to the countries (after an orthogonal PCAVi suppressing the effect of the countries, strongly linked to the effect of religions), the values are related to the level of instruction of in-service teachers: the higher is their level of training the more evolutionist they are.



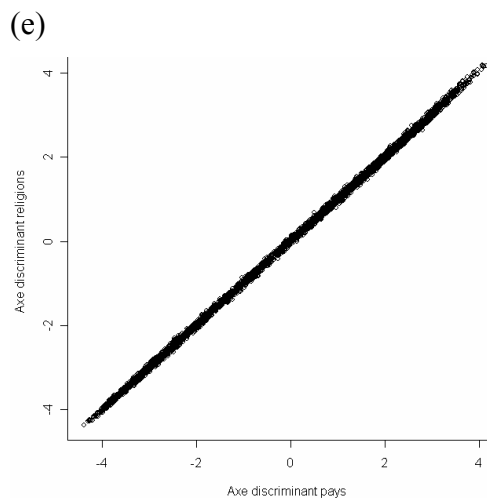
**Figure 8 - (a)** PCA between countries: TN = Tunisia, SN = Senegal, MA = Morocco, LB = Lebanon, RO = Romania, CY = Cyprus, HU = Hungary (hidden by PT), PT = Portugal, IT = Italy, FI = Finland, ES = Estonia, FR = France.

**(b)** PCA between countries: questions which define the axes 1 (values) and 2 (knowledge)

**(c)** PCA between religions: MUS = Muslims, CHR = Christian, AGN = Agnostic, ELS = other (mainly no answer)

**(d)** PCA between religions: questions which define the axes 1 (values) and 2.

**(e)** Very significant correlation between the axes 1 of the figures a and c.



The 2 PCA from 15 questions and 5189 persons

**In conclusion**, our results show an interaction between knowledge and values, herein from the example of conceptions related to evolution, and suggest that when the knowledge increases, the values also can change to be more evolutionist. In other communications in this meeting, we present the same type of results for Health Education (Carvalho et al 2007b) and for Sex Education (Berger et al 2007).

### Technical support

These statistical analyses have been done by François Munoz with the Environment R (version 2.2.0 and later, <http://www.r-project.org/index.html>), with the basic R packages and the complementary package ADE4 (Analysis of Environmental Data : Exploratory and Euclidean methods in Environmental sciences, <http://pbil.univ-lyon1.fr/ADE-4/>) (Munoz & Clément 2007).

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