Science in school and the future of Scientific Culture in Europe

The swiss report

30.10.94

André Giordan
Hervé Platteaux
LDES Université de Genève

Scientific education was progressively introduced in Switzerland during the 19th century. Today it is given at all levels of schooling, more often than not in a disciplinary form[1]. It is at first taught together with history and geography under the heading of "environmental studies" which is more of a study of local surroundings rather than a real education in environmental sciences.

Yet it is difficult to give a comprehensive view of scientific education in Switzerland, the country being a federation of 23 states, called "cantons". These benefit from great deal of independance in the setting of policy. Each canton is administrated by local government under the legislative authority of a directly elected parlement. Specific scientific programmes are therefore locally determined and discussed. Such autonomy and independance is deeply rooted in the make up of the country and considerable differences and discrepancies may be found in the application of the curriculum from one establisment to another.

Futhermore, Switzerland is made up of four distinct linguistic areas and recently a cultural divide has appeared between the french speaking and german speaking parts of the country[2]. A further important divide is now apparent between urban and rural areas.

[1] We will concentrate in this text on a study of primary and secondary education in science in the general curriculum.

[2] Romanche and italian speaking populations are smaller and can be linked to one or the other.

In the same time profound changes are taking place in the country. The actual state of the economy, the crisis and the unemployment are forcing as reassment of well established ideas in the field of education. The idea of efficiency within the educative system is now an important issue. For the past ten years, teachers, individually or within the framework of professionnal organisations, especially in the french and italian' speaking cantons, have been questionning traditional education and attempting to develop new practices with the help of our laboratory[3] .

1. SWISS SCHOOL CONTEXT

In Switzerland fundamental education is primarily provided by canton administratred schools, generally public. Such tuition leads, after 14 years of schooling, to a diploma called "maturité" equivalent to the french "baccalauréat" or the german "Abitur". Under 20% of each age classe reaches this stage, while schooling is only compulsary until 16.

Generally speaking, the swiss school system is divided into different levels which have some differences depending on the canton and also on the curriculum direction (see Annex 1):

- Prescolar school:
  - before 6 years old
- Obligatory school:
  - Primary school: from 6/7 years old to 9/10 (or 11/12) years old
  - Secondary school (level 1): from 10/11 (or 12/13) years old to 14/15 years old (secondary school level 1 is also called Òcycle dÕorientationÓ)
- Post-Obligatory school:
  - Secondary school (level 2): from 15/16 years old to 17/18 (or 19/20) years old
  - there are two main directions:
    - general formation which is called ÒcollegeÓ
    - professionnal formation
- Superior school (usually called 3rd level):
  - University and ÒHautes EcolesÓ
  - ÒEcoles NormalesÓ (preparation for secondary school future teachers)
  - Superior Technical School and Superior Specialised School

In 1982/83, the total number of pupils in the swiss scholar system were:

- at the obligatory level: 797 700 (408 600 masc. and 389 100 fem.)
- at the post-obligatory level: 314 500 (179 000 masc. and 135 500 fem.)

---

[3] LDES (Laboratory of Didactics and Epistemology of Sciences), created in 1980 at the Geneva University, has a vocation to question scientific education and to promote at the school level new teaching methods and training tools based on its work on the learning process.

- at the superior school: 90 500 (61 300 masc. and 29 200 fem.)

And during the same year, in the superior schools, according to the curriculum direction, the ratio of students was:

- in human and social sciences: 56.8 %
- in exact and natural sciences: 16.3 %
- in medicine and pharmacy: 16.2 %
- in technical sciences: 10.7 %

Annex 2 gives the number of students at Geneva university according to the curriculum directions (state of the art at 31.12.93).

Regulations are now in the process of being changed, standards in scientific education will theoratically be lowered. The scientific community as well as industry are protesting but it seems in vain. We may add that the academic community in Switzerland has never been very active in matters of scientific education policy (whether it be formal or unformal). Only a few non professionnal, traditional societies have been promoting leasure scientific activities (mainly in the field of natural sciences). Education remains essentially in the hands of teacher associations in primary school and professional bodies organized around each discipline at the secondary level.

Annex 3 gives the total number of students (state of the art at 31.12.93) at the secondary school (levels 1 and 2, non vocational formation only) in the Geneva canton. It details the ratio of students in the different main possible curriculum directions:

- ÒclassiqueÓ means latin and greec as a main option
- ÒlatineÓ means latin and one foreign language as a main option
- ÒscientifiqueÓ means experimental sciences and mathematics as a main option
- ÒmoderneÓ means foreign languages as main option
- Ògénéral et pratiqueÓ means level 1 preparation for professional formation at level 2

Vocational training is well developed: more than the three quarters of the students, at the post-obligatory school (level 2), are following a vocational formation (see Annex 4).

A "professional maturité" is being created in which science and technology will have a great part. Likewise some well established "popular universities" provide a number of science and technology classes. Yet these institutions do not hand out official diplomas.

There is practically no programme or policy for the public promotion of science in Switzerland[4]. Even though questions of science, technology or even medecine are often raised by lobbies

[4] There is a Federal Office for Education and Sciences (OFES). Yet ist role remains limited at the internal level as cantons are so jealous of their prerogatives.

(environmental, feminist, or concerned with animal rights) during public "votations" (referendums). A few television programmes, some newspapers articles or campains of information on the presentation of AIDS, drug abuse or even contraception, sponsored by the medical fields, do have some scientific content. In the same time, the nuclear, the chemical and the food industries do try even though discretally to promote new technologies threw the medium of brochures, educative material, exhibitions or even by sponsorship of public campains.

2. CHARACTERISTICS OF SCIENCE EDUCATION IN SWITZERLAND

As we have schown earlier, what characterises mostly scientific education in Switzerland is the great autonomy given to schools, or even teachers, on an individual basis (Annex 5). A few dominant trends stand out nonetheless where discipline', schedules, course contents and teaching methods are concerned.

Annex 6 gives a general text definition for the curriculum content for the college students. This text was made 1992 by the swiss federal conference of the public instruction canton directors.

2.1. Discipline and schedules

Generally scientific education remains rather traditionnal. Pratically from the middle of primary education onwards, it is offered under 3 separate headings: physics, chemistry and biology. Extracted from the 1992 swiss federal conference of the public instruction canton directors, the main objectives for physics are aimed at developing the understanding of natural phenomena and of technical realisations. It should lead pupils to explore the multiple mecanisms of the universe at the atomic, human and astronomical scales and to understand the role of the experimental methods and of the theorical representations.

The main objectives for chemistry are aimed at awaking the pupil interests for his/her every day environment. Chemistry should also give the means for knowing the structure, the properties and the transformations of living and non living matter while beeing based on experiment and on reasoning using atomic models so that the interpretations of observable properties can be made from representations of molecules and atoms.

The main objectives for biology are to acquire a better consciousness of nature. It should stimulate the curiosity and the enjoying for the discovery with the contact of plants and animals. While using both an experimental approach and an historical vision, it should permit to reach a better understanding of life.
When these disciplines are taught by the same teacher, he becomes in turn specialist in each branch. As an exemple, at the level 2 of secondary education, timetables vary greatly, depending on the chosen disciplines, years of attendance and even chosen majors.

In scientific options it is usually as follows:

in physics: 1st year	2nd year	3rd year	4th year	
Weekly time allocation in				
compulsary classes	2 Hrs	2+1(lab)	-	-
normal option	2 Hrs	2 Hrs	2 Hrs	3 Hrs
major option[5]	-	-	3+1 (lab)	3+1 (lab)

in chemistry:	1st year	2nd year	3rd year	4th year
Weekly time allocation in				
compulsary classes	1 to 3 Hrs	3 Hrs	3 Hrs	-
normal option	1 to 3 Hrs	2 Hrs	2 Hrs	-
major option	1 to 3 Hrs	2 Hrs	2 Hrs	4 Hrs

in biology: 1st year	2nd year	3rd year	4th year	
Weekly time allocation in				
compulsary classes	-	-	2 Hrs	2 Hrs
normal option	-	-	2 Hrs	2 Hrs
major option	-	2 Hrs	4 Hrs	3 Hrs

At the level 1 of secondary school, hours of tuition may vary from 2 to 5 hours weekly depending on cantons[6], years of attendance or chosen majors, often divided between the three disciplines taught. Some courses under the heading of "sciences" are offered to students, but are in fact rarely integrated in programmes. On the other hand there are some scientific observation courses, based on the apprenticeship of experimental and observation medhods. Equally initiation to the history of sciences may be proposed.

At the primary school level, at least according to programmes, hours of scientific tuition also vary from 2 to 5 hours depending on cantons. In most cases science is pratically not taught at all[7] as teachers do not always feel comfortable with these disciplines.

2.2. Content

In official texts is is noted that scientific education must facilitate the learning of other scientific disciplines, the understanding of main natural phenomena, simple technical applications as well as

---

[5] Pupils now have the possibility to receive reinforced tuition.

[6] Depending on cantons, primary education can range as far as the end of compulsary schooling.

[7] Some rare teachers can teach up to 8 or 10 hours of scientific practice.

the capacity to follow scientific evolution (as presented in the media for exemple). Yet in reality, tuition aims merely at providing information most often to do with the history and the working of each discipline.

For instance, at level 2 in secondary education, in physics, the following programmes are studied.

In the first year:

1. <u>Matter and energy:</u>

Physical ÒGrandeursÓ (definition, geometrical charateristics, MKSA unit system) - Position and notion (position and reference systems, time, velocity, uniform linear motion, acceleration, uniformely accelerated notions) - Masses and forces (the quantity of matter, inertias, force, weight, force momentum) - Work and energy (work, energy, energy conservation, power, performance)

2. <u>Matter and structure:</u>

States of matter (discontinuity, atomes, molecules, energy and matter, specificities in states of matter, calorific energy, state changes energy) - Force and matter (notions of tension and pressure, tension effects, tension and pressure measurements, properties and structure, pressure, the Boyle and Maryotte law, absolute temperature, state equation, cinetic theory, real gas) - Liquids (structure and properties, pressure, Archimedes law, cohesion of liquids, flow of fluids, liquid cristals, atmospheric pressure) - Solids (the crystal, amorphous solids, symetries, cristalline'solids, mechanic and thermic propecties)

In the second year:

1. <u>Electricity:</u>

General notions (charge, current, voltage, power, resistance, electrical current, resistance equivalence) - Mechanisms of conduction (in vaccuum, solids, liquids and gas) - Conductors and semi-conductors - T.V. vacuum tube - Elements of lab electronics.

2. <u>Light properties:</u>

The nature of light - Spectrum - Different sources (black body ray spectrum emission, laser). Receptors (the eye, photosensitive cells, colors). Diffraction and interference phenomena - Optical devices (flat and spherical mirrors, lenses, prismes, usual devices).

3.<u>Waves:</u>

Different types of waves - Waves characteristics - Propagation laws - The interference theory - Diffraction, reflection, refraction (stationnary waves, pulses, resonance) - Wave construction laws, reflection, refraction (stationnary, waves, pulses, resonance).

4. <u>Sound:</u>

Nature (intensity, pitch, timbre) - Sources - Musical instruments - Audition.

5. <u>Other possibilities:</u>

Water in nature - Radioactivity - Stars - CERN - etc...

In the 3rd year (normal option).

1. Electricity:

Electricity and matter - Current - Voltage - Characteristics and resistances - Electrical circuits - Kirchhoff laws - Mechanisms of conduction - Conduction in vacuum, gas and liquids. Band models for conduction in solids. Conductors, insulators, semi-conductors, superconductors - Applications.

2. Light:

The nature of light - Different light sources - Ray and continous spectrum - Black body laws - Receptors (photoelectrical effects, the color of things). Propagation speed of light - Laws of light propagation (Fermat, Malus, Huygens). Polarisation - Interference - Diffraction - Diffusion - Optical systems - Reflection (place and spherical mirrors) - Refraction (lenses) - Optical devices (microscope, telescope, photographic camera, etc.)

According to which options are chosen, the following may be further developped.

1. Astrophysics:

Astronomical instruments - Basic notions in astronomy (distances, magnitudes, H.R. diagramm - Stellar evolution - Celestial objects - Cosmography and the Universe - Structure of the Universe and elementary cosmology.

2. Basis in mechanics:

Interaction and matter - Principle of inertia conservation laws (impulse, energy) - Simple interaction applications (elastic or soft collisions in 1 or 2 dimensions) - Propulsion (reaction in fluid environments, rockets) - Study of selected notions (Newton's equation application and fundamental principles to homogenous gravitation fields or to the accelerated referential, to the uniformely rotating referential (solid body rotation), to the harmonic notion (oscillation problems)) - Trajectories (movements at the surface of the earth, central force trajectories (planetary motion)) - Application to the gravitationnal field of celestral bodies.

3. Electromagnetism:

The electrical interaction defined electrical field - The influence and the relationship between the field and its sources - Energy and the electrical filed, applications - The magnetic field as a relativistic effect, spectrum - Induction and its formulation (applications to different devices) - Magnetism and matter (actions of the magnetic field and energy, applications: oscillating circuits and industrial machinary) - Fields (non stationnary fields: Maxwell's equation, electromagnetic waves) - The space-time notion (its relativity, metric aspects: Lorenz transformation, its limits: Gables's transformation and motion additions) - Interactions and inertia. Energy and impulse (high and low energy interactions: different collisions, interaction forces and non inertial notion: specifically circular) - Gravific notion (planetary) - Application to classic notion (accelerated uniform motion, circular uniform motion, harmonic oscillation and rational motion of solids)

4. Fields theory:

Development of common aspects to all fields encountered in physics - Links between examples used to introduce vectorial representations and its operations - Representation of connections between scolar and vectorial fields and distinction of tonic-space properties in different types of fields - flux and circulation in differential and integral form - Limits of classical physics - A new description (quanta, elements of quantic mechanics: conceptions and representations, simple interaction mechanisms, some simple systems) - Heisenberg's inequalities - Symetry and laws of conservation.

2.3. Teaching methods and resources

The philosophy of the public school system is based on the wish "to give every pupil the means to acquire the best knowledges in the perspective of his/her future activities while also to give rise to pupils the permanent desire of knowing" (extracted from a brochure called ÒCycle dÕorientation de lÕenseignement secondaire, Genève 1994Ó). Extra-school activities which can bring good inputs into the pupil education (theater, museums, botanical garden, etc...) are also well enhanced.

Different other annexed documents improve the idea we can have on the available resources for the public school system:

- Annex 7 generally describes the teacher profiles (age and sexe) for the Geneva canton for the year 1993-94.
- Annex 8 gives the total money amount spent out for the different swiss cantons for the public obligatory school system (1983 state of the art)

It is really interesting to also have a look on the different possibles courses a teacher can register for training. Annex 9 gives the list of the courses proposed, for the year 1990-91, by the Swiss Centre for the Improvement of the secondary school teachers (called CPS). We want to emphasize on two main remarks:

- the CPS course topics are really linked with the scientific and technological actuality,
- the people teaching these courses are real specialists of the field

Where the spirit of teaching sciences is concerned, the aim is not just to provide students with steer knowledge but also to form the mind in a way which may also be beneficial in other topics. The ability of understanding and of reflection should develop (necessity to go beyond sheer application of formulae) as proposed by preliminary statement in programmes.

Unfortunately, teaching methods ar more often than not frontal and dogmatic, consisting primarely in documented presentations where the course is concerned and supervised activities (i.e.: a series of manipulations following a preestablished protocal), where practical experimentation is concerned.

In a growing number of schools, efforts are being made to illustrate the course by presenting fundamental facts under the form of experiments. Likewise audio-visual means (i.e.: slides, video,

films) or computers (i.e.: computer assisted tuition or computerised labo activities), facilitate the step between a fact and its illustration, that is to say, the stop between the elaboration of a model and the verification of its implications.
Qualitative evaluations show that such teaching methods do not achieve expected results. Their impact remains low if not totally nul. Concepts are forgotten after a few months or even a few weeks. Furthermore, a number of mistakes reccur as pupils have a foaffling ability to reproduce without understanding even after successive classes on the same topic (see Annex 10).

At the end of secondary schooling, future higher education students show great difficulties in clarifying situations or in dealing with multiple causes to a given problem. They often only reason in the short term using rudimentary logic, as taught in mathematics (Encyclopedic knowledge being the norm) and confused with details they are unable to discriminate between the essential and the accessory, to be critical, to work in groups, to show any experimental method or even to take decisions. For instance they are often confused by different levels in the structure of matter and cannot differentiate between quarks, atoms, molecules, cells, individual specimens and ecosystems.

What is more, such tuition creates boredom and disinterest in a majority of students. Scientific inquisitwiness decreases throughout schooling while the interest in the occult and the irrational increases within Swiss society (astrology, numerology, etc.).

3. NEW TRENDS IN SWISS SCIENTIFIC EDUCATION

The picture is nonetheless not totally bleak in the field of scientific education in Switzerland, far from it. For now well over 10 years, teams of teachers and education professionnals have been taking into account these inefficiencies and are now turning towards new directions.

Relging on the direct help LDES or just using some of our work, such innovations focus on the taught contents of courses as well as methods of teaching. Some of these new trends are in the process of becoming widespread in cantons (programm reform commissions, early education or training) or even within the new school cuurriculum plan which leads to the new "maturité fédérale" diploma.

3.1. Innovations in programme contents

Still widely diciplinary, these innovations are opening towards more transverse approaches. Among some of the more accomplished, we shall now describe a few recent characteristics, taking into account the specificities of each discipline.

New trends in the teaching of biology primarily aim at a more responsable behavior faced with nature and the environment. They are designed to allow the student to take an uniformed stand in regard of fundamental problems such as sexuality, illness, diet, aguig, and death as well as in relation to great challenges of our time: questions of ethics, animal experimentation, biotechnologies and genetic manipulations.

Other contributions focus on the importance of biology in the personnal research of a meaning to life under are hand and health and environmental education on the other hand. A clear view of systemic interactions precedes the formulation of decisice questions, the estimation of risk factors and the discussion of alternative solutions.

The emphasis is they primarely put on the understanding of major principles in nature rather than on the knowledge of hindering details:
- functions in the living such as metabolims, procreation, growth development, behavior, information processing, memory processes;
- molecular and cellular structures;
- unicity and diversity of organisms (animal and vegetable);
- major interactions in general and applied environmental sciences;
- heredity and evolution.

Proposed innovations offer a choice of topics directed towards:
- possibilities of observation and experimentation in nature;
- personnal corporal experience;
- the needs of the young generation;
- contemporary problems and questions on society.

Their goal is not just to present students with raw results and figures but rather to give rise to questionning, to develop strategies in problem solving and to test them and more importantly to teach how to reach results in practice. They also propose to arouse and stimulate curiosity and the pleasure of discovery threw contact with plants and animals.

New trends in the teaching of physics aim to reach beyond simple appearances. The pupil is led to explore (often in parallel) atomic, human and astronomic scales as well as to appreciate the role of experimental methodology and theoretical models. On these aspects, particular attention is paid to the rigorous, logical and objective analyses of chosen material or situation, analysis that the student is lead to express in a clear and complete manner, may it be in everyday language or with the use of mathematical formalism.

In contact with given situations, the student learns to sense, observe and describe what he sees before proposing himself an analysis and an explanation. The aim is to stimulate by imagination and curiosity while allowing him to proceed by trial and error, to make mistakes and correct them himself. On this basis, models are proposed representing the mechanisms and hidden principles of numerous natural phenoma.

This approach of physics therefore develops primarily a better understanding of natural laws based on intuition. Fundamental knowledge is tackled in a way which essentially takes into account, the backgroud, the age and the anterior knowledge of the pupil with a priority given to the acquisition of learning processes and attitudes:

- to develop taste for action, creation and involment: to build, dismantle, reconstruct, repart and invent devices;
- to imagine, invent, construct, discuss conceptions to explain concrete phenomena and be able to deal with them;
- to have a taste to structure thought by relying an hypothesus (possibility by trial and error, self criticism and finally experimental verification);
- to respect the right to make mistakes and to doubt;
- to develop a taste for understanding triggered by curiosity;
- to enhance reasonning potential by drawing from different areas of physics as well as other disciplines;
- to research and exploit documentation and enrich ones knowledge threw critical reading of reviews, articles, scientific publications and by attending conferences and listening to scientific programmes;
- to process observation results in a given project and hence discriminate between facts and hypothesus, between causes and effects;
- to experiment individually or in groups;
- possibly, to make use of the mathematical tool;
- to structure thoughts, ideas and intuitions rigorously;
- to muster one's knowledge in new situations;
- to express oneself and argue in simple but specific teams in order to gain in clarity and consciousness;
- to be able to communicate on technical and scientific problems with specialists as well as the layman;
- to remain aware of the consequences and the limits of one's behavior as well as that of all human intervention.

Yet understanding developed threw intuitive and analogical representation even though essential in sciences is insufficient. Some of these innovations help us to confront the learner's mental framework with reality by using experimentation or measurements in order to eleborate qualitative or quantitative models.

Furthermore by the study of the historical evolution of ideas in physics, the student learns to relativize theories and recognize their limitations. The understanding of basic laws of nature allows the pupil to take responsabilities faced with environmental problems and to take a stance as a citizen on increasingly intricate and technical problems. It also provides a critical view of ancient ot contemporary modes of thought whiles replacing the essential role of physics in our culture.

New trends in the teaching of chemistry also strive to awaken the interest in our daily environment and our desire to better understand it. Emphasis is put upon:
- the observation of matter and its transformation;
- the mastery of scientific method or in order words, the ability to study material phenomena by asking questions, and by elaborating hypotheses before testing them by conclusive reproductible experiments (room being given to scientific literature);
- the application of theoretical knowledge to laboratory experiments as well as to everyday activity.

Besides this methodological aspect, their aim is to:
- provide under one hand, the means of understanding the structure, the properties and the alterations of living and non living matter threw experimentation and reasonning. Models are introduced in order to allow interpretation of noticeable properties at the molecular and atomic levels;
- bring to the fore, on the other hand, the importance to human existence of the knowledge in substances and chemical processes. Human activity is linked to cycles and material balance in nature: the pupil is brought to understand the consequences of the production and consumption of substances on the environment.

In collaboration with the other sciences, these trends tend toward making us aware of the necessity for pluridisciplinary action in order to solve fundamental problems (while considering epistemological, ethnical and cultural aspects of chemistry). Chemistry contributes to the development of essential human activities such as agriculture, the food industry, public health, etc. Many everyday life substances (i.e. paper, plastics, medecine, detergents, textile fibres, glass, metals, etc.) are extracted from the ground, the sea and the air by chemical processing. Finally, the greater part of consumed energy (for heating, transport, production of goods) is of chemical origin. All human activity creates waste and weakens natural ressources. All production and consumption of matter or energy has its drawbacks such as the impoverishment of natural ressources and the prejudice to the environment. Such realisations should allow a change in personnal behaviour especially in our consumer society and faced with galloping demography.

3.2. Innovations in methods for teaching

In Switzerland, notably in primary schools and level 1 of secondary school, a growing number of teachers are attempting to transform teaching practises by resting on didactics and new ideas on "learning and understanding" as developed by LDES. These attemps concentrate on the pupil's ability to link new knowledge, which he must master, with anterior knowledge (here called conceptions).

These different innovations rely on the idea of an "acting pupil" progressively acquiring knowledge throughout his social history. In other terms, the "learner's" (in french "apprenant") own action is placed at the heart of the learning process. He alone analyses, processes and structures what originates in his environment (of which situations to which he is confronted in school) in order to elaborate his own answer according to his own "mental processes" and what he perceives to be at stake in a given situation.

At this stage in our reflection, a few educational practises may be observed. The most common technique encountered globally consists in allowing the pupil to "speak" first in order "to know him better" and then to intervence. Some go as far as to elaborate a complete course, a "teaching module" or even a curriculum aimed at the mastering of conceptions.

However, behind these innovative aspects lurk a few educational misconceptions that another educational model, the allosteric model (Giordan, De Vecchi, 1987) tries to overcome. Its aim is to be beyond the dominant constructivist model. It provides widely corroborated hypotheses which can be summarized as follows.

The acquisition of knowledge proceeds from a learner's activity of elaboration confronting new information with his mustered conceptions whiles producing new meanings more able to answer by questions. The learner's own activity is central to the acquisition of knowledge. He is the one to sort out, analyze and organize data in order to formulate his own answers. It should be noted that such a process is not simply given, it develops depending on structures of thought in action (questions, frame of reference, mastered operations) and the issues the learner perceives in a given situation. Nor is it immediate, new knowledge is not understood or memorized right away for different reasons. The necessary information might be missing for example. In other cases, the necessary information might be avaible but the learner does not feel motivated towards it. It might also be unaccessible to the learner for reasons of methodology.

Often, specific elements necessary to the management of effective understanding or lacking. In the case of fundamental education, the knowledge to be acquired does not inscribe itself directly in line with anterior learning which often even hinders its integration. Tuition must trigger radical changes in the student's conceptual network. This can only be achieved if the learner is:
- placed in a position to overcome the fabric of familiar knowledge;
- confronted with the groups of converging elements filled with contradiction which hinder its management;
- able to rely on organizing models which allow him to structure knowledge differently (in order to be able to answer questions more relevently for example).

Furthermore, concepts which are now being developed demand, in order to be operationnal, to be progressively differenciated and encompassed in their field of applications, and then to be reinforced by a mustering of knowledge in other situations where they may be applied. This implies that the pupil has deliberated control over his learning activity and the processes which command it. The learner must reorganize information which is presented to him (or that he collects himself) according to his evaluation of situations, to meanings he can extract from it and to the representations of the knowledge which he establishes. He must reconcile the above stated parameters in order to constitute, in as far as it may be used, new knowledge. He must pick out similitaries and differences within the old and the new knowledge and ofter salue their contradictions.

Finally, not happens but with time: basic learning requires time, it is a step by step process. If all these conditions ar not fulfilled, apprenticeship on the whole might be comprimised.

Thus, the pupil learns at the same time "thanks to" (Gagné) "from" (Ausubel), "with" (Piaget) the fonctionnal knowledge in his mind. In the same time, he must understand "against" it (Bachelard). The learner must ofter go againt his own initial conception. But he will only be able to do do if he does "with" it as it is the only tool at his disposal; thus until it "cracks" when it will appear to limited or less fruitful than an other already formulated.

All acquisition of knowledge therefore proceeds from activity of elaboration of a learner confronting new information and his own mobilized knowledge and creating new meanings more able to answer his question and the issues which he perceives. Between the learner and the object of knowledge, a system of multiple interrelation must be weaved. This is never spontaneous and the probability that a student might discover all the elements able to modify his questionning is pratically inexistent. On the other hand, these approaches may widely benefit from a didactic environment provided by the tutor (or educationnal team).

At the start of all apprenticeship, one must introduce one or a set of descriptions in order to perturb the learner's cognitive network (mobilized conceptions). These descriptions create a tension which upsets the delicate balance the brain has created. In the some time, the learner must be confronted to:
- significant elements (documents, experiments, arguments);
- confrontations (between pupils, between pupils and reality, between pupils and information, between pupils and teachers);
- restricted formalims (symbols, models, graphs, diagrams.

We must add that a new formulation of knowledge cannot be substituted to an anterior unless the learner finds it rewarding and learns to utilize it. To these stages, new confrontations adapted to situations as well as selected information prove to be necessary. A knowledge on knowledge itself (epistemological approach) being equally necessary.

3.3. Innovations in the field of integration knowledge

Great efforts are being made in Switzerland to develop in an integrated manner formative goals. Sciences are increasingly favoured as a dsicipline for the development of the powers of reflection. Let us note among the main formative goals presented:

- to learn to establish relations between phenomena and understand them (approach of concepts);
- to develop reasonings in constant view of the daily reality of the pupil;
- to learn to link immediate observation data (muscular effort for exemple) to elaborate notions (developed power) and then to models;
- to tackle and grasp different working methods (notably in the fields of the mastering of information, modelisations and simulations);
- to understand, interpret or even critize scientific data.

Children must have at their disposal a set of learning and problem solving strategies. To be able to show curiosity, to express hypotheses, to draw conclusion, to proceed methodologically, to make rigorous use of concepts and to be able to sustain an argument being their main constituants.

Work on sources of information such as the media (press, T.V. interactive media) is particularly favoured. Access to sources of information and databanks is easier than ever with the new technologies of communication. But this accessibilty in order to be profitable must be coupled with useful information research skills and be set in the wider perspective of a "learning to learn" approach required today by training.

Taking into account the obselescence of knowledge in our changing societies, such as apprenticeship is a real challenge which reach for beyond school alone. The aim is to constantly increase the individual's stock in reading techniques and information processing skills. Applied methods rely particularly on detailed knowledge of avaible sources. The pupil can learn where and how to find information, how to use different instruments (files, bibliographies, archives or other material), learn the use and function of codes and conventions and grasp the logic behind a documentation system. it is also important that he may be able to transfer from one discipline to another his methodological skills.

The introduction of processes using computers constitutes an important asset in this field of expertise. The mastery of such tool offers an opening to a wide new range of interdisciplinary uses. In the same time, to explain new information and communication technologies as socio-political phenomena constitutes an important consciousness raising task. A reflection on the place, the value, the meaning, the limits and the dangers of new technologies is today essential. To grasp their potential and dangers is a prime condition to the understanding of our world which is increasingly reliant on them. Technology is a sub-system of the socio-political order and demands to be studied according to ethical, economical and environmental crite

In parallel to the teaching of different disciplines, invitations to the characteristics of scientific research are also proposed. The pupil learns to judge the objectivity of an intellectual task, to detect ideological bias within a reasonning and recognize his own partialities. Where epistemological reflection is concerned, he must learn to ask questions on the meaning and the limits of scientific knowledge, scientific responsability and scientific freedom.

In higher classes, the student can then interrealte his scientific knowledge with political legal social and economical issues. This allows him to grasp the powers of the state, their control, the involment of citizens and creates a basis from which to reflect on them. An approach of economical, political, social and technical mechanisms highlightning all the constraints among which the individual operates is also introduced.

Finally two new transverse fields are favoured, that of the environment and that of health. To face today's challenges regarding the biosphere, many approaches are undertaken at all levels to understand nuisances, pollution, degradation and development of the environment. Theses teachings often study more local problems before developping more global issues: demography, the ozone layer, earth warming. They usually also emphasize less developped approaches such as the pragmatic approach, systemic analysis, project management.

The approach of health issues draws more and more frequently from the many questions and changes which appear during childhood and teenage: quest for identity, awakening of sexuality, relations to the environment, confrontation to higher standards and demands, uncertainty about the professionnal future, encounters with darker aspects of life (drugs for example) awareness of health related hazards (S.T.D., AIDS, trafic accidents). Scientific education spends increasing amounts of time on these personal issues with regard to the younger generation's needs while respecting their individuality. The foundations to a health education are given during compulsary schooling: affective and emotional balance, self confidence, self control and concentration ability.

Pupils can also leat to recognize their own limitation. Beyond questions of personal health, the student must also be able to regard health as a social issue with its historical, sociocultural, scientific and economic implications.

4. POPULARIZATION OF SCIENCE IN SWITZERLAND

Telling about the future of the scientific culture in Europe, it is difficult to avoid speaking of the popularization of science and techonology. Furthermore, convinced of the fruitfulness of comparisons attached to differences and particularities, we aim in the following, to present the main characteristics of this activity in Switzerland.

We could describe it in its main lines, by the following forms: the importance of the extracurricular field, museological tradition, the opening of firms and universities to the public, a definite presence of the press and of television, the importance granted to the quality of distribution mechanisms. Let us now study in detail these different aspects. We shall illustrate them by particularly significant exemples.

4.1 The importance of extracurricular activities

In a country of militia, it is only natural that the extracurricular field should be widely developed. In fact, the acquisition of scientific and technical konwledge is highly prized in this country for the possibilities of cultural enrichment it offers. Most cantons favorize activities complementary to or independant of school programs.

In practice, these activities can take different forms. They may be practical work, workshops organized by school teachers (in primary or secondary schools) or conferences with outside contributors. Themes are excessively varied but always precise: solar energy, drinking water, the ecology of lakes, human genetics, photosynthesis. These activities generally take place outside school time. Yet they may also be taken as options to complete a basic scientific or vocationnal training.

Private and public schools also have a tradition of exhibiting in their midst. These exhibitions designed by students or lent by institutions or firms, do not only function internally but are widely opened to the public (parents, children from other schools, neighbors).

Doctors or paramedics often lead prevention and information campains relying on exhibitions (AIDS, diets, stress, sexual education, tobacco, drugs). Likewise with engineers and technicians who intervene to present a local industry (watchmaking industry, precision enginering industry) or new technology.

We must also point out the importance of vocationnal training in Switzerland. It is often supplemented with such activities or by training periods in companies, in contact with traditionnal or new production means.

They may also consist in fields activities: bird population census, study of protected environments, pollution, nuisances. Secondary schools, systematically organize school trips; 15% of which are directly concerned with the scientific field. In numerous other cases, they can be concerned with interdisciplinary work: study of the Gothard pass, of Burgundy or of the Camargue where the study of the flora, the fauna or even of local techniques has an important place. Such actions benefit from numerous, private or canton run, accomodation facilities (WWF, nature protection societies) as well as from companies and museums.

A competition "science calling youngsters", organized at the federal level, plays a stimulating role by rewarding particularly well organized operations. Many popular associations and scientific societies collaborate with scientific authorities: botanical, ornithological, mycological. These associations organize excursions, work sessions and conferences at the canton's or even national level. They also participate in the elaboration of catalogues on flora, fauna, etc.

4.2 A renewed museographical tradition

Swiss museums have a long tradition which can be traced as for back as the 18th century natural history Societies. There is a guide book to Swiss museums which describes the contents of exhibitions and collections with indications on days and hours of opening.

In 1984, this guide listed 595 museums of which 90 had a scientific vocation (natural history museums, technology museums) which represents approximatively a total of 16% of science and technology museums.

Since 1980-81 a map of Switzerland completes this guide, indicating precisely their geographical location. Such publications facilitate the access to museums and participate at their popularization. But, this guide only lists institutions usually classified as museums. Numerous other organizations, organize scientific exibitions as for exemple CERN "Microcosm" or the Sauvergny observatory, in the Geneva region.

One must also take into account other exhibition sites such as the large swiss commercial fairs (MUBA-BEA, "Comptoir suisse" etc.), banks or department stores, shop fronts, often devoted to scientific topicality. Different private companies can present their work and the pharmacentical and chemical industries prize them greatly.

Without having exact figures, which would require a complete study, it is obvious that technical and scientific exibitions are multiplying all over Switzerland. A number of museums (particularly natural history museums) are being refurbished, techniques in museology have evoluted, their architecture is changing and openings to the public are on the increase, notably with the help of the media (radio, local press). We must also say that most museums are really locally established. The following exemples will illustrate this evolution.

The swiss transport museum in Luzern is of national if not international importance and welcomes more visitors than any other swiss museums with over 600 000 entries every year. Its continuously renewed collections (railroad, air transport etc.) are particularly well adapted to the public's expectations and to new technologies. They try to be as close to reality as possible, to surprise, to create an atmosphere and to put the public in situation. Recently a new area devoted to air traffic control has been inaugurated. A film presented on 3 different screens, a real radar console reproducing the exact place of air traffic controllers, a computerized information and simulation game being the main attractions which contribute in rendering the experience as real as possible.

The "Technorama" in Winterthur is centred on the presentation of technology, in exhibition cabinets, films and videos and demonstrations. It presents contemporary technology important in the swiss economy. But the originality and the success of this museum are mainly due to its "Jugendlabor". This laboratory for children and youths allows all sorts of experiments in chemistry, physics and biology. Work stations are prepared where everyone can take place with all the necessary equipment to experiments. Concellors are present to answer questions and to help children.

The zoological museum in Lausanne has been refurbushed recently. It is attractive for its film sessions and for its special events, the invitation of local animal life artists for instance. Its curator also produces radio programs to attract the public, where he recounts true, wonderful and often surprising anecdotes on animals. Thus the fear to enter museums tends to disappear. Children, their main target, gladly visit them. The public comes to ask questions and often even brings animals. This museum can boast 60 to 70 000 entries a year.

The natural history museum in Soleure has been referbushed some years ago. Today, it counts 40 000 visitors every year in a town of 15 000 souls. To achieve this result, officials in charge of the museum have worked in collaboration with schools: 60% of all visitors are schoolgoers under 16. They come with insects to be determined, wounded animals or minerals to classified. Other questions are considered in relation with school research or survey work based on science in its wider aspects, on energy, on the environment, on electricity. Families also visit the museum often prompted by children.

The "Alimetarium" in Vevey banks on the originality of the topic, it is constituted around four main areas. A scientific department which explains the processing of food in the body, human body physiology and food chains; a technical department which studies the transformation of foods; an ethnographic department which highlights the role of food in different populations and an historical department which traces the importance of alimentation in human history. Temporary exhibitions complete these themes. A laboratory is apppended to some of them to allow children to work with food: "make your own chocolate", bake your own cake" etc. A specialist is present to help children.

To further underline the dynamism in this field, we can mention a few other projects "Electrobroc" opened in the town of Broc (canton of Friburg) in 1990. This centre on electricity was opened by the electrical board of Friburg (EEF) at the occasion of their 75th anniversary. It presents electricity by going upstream from the consumer to the producer.

The exhibition takes place in a working electrical plant. Different rooms have been converted into exhibition rooms where the notion of electrical power is explained, where energy consumption comparisons are proposed and where the transportation of electricity and electrical networks (Europe of electricity) are shown. Benefiting from the presence of a working plant, the different processes of electrical production can be explained. A workshop is at the disposal of all experimentations, a library offering different information sources provides data on the topicality of energy. Visitors can also attend a spectacular display on the magic of the electricity. Different renewable energies are also presented outside in the picnic area.

We cannot end this chapter without mentionning the temporary exhibition "Phenomena" which had an international impact. Organized in 1984 in Zurich and presented under several bug tops as well as in the open air, ÒPhenomenaÓ required the participation of the public: everyone could experiment with his body and senses as well as many physical phenomena: optics, acoustics, equilibrium, weightlessness, etc.

One could: touch, manipulate, jump, laugh, play... The aim of this exhibition was not just to provide scientific explanations, nor to introduce complicated formulas, but rather to offer a direct contact with phenomena and provoke questioning, surprise and admiration. The aim of the ensemble, the site itself on lake Zurich, the placing of tents, the succession of presentations, everything was meticulously prepared. Even though it took its inspiration from the "Exploratorum" in San-Francisco, "Phenomena" had its own strengh and originality. 15 000 visitors a day on average, or over 1 million visitors from many countries, came to see or experience ÒPhenomenaÓ in Zurich during the six months it lasted. This exhibition was also shown in other european cities.

4.3 A definite presence of television

Contrary to alter european countries, television in Switzerland is not on the decline where scientific and technical information is concerned. Under one hand, such inofrmation is well represented in news broadcasts and, on the other hand, the number of scientific programs is progressing and they are even being broadcasted during prime time.

TSR's (Télévision Suisse Romande) main scientific program is called Telescope and has been broadcasted regularly since 1981. It then appeared at 10 o'clock in the evening whiles it is today broadcasted at 9:30 or at 8:30 every two months with ever increasing ratings. It is to be noted that it is the viewers positive reactions and interest which caused the change in broadcast times. Considered themes are often determined by scientific topicality (green house effect, ozone layer, test tube babies) yet they also consider more specific topics (builders of cathedrals...) or explain medical topics (ears, teeth, sexes, etc.). Programs are either telescope's own productions or originate in other television companies documentaries.

The swiss german television's main program is called "Menschen, Technik und Wissenschaft" (MTW). Broadcasted now for many years, this program has evoluted. For the past 10 years, the political implications of science have taken an important part. MTW always considers scientific issues in relation to daily life, the economy or politics. Each program tries to study a specific problem and to propose solutions. It does not just sound the alarm or broadcast sentationnal information, but it also opens perspectives on remedies. This program used to be broadcasted every fortnight but since 1990 it benefits from better exposure. The number of viewers is now estimated between 340 000 end 600 000.
Another scientific program "Schurmbild" is broadcasted monthly. It mainly covers scientific and medical topicality. Since 1989, swiss german television also broadcasts two other programs: a medical of 39 minutes called "Pouls" broadcasted 10 times a year and a program on the environment "Netz" of 59 mn programed 4 times a year.

Swiss italian television (T.S.I.) does not regularly broadcast scientific programs. In 1990 a series of 13 programs was proposed on ecology. They were documentaries bought from english television. Medical issues are not regularly treated but can be the object of ponctual programs.

At the occasion of the 700th anniversary of the Swiss confederation and with the collaboration of national funds, the 3 swiss channels broadcasted a series of 5 scientific programs with the following titles: Man and the environment, Man and health, Man and work, Mand and food, Man and energy.

4.4 The opening up of industry and universities

As we have seen earlier, industries and universities are interested in presenting their work to as wide an audience as possible. This evens appears as a necessity, for industry to promote a public'image or because research institutions partly or totally rely on public funding and in these matters, the population has a direct say (threw referendums).

These actions can be continuous; often an exhibition or visitors room is provided in companies or universities (i.e. Sauvergny observatory, "Microcosm" exhibition in CERN). Private or public companies (waterelectricity boards) widely publish numerous documenty, notably in matters of energy savings, health or protection of the environment.

Geneva University has even gone further by creating a public of scientific information service and on annual prize for the popularization of science. Conferences, opened to the public' are organized by researchers themselves. A specific laboratory (LDES) specialises in studying knowledge acquisition and distribution mechanisms.

Other operations are linked to events. For example, at the occasion of its 100th anniversary, in 1990, Friburg University celebrated by organizing an exhibition called "Uni 100". It presented spectacular work done by the science faculty. An opened day was devoted to the public. Visitors could discover ongoing experiments and demonstration devised for them by crossing the different laboratories.

For the 700th anniversary of the swiss Confederation, the national found for scientific research, initiated a national exhibition on research which took place in Zurich from May to October 1991. The aim of this exhibition called "HEUREKA" was to reflect the state of science in Switzerland. Universities and colleges, but also private industries were invited to participate and present to the public the state of scientific knowledge in social and exact sciences.

The HEUREKA presentations were organized around themes: biology, medecine, ecology, social sciences... Each area showed attractive and spectacular aspects of their activity. A "road to knowledge" was opened to allow everyone to learn or relearn fundamental notions in each subject. Finally with the help of councellors, visitors could discover aspects of research actually being led in Switzerland. Still in the setting of these celebrations, a film called IMAX, representing Switzerland, had many sequences devoted to actual swiss research.

4.5 The quality of knowledge distribution mechanisms

Quality in swiss technology is of course renowned and it can also be encountered in the care and dependability of museological elements. But what is less obvious is the paralell importance granted for the past 10 years to the mastering of knowledge acquisition and distribution mechanisms. For example, to carry out the "Electrobroc" exhibition, officials appealed to exterior specialists to represent the public in general or to give advice on museology. The Òair transport" department in the Luzern museum was established relying on an evaluation conducted by specialists supplemented by a public survey. Identical approaches were undertaken for other exhibitions (Microscosm", "Heureka") or for the realization of popularization documents in matters of health (Geneva Youth Health Service).

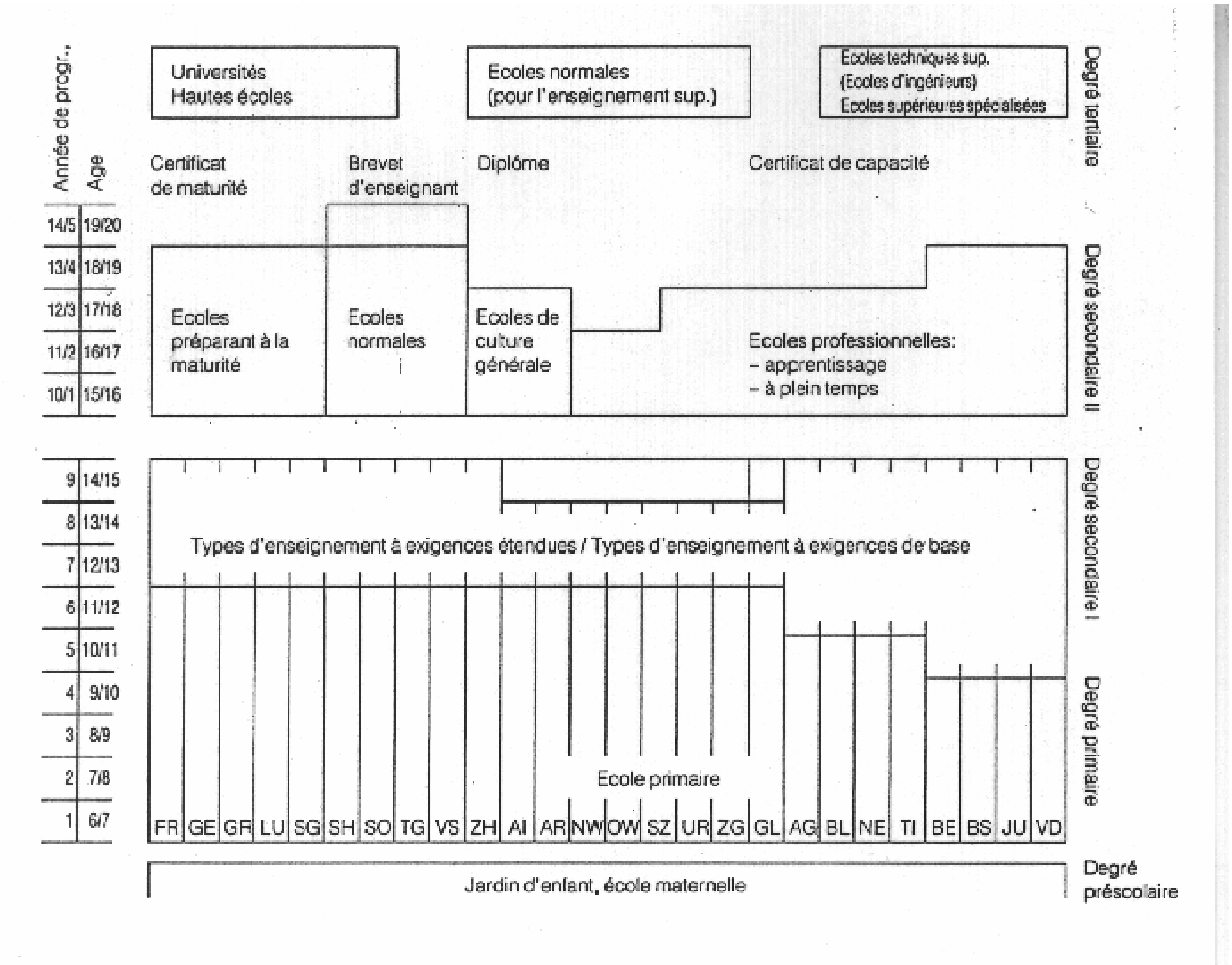
Officials are very interested in public response even before on opening. Surveys on the reactions, the understanding and reading mechanisms of visitors avoid major museological mistakes. They allow to improve the concerned areas so that may better correspond to the public's expectations.

This approach develops a new organization and a new philosophy in the conception of exhibitions by introducing new work views, new ideas and above all, a budget for "remedy". It is in effect necessary to make initial stages of a project. This new perspective appears profitable in terms of quality and costing.

To face these new requirements, private companies and university research laboratories were developed. "Expo-vision" for instance is a campany specializing in the field of scientific exhibitions. It helps exhibitors to define their objectives and the most appropriate museographical means. Expo-vision has answered many demands, for evaluation and has shown the place and the importance of the public's opinion in the setting up of exhibitions. It has participated in the elaboration of many scientific and technical exhibitions by highlighting play and the museological aspect in their mediative actions.

To answer the need for broadening of knowledge, Expo-vision also offers a documentation service and a scientific exhibition distribution service as well as a museological database.

Annex 1: Simplified schematic of the swiss school system



Annex 2: Students in Geneva University according to the main curriculum directions (31.12.93)

	TOTAL	FEMALE	FOREIGN
Facultés et écoles	**13'000**	**7'098 4'466**	
Sciences	*2'024*	*41*	*46*
Médecine	*1'380*	*46*	*22*
Lettres	*2'387*	*68*	*29*
Sciences éco. & sociales	*2'830*	*41*	*36*
Droit	*1'408*	*50*	*28*
Théologie	*82*	*40*	*39*
Psycho & Sc. éducation	*1'931*	*77*	*27*
Ecole d'architecture	*349*	*41*	*36*
Ecole de trad. et interpr.	*383*	*80*	*68*
Ecole de lang. et civ. française	*211*	*81*	*88*
Ecole Edu physique & sports	*15*	*27*	*13*

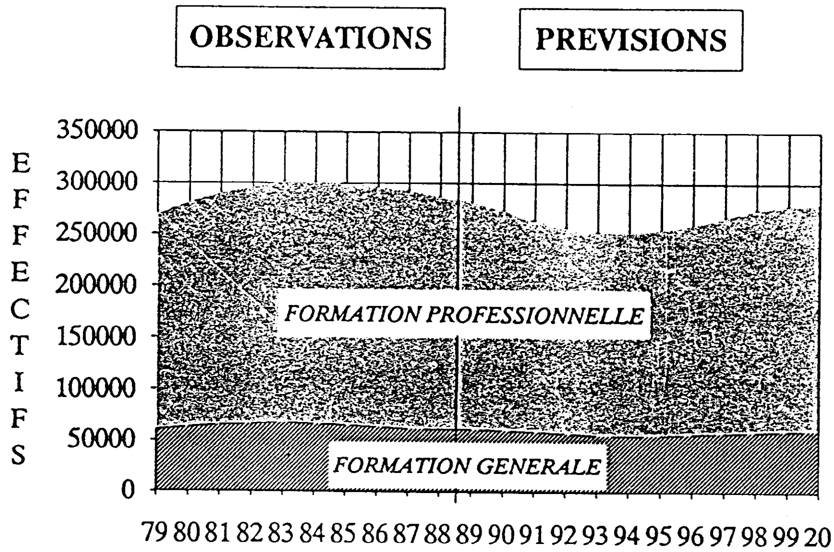
The second column indicates the ratio of female students.
The third column indicates the ratio of foreign students.

Annex 3: Students at the secondary school level in the Geneva canton according to the main curriculum directions (31.12.93)

	TOTAL	%	%	%
Cycle d'orientation	**10'712**	**49**	**8**	**59**
dont:				
latine	*1'882*	*65*	*1*	*77*
scientifique	*2'892*	*36*	*4*	*66*
moderne	*953*	*73*	*4*	*59*
générale et pratique	*2'655*	*44*	*9*	*47*
niveaux-options	*1'796*	*49*	*5*	*60*
CollègedeGeneve	**5'566**	**58**	**2**	**71**
dont:				
classique	*279*	*57*	*-*	*75*
latine	*691*	*60*	*-*	*81*
scientifique	*1'097*	*34*	*1*	*72*
moderne	*1'129*	*75*	*1*	*67*
artistique	*516*	*71*	*1*	*84*
niveaux-options	*1'817*	*57*	*2*	*66*

The second column indicates the ratio of female students.
The third column indicates the ratio of foreign students (immigrated at least 3 years before).
The fourth column indicates french language students.

Annex 4: Ratio of students in general and professionnal formation in Switzerland



Source:
This table is extracted from a 1988 prospective study.

Annex 5: Extrait du règlement de lÕexamen de maturité pour le Canton et Etat de Genève

Pour avoir droit au certificat fédéral de maturité de type D, le candidat doit également souscrire aux normes définies par chaque établissement:

a) au collège Calvin il doit obtenir un total de 18,0 points pour les cinq disciplines suivantes: français, allemand, anglais, italien, mathématique; l'histoire peut remplacer l'anglais ou l'italien;

b) au collège Voltaire il doit obtenir un total de 18,0 points pour les cinq disciplines suivantes: français, allemand, anglais, italien~ mathématique; I'histoire peut remplacer l'anglais ou l'italien;

c) au collège Rousseau il doit obtenir un total de 16,0 points pour les disciplines suivantes: français et trois disciplines suivies en option forte dont deux langues vivantes, ou de 20,0 points pour les disciplines suivantes: français, deux langues vivantes suivies en option forte et deux disciplines suivies en option normale parmi la physique, la chimie ou la biologie; le candidat peut passer avant Pâques, et dans la mesure où la session porte sur six disciplines, un examen anticipé en cours obligatoire de mathématique ou en option normale d'une langue nationale;

d) au collège de Candolle il doit obtenir un total de 18,0 points pour les cinq disciplines suivantes: français, allemand, anglais, italien, mathématique; l'histoire peut remplacer l'anglais ou l'italien;

e) au collège Claparède il doit obtenir un total de 18,0 points pour les cinq disciplines suivantes: français, allemand, anglais, italien, mathématique; l'histoire peut remplacer l'anglais ou l'italien;

f) au collège Sismondi il doit obtenir un total de 16,0 points pour les disciplines suivantes: français et trois disciplines suivies en option forte dont deux langues vivantes, ou de 20,0 points pour les disciplines suivantes: français, deux langues vivantes suivies en option forte et deux disciplines suivies en options normale parmi la physique, la chimie ou la biologie; le candidat peut passer avant Pâques, et dans la mesure où la session porte sur six disciplines, un examen anticipé en cours obligatoire de mathématique ou en option normale d'une langue nationale;

g) au collège de Saussure il doit obtenir un total de 18,0 points pour les cinq disciplines suivantes: français, allemand, anglais, italien, mathématique; l'histoire peut remplacer l'anglais ou l'italien;

h) au collège de Staèl il doit obtenir un total de 18,0 points pour les disciplines suivantes: français, deux langues vivantes en option forte...; dans tous les cas au moins trois de ces disciplines doivent faire l'objet d'un examen de maturité; pour l'ensemble des disciplines sont admises au maximum quatre notes comprises entre 1,5 et 3,4 pour autant que la somme des écarts à 4,0 de ces notes ne dépasse pas 3,0.

Annex 6: The 1992 federal definition of the curriculum content for colleges

LES PLANS D'ETUDES CADRES EN BREF
Les plans d'études cadres pour les écoles de maturité suisses (PEC)

Pourquoi des Plans d'études cadres?
Hormis les programmes de maturité (seuls applicables aux examens de la Confédération), il n'y a pas de directives cornmunes sur les objectifs d'apprentissage des études gymnasiales suisses. Dans la perspective d'une réorganisation des études gymnasiales, les chefs de département de l'instrudion publique ont mis en oeuvre, en 1987, 1'élaboration de plans d'études-cadres (conformément au concordat scolaire, art. 3). Le projet qui vient d'être publié sera mis en consultation et éventuellement modifié selon les réactions. Il sera entériné définitivement en 1993, décision qui est en étroite relation avec une réorganisation de la reconnaissance des certificats de maturité (ORM) et qui fera également l'objet d'un débat public, en 1992. Les PEC seront un fondement pour le renouvellement de l'enseignement gyrnnasial pour autant que les cantons et les régions soient disposés à faire l'effort de leur mise en pratique (projets de développement à mettre en oeuvre).

Que veulent les *PEC?*
Les PEC proposent des objectifs d'apprentissage de nature générale que tous les bachelières et bacheliers devraient pouvoir atteindre à la fin de leurs études gymnasiales. Ils définissent la mission éducative et intellectuelle du gymnase dans un angle de vue global. Ils répondent aux besoins de la société, des hautes écoles et aussi des adolescents.

A quoi servent-ils?
Il ne s'agit pas d'une carte détaillée au 25 millième mais plutôt de jalons servant aux cantons et aux écoles de repères à grande échelle pour analyser leur situation et engager la réflexion sur le renouvellement de leur pratique pédagogique.

Les différentes fonctions des PEC:
Pour les cantons:
- Référentiel pour le renouvellement, le développement et la coordination des études gymnasiales.

Pour la Confédération:
- Document de base pour la reconnaissance des certificats de maturité (selon l'ORM).

Pour les directeurs d'école et les enseignants:
- Document mettant en évidence les finalités de leur institution, ce qui leur permet de choisir les priorités adéquates et facilite la communication entre les enseignants des différentes disciplines.

Pour les Hautes Ecoles et les Universites:
- Référentiel sur les acquis des étudiants débutants qui permet aux professeurs d'adapter leur enseignement. Ce référentiel est indispensable pour garantir l'accès à toutes les facultés.

Contenus et structure:
1. Les 10 thèses de la Commission Gymnnase-Université de 1985 qui ont fait l'objet d'un large débat au niveau suisse et dont les postulats ont connu une adhésion quasi générale, ont été adoptées comme idées directrices du projet PEC.
2. Les Orientations générales des études gymnasiales rassemblent tous les objectifs inter- ou supra-disciplinaires ou les objectifs appartenant à plusieurs disciplines d'enseignement. Tous les responsables de l'enseignement sont appelés à joindre leurs

efforts pour les réaliser en priorité. Ces orientations sont destinées à alimenter les débats dans les différents corps enseignants. C'est sur la base de ces débats que pourront être réalisés, par la suite, les objectifs des différentes disciplines.

3. Les domaines d'études

Les disciplines d'enseignement connues (auxquelles sont nouvellement associées la philosophie, la pédagogie et la psychologie qui ne sont pas encore reconnues par l'ORM) sont regroupées en quatre domaines d'études à parenté interne étroite Ces domaines d'études engagent à un premier palier de vision interdisciplinaire (le niveau supérieur étant proposé dans les Orientations).

Les domaines d'études:

1. les langues
    - les langues premières
    - les langues secondes
    - les langues anciennes
2. les sciences humaines
3. les sciences expérimentales et les mathematiques
4. l'éducation artistique et physique

4. Les plans cadres des branches ou disciplines d'enseignement ont été développés par les sociétés affiliées de la SSPES selon une grille commune: Objectifs généraux, Considérations ou explications, Objectifs fondamentaux. Ils ne contiennent pas de matières détaillées à enseigner, car ceci est la tâche de plans d'études et non de plans cadres.

La validation des PEC:

Au cours d'une procédure à plusieurs étapes, les projets de PEC ont été "validés", c'est-à-dire évalués quant à leur conformité au mandat et à leur niveau d'adéquation pour les exigences universitaires.

Annex 7: Teacher profile in the Geneva canton (year 1993-94)

age	women	men
61-65	25	4
56-60	100	15
51-55	233	42
46-50	425	75
41-45	445	101
36-40	325	75
31-35	245	50
26-30	192	43
21-25	94	6

Prescolar and primary school
(Total: 2495 teachers; 17% men; 83 % women)

age	women	men
61-65	25	19
56-60	41	35
51-55	102	105
46-50	185	145
41-45	170	119
36-40	155	155
31-35	130	125
26-30	90	54
21-25	7	0

Secondary school
(Total: 1662 teachers; 46% men; 54 % women)

age	women	men
61-65	18	64
56-60	53	127
51-55	118	241
46-50	182	320
41-45	141	244
36-40	150	228
31-35	127	150
26-30	92	74
21-25	8	40

Postobligatory school
(Total: 2367 teachers; 62 % men; 38 % women)

Annex 8: Money spent out for public schools in Switzerland (1979)

Cantons	Cantons (%)	Communes (%)	Total (in 1000 of FS)
Zürich	31.1	68.9	909 989
Berne	36.3	63.7	627 584
Lucerne	51.7	48.3	188 619
Uri	56.0	44.0	19 786
Schwytz	21.8	78.2	68 179
Obwald	6.1	93.9	14 582
Nidwald	18.8	81.2	19 359
Glaris	40.7	59.3	25 652
Zoug	33.4	66.6	64 798
Fribourg	45.4	54.6	97 423
Soleure	30.7	69.3	156 210
Bâle-Ville	98.7	1.3	84 770
Bâle-Campagne	52.0	48.0	166 864
Schaffhouse	47.3	52.7	44 733
Appenzell Rh. Ext.	26.3	73.7	25 398
Appenzell Rh. Int.	36.6	63.4	7 309
Saint-Gall	28.7	71.3	256 232
Grisons	35.1	64.9	115 346
Argovie	66.9	33.1	324 573
Thurgovie	21.1	78.9	130 950
Tessin	53.3	46.7	169 172
Vaud	50.7	49.3	334 497
Valais	57.0	43.0	182 898
Neuchâtel	47.1	52.9	93 365
Genève	91.0	9.0	334 522
Jura	43.3	56.7	45 069
Total	45.6	54.4	4 507 906

Source:
Federal Administration for Finance, Berne, 1983

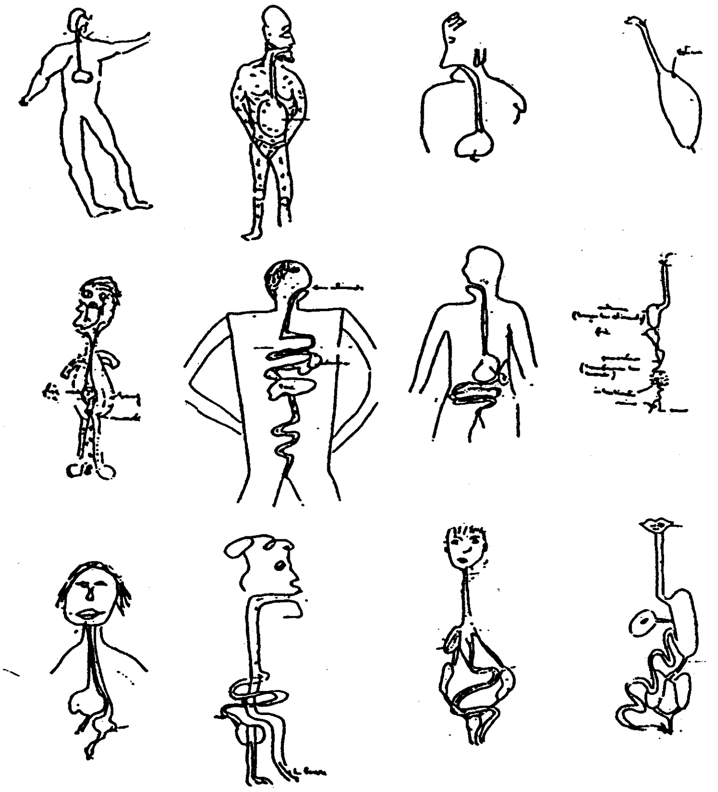
Annex 9: 1990-91 training course programme for swiss teachers of secondary schools

Cours du CPS

Langue maternelle
Langues étrangères
Langues anciennes
Mathématiques
Physique
Biologie
Géographie
Astronomie
Education civique
Sciences économiques
Histoire
Philosophie
Education religieuse
Education artistique
Education musicale
Gymnastique
Informatique
Education à l'environnement
Travail manuel
Cours interdisciplinaires
Pratique pédagogique
Formation des enseignants
Psychologie de l'éducation
Gestion, organisation
Plans d'études-cadres ORM
Séminaires spéciaux

Annex 10. Recurrent misconceptions (about digestion) of pupils along schooling

8 years 12 years 16 years 25 years



digestion = stomach

digestion corresponds to
a journey through organs

there is a double digestion
process:
- one for solids
- one for liquids

Source:
Giordan (A.), De Vecchi (G.), Les origines du savoir, Neuchâtel, Delachaux et Niestlé, p. 19