# Interdisciplinary education – challenge of 21st century

## GUIDEBOOK

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# Interdisciplinary education – challenge of 21st century

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# I
# Introduction

# Interdisciplinary Education in Science

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*Secretary, International Council of Associations for Science Education (ICASE)*

## Introduction – Integrated Science

During the 1970's and 1980's, UNESCO promoted Integrated Science (I.S.) and published a series of New Trends in Integrated Science books (UNESCO, 1990). This was in an attempt to promote science to students as a unity, rather than a fragmentation of many sub-disciplines, and to encourage teaching away from factual recall and into guided discovery, or guided inquiry. As a result, science courses were adapted or developed in many parts of the world with less exposure to facts and more emphasis on the processes of science. Efforts were made to give these courses an experimental bias and to ensure the experimental component preceded the theory i.e. it was 'discovery' rather than 'verification'. By and large, the integrated science courses consisted of some biology, with some chemistry, with some physics, but there was evidence of true integration e.g. energy transformations in biology, chemistry and physics domains; photosynthesis taught as part of the teaching of common gases.

A major hallmark of I.S. courses was – the courses were science and intended to be taught by a single teacher. Any links to everyday life (and these were encouraged) were as examples of an application i.e. technological use of a scientific principle. The science, if well taught, was part of finding out about scientific principles using guided discovery (inquiry). This approach involved the students in learning the skills of meaningful observations, experimenting, thinking about the ideas involved and then seeing its usefulness through applications.

The guided inquiry courses were generally accepted at grades 7–9, where teachers have some science background. They were also accepted at grades 1–6 if the need for teachers to stress conceptual ideas was minimised (at the grade 1–6 level the teachers had little science background and soon lost confidence if called upon to teach academic, conceptual ideas). But integrated science tended to be rejected at higher levels where abstract ideas were introduced, such as atomic structure/bonding, structure and work, biochemistry. Here there was a demand that ideas be explored in more depth and the inter-relationships between subjects minimised. Teachers insisted on teaching their specialisation and this was amply encouraged by University professors concerned about the dilution of their subject with a subsequent loss of future PhD students.

## The Need for Change

As education for all became more dominant, the I.S. movement, with its pure science teaching, spreading around the world and more students began studying science subjects. This need for a background in science was being linked to the economic development of a country and there was a demand for science to become a core subject, taught to all students, at least for the first 9 grades. However, achievements in science education were not high in influential countries like the US and in the 1980's, it was clear a rethink of the purpose of science education was needed and its isolation from society and technology education abandoned. This led to the STS (Science-Technology-Society) movement and following this, the recognition of the need for scientific and technological literacy for all (STL).

**Scientific Literacy**

The movement to encourage science curricula away from pure science content were slow to gain ground, as they needed to relate science education much more to educational needs. Initially this was through emphasis on skills development, closely linked to Bloom's taxonomy where the hierarchical ideas of factual recall, understanding and application led to higher order thinking involving synthesis, analysis and evaluation. But science educators and curriculum developers also saw the need for problem solving skills in which scientific questions were investigated in an everyday context through planning, experimenting, analysing and communicating the outcomes. By the end of the 1980's, the need for society to become more scientific aware was being recognised and moves towards trying to promote a more scientific literate populace were emerging. The following is based on a report from the National Science Teachers Association of America (NSTA, 1990–91). The rearrangement of the points into the headed sub-groups has been undertaken by the author.

**Science Literacy Goals**

A scientific person:

*Intellectual (Higher Order Thinking Skills)*

1. uses concepts of science and of technology, as well as an informed reflection of ethical values, in solving everyday problems and making responsible decisions in everyday life, including work and leisure.
2. locates, collects, analyses, and evaluates sources of scientific and technological information and uses these sources in solving problems, making decisions, and taking actions.
3. distinguishes between scientific and technological evidence and personal opinion and between reliable and unreliable information.
4. offers explanations of natural phenomena that are testable for their validity.
5. applies skepticism, careful methods, logical reasoning, and creativity in investigating the observable universe.
6. defends decisions and actions using rational argument based on evidence.
7. analyses interactions among science, technology and society.

*Attitudinal*

8. displays curiosity about the natural and human-made world.
9. values scientific research and technological problem solving.
10. remains open to new evidence and the tentativeness of scientific/technological knowledge.
11. engages in science/technology for excitement and possible explanations.

*Societal*

12. recognises that science and technology are human endeavours.
13. weighs the benefits/burdens of scientific and technological development.
14. recognises the strengths and limitations of science and technology for advancing human welfare.
15. engages in responsible personal and civic actions after weighing the possible consequences of alternative options.

*Interdisciplinary*

16. connects science and technology to other human endeavours e.g. history, mathematics, the arts, and the humanities.
17. considers the political, economic, moral and ethical aspects of science and technology as they relate to personal and global issues.

For the development of scientific literacy, it is clear that a content oriented course is no longer appropriate. Science education has to be more related to the intellectual, attitudinal, societal and interdisciplinary needs of society. Inevitably this means that the goals of science education need

to be more in tune with the goals of education. To remind us of what these might be, and recognising that these are somewhat similar around the world, an example is taken from Hong Kong (Education Department, 1993) where the goals are split into sections:

**Educational Goals**

Intellectual

1. To develop in students the ability to think conceptually; to apply principles of logic; to be creative; and to make decisions based on reasons.
2. To provide students with the main mathematical, scientific, technical and commercial knowledge and skills needed for functioning in a highly technological society.
3. To help students develop the habit of independently acquiring the on-going knowledge and skills that they may require to meet the social, informational and technical transformation of a fast-changing community.

Communicative

4. To foster students' ability to communicate effectively in both Chinese and English in relation to the integrating and instrumental roles that each language plays in the Hong Kong community.

Social and Moral

5. To support students in identifying and cultivating personal, ethical values and in applying these values to contemporary social issues.
6. To train students in the habit of acquiring information and understanding about matters of concern for Hong Kong, China and the world and in making personal contributions towards the resolution of these places within the limitations of their circumstances.
7. To make students aware of the noteworthy aspects of Chinese culture, to strengthen their esteem for it and to help them develop a positive attitude towards other people, cultures, values and ways of life.
8. To help students appreciate the cultural richness of Hong Kong's international life and to help them acquire the habit of adapting it for their personal development.

Personal and Physical

9. To promote students' mental and physical health with good balance; to develop cultural and recreational interests and to guide them in making good use of their leisure.
10. To help students to learn about themselves, to develop a positive, realistic self-image and an appreciation for their roles in the family and the community.

Aesthetic

11. To help students to identify their areas of cultural interest and expertise, and to encourage them to develop their imagination and creativity.

Is there a similarity between these goals and those for scientific literacy?

**Interdisciplinary science**

What is clear is that, if science education is to meet the above goals, then it needs to inter-relate science with subjects such as environmental studies, economics, history, social studies and civics/political education, rather than simply its traditional link to mathematics. Of much less importance is the recognition of the boundaries content sub-divisions, for example, whether electron transfer is to be taught in chemistry, electricity flow as part of physics, or electrical impulses in muscles within biology. The science processes, or the nature of scientific inquiry, are the same. In fact, it becomes obvious science education, under whatever guise (biology, chemistry, physics or science itself), needs to become more holistic in its coverage of educational goals and hence more interdisciplinary in its approach to learning. And with this, the old *'science for the scientist'* concept is being discarded, in favour of *'science for the citizen'*.

The author contents the shift is towards the need to address the '*concerns and issues of* society' and, in turn, the need for *'relevance in science education'*. While environmental issues are coming to the fore as areas of societal concern, there are also ethical, moral and cultural issues that have scientific and technological origins and there is also a place for indigenous technology to be addressed. Science education needs to encompass discussions and decision making within its teaching approaches, as well as investigations to determine the scientific need for truth and problem solving. Thus, science education needs to be seen primarily as education, not science, and the interdisciplinary goals of science education might be summarised, as shown by Bybee (1993), where he puts forward five components that underlined the organisation of curriculum and instruction. They are given here, for convenience, as four components by combining the personal and career awareness components (Holbrook 1997):

1. social development or achieving the aspirations of society
2. scientific methods of investigation
3. personal development of the student and career awareness
4. conceptual understanding of scientific ideas

Two crucial points are highlighted with respect to the promotion of interdisciplinary science education:

a) How much factual knowledge is necessary for a person to claim to be scientific and technological literacy? We all know that we forget factual information. In case you need a reminder, reflect on all the knowledge you have forgotten since your degree studies!! And, as most of you are teachers and use much of this in your day to day teaching, you are the ones who have probably forgotten the least!!

A new OECD study (OECD, 2000) is looking at science taught in school that can have a lasting effect on scientific literacy. For this it is developing test questions for 15 year old students that relate to a concept of scientific literacy as being able to:

> *combine science knowledge with the ability to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.*

The questions focus on process skills. Although it is realised that these skills are intimately related to knowledge, the emphasis is on recognising questions, identifying evidence/day, critically evaluating conclusions and communicating to others (Fensham and Harlen, 1999). Content in itself is not seen as a crucial component of scientific literacy and is not examined.

The move to reduce content, and the amount of factual information, clashes strongly with the design of most textbooks. No wonder that Project 2061 in the US (AAAS, 2000) is finding that textbooks are unsuitable. Either there is a need to drastically rewrite textbooks for an interdisciplinary approach to the teaching of science, or teachers need to move away from using textbooks as the major, and most certainly as the only, source of guidance.

Can teachers move away from the textbook? My experience says yes and this now leads me to my second point and a key aspect for interdisciplinary teaching of science subjects in schools. This point is not a concern as to whether we need to develop a biology interdisciplinary course, a chemistry interdisciplinary course, a physics science interdisciplinary course, or even a science interdisciplinary course. This in some ways is irrelevant to the issue. The point is:

b) Are teachers able to teach in an interdisciplinary manner? Can teachers be given, and then make use of, guidance to teach in this way? And will teachers be willing to move away from teacher centred modes of transmission to ones where citizen skills are seen to outweigh the need for the retention of factual content?

This is proving to be a real challenge. Teachers are uncomfortable with change. Teachers don't know how to change. Teachers often feel they have changed for interdisciplinary teaching

already, but observation clearly shown otherwise. It most certainly seems that the traditional, isolated, in-service courses for teachers lasting for 2–3 hours, or even 2–3 days, are not enough.

Interdisciplinary education in science needs teachers who are able to include a wide range of techniques in their teaching. It needs teachers who recognise that students need to learn how to learn and that this is more important than the *'teacher covering a syllabus'*. It needs teachers who recognise the need for meaningful learning through student involvement, even to the extent that students have *'a say'* in what is taught. And, it is proposed, interdisciplinary teaching needs to be relevant *'in the eyes of the students'*. For that, it is argued, science education needs the issues and concerns of society to be a driving force for the conceptual learning to be gained. Such relevance is important to motivate students to understand the science in their world and for the decisions a responsible citizen is called upon to make.

A workshop held in Estonia in 1996 made a stab at developing a philosophy for such interdisciplinary education through science and in creating related teaching material. This education is known as STL (Scientific and Technological Literacy for All) and further workshops around the world have developed additional teaching materials in this area. The idea of teacher ownership is very strong in the workshops and hence teachers develop the materials themselves. Research results have indicated a strong student liking for the teaching associated with the approach, but that it is extremely difficult to get teachers to change their teaching direction and appreciate the needs that ownership of STL is demanding. Teaching for STL needs well motivated teachers as, in their words, 'the curriculum, the examination and the working conditions are not conducive to such change'. This challenge is even more significant, because we need to reflect on what actually comes first – *motivating the teacher to want to change, or making changes in the curriculum that teachers do not understand and thus tend not to implement* ?

**Criteria for Interdisciplinary STL Teaching**

STL interdisciplinary teaching is based on a few fundamental criteria (Holbrook and Rannikmae, 1997):

a) *The teaching covers a range of educational goals (the Bybee categories), within each topic*
   – a wide range of education goals are stipulated and form the major focus of teaching i.e. students are participating in the process of educational learning, appropriate for the goals of the country and their intellectual development. These goals not only relate to science concepts and scientific method, but also include social values and the development of personal skills.

b) *The teaching of a topic starts from a relevant aspect (relevant in the eyes of the students)*
   – the material is societally related and draws on an issue or concern within the society. Students are familiar with the situation, can thus appreciate its relevance and are able to build on constructs already formed. The material is directly relevant in the eyes of the students. Teaching about pressure, or bonding, or photosynthesis is not, it is suggested, directly relevant because the relevance is not overt. Creating teaching situations on the correct inflation of bicycle or car tyres for safety; the need to moisturise the skin for healthy living; or the issue of the Amazon rain forests for global warming are seen as more relevant. The relevance is clear even though the conceptual science may not have changed.

c) *Students are involved in demanding (higher order) thinking*
   – undertaking the activity, or answering questions from the teacher, are expected to involve the learner in an intellectual challenge, at an appropriate level for the student. In this the teacher utilizes constructivist principles – moving from information and understanding already in the possession of students, to the new learning situation. It involves students in analytical or judgemental thought.

d) *Lessons are student participatory*
   – the teaching approach and activities are designed to be student participatory either individually or in groups, for a considerable amount (>60%) of the teaching time. This does not necessary mean the teaching is experimentally orientated (although this is important), but it does mean attention is paid to the incorporation of a variety of teaching approaches and activities through which students can participate. Listening to the teacher is not considered student participatory, neither is the teacher asking questions (discussing) in a whole class situation.

e) *Students are involved in developing a range of communication skills*
   – due consideration is given to enhancing a wide range of communication skills appropriate for the dissemination of scientific ideas and social values. This is seen as involving oral (group discussion, debate, role-playing), graphical, tabular, symbolic, pictorial as well as written forms.

f) *The interdisciplinary teaching is clearly seen as science education*
   – whilst the teaching can be expected to link science teaching to social science (particularly by the scenario from which the teaching is developed), the teaching still retains science concept acquisition and gives attention to the development of scientific processes. The teaching needs to be definitely 'education through science', not a social science add-on to a previously taught 'academic science component' (in other words, the science concepts are an integral learning part of the whole learning approach).

ICASE recognises that interdisciplinary STL teaching is becoming the challenge for teachers, whether it is in science lessons, physical science lessons, biological science lessons or in lessons of the separate sciences. And as an international NGO (non-governmental organisation) supporting teachers through national Science Teacher Associations, ICASE is keen to play its role in assisting this change. To this end, ICASE has run a number of STL workshops around the world.

## References

AAAS. 2000. 2061 today. *Project 2061 newsletter*, vol 10, no.1, Spring/Summer 2000.

BYBEE, Rodger. 1993. The New Transformation of Science Education. In R. Bybee (ed.): *Reforming Science Education – Social Perspectives and Personal Reflections.* Teachers College Press. Columbia University, New York, USA.

Education Dept, Hong Kong. 1993. Guide to the 6th Form Curriculum. Prepared by the Curriculum Development Council. Hong Kong: Curriculum Development Institute.

FENSHAM, Peter and Harlen, Wynne. 1999. School Science and public understanding of science. *International Journal of Science Education*. Vol. 21, no.7 pp. 755–763

HOLBROOK, Jack. 1998. Operationalising Scientific and Technological Literacy – a new approach to science teaching. *Science Education International*. Vol. 9 no. 2, June.

HOLBROOK, Jack. 1997. Resource Materials for Science Education Reform. In KEDI: Globalization of Science Education – moving toward Worldwide Science Education Standards. *Proceedings of the International Conference on Science Education*, May 26–30, 1997, Korea.

HOLBROOK, Jack. 1994. Scientific and Technological Literacy for All – The Role of Educators. *Science Education International*, Vol. 5, No. 3, September 1994, pp. 10–16.

HOLBROOK, Jack and Rannikmae, Miia (eds.) 1997. *Supplementary Teaching Materials – Promoting Scientific and Technological Literacy*. Tartu, Estonia: ICASE.

NSTA. 1990–91. Science/technology/ society: A new effort for providing appropriate science for all (Position Statement). *In National Science Teachers Association (NSTA) Handbook*, pp. 47–8.

OECD. 2000. *Measuring Student Knowledge and Skills: the PISA 2000 assessment of reading, mathematics and scientific literacy*. OECD Publishing Service, Paris, France.

UNESCO. 1990. *New Trends in Integrated Science, vol. 6*. Paris

YAGER, Robert E. 1996. Meaning of STS for Science Teachers. In R.E.Yager (ed.) *Science/ Technology/ Society as Reform in Science Education*. Albany, New York: SUNY Press.

# II
# Interdisciplinary education – case studies, state of art and perspectives

## 1. Interdisciplinary education in primary and secondary schools

# The Teaching of Experimental Sciences at Elementary and Middle School Level: a View from Italy

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## THE PROBLEM OF INTEGRATION BETWEEN EXPERIMENTAL SCIENCES

### The Varna Conference on the integrated teaching of science

In 1968 an important International Conference on the integrated teaching of science was held at Varna (Bulgaria) (1); here as follows are some of conclusions of this Conference.

1. The *teaching of integrated science* contributes towards general education, emphasises the fundamental unity of science and leads towards an understanding of the place of science in contemporary society. It avoids unnecessary repetitions and permits the introduction of intermediate disciplines.
2. A course of integrated science should emphasise the importance of observation for increased understanding of the environment; it should introduce pupils to logical thinking and *scientific method*.
3. The *extent of integration and the balance between integration and coordination* will depend on the age of the pupils, the type of educational institution and local conditions. *At the earlier stages* of secondary education, a totally integrated course in experimental science appears generally desirable. *At the higher stages* of secondary education such a course may also be desirable especially for those students who have decided not to specialise in science.
4. Science is an important part of *primary education*, particularly in arousing scientific curiosity and in developing scientific attitudes and skills.
5. Studies into *concept formation in science* should be carried out, principally for younger children.

6. Further experiments in the development of *new integrated curricula* and the production of *teaching materials* are needed, drawing on those resources that are already available. The results of such experiments must be widely disseminated.
7. The *training of teachers* for primary schools should include science closely linked to pedagogical aspects of teaching science. Secondary teachers should receive an education in science at university level and this education should include pedagogical aspects, both in theory and practice. In-service training, both scientific and pedagogical, is considered to be essential.

**The integrated teaching of experimental sciences: motivation and objectives**

Gadsen, Becht and Dawson have analysed over 100 projects for the integrated teaching of experimental sciences prepared in various countries throughout the world, examining in particular the motivations and objectives of the projects examined. (2)

The motivations include the following:

i) the conviction that the understanding of each single scientific subject area requires an external contribution: for example, the teaching of biology requires the application of a number of chemical notions, which in turn are related to physical knowledge and laws;
ii) an awareness of the fact that the quality of scientific teaching can be improved: in order to make progress in the field of integration it is above all necessary to examine traditional didactic methods critically and renew methods and contents.

The same authors have also recognised 23 types of general objectives and have attempted to classify them in 5 basic groups (objectives related to themes of a scientific nature, objectives related to personal growth, objectives of social relevance, objectives of personal interest, general education objectives).

The interdisciplinary aspect of science corresponds, therefore, to the requirements of present-day society to educate individuals in a harmonious and balanced manner. Each discipline, due to its links with others, contributes to the realization of this objective.

This basic aim has inspired many of the integrated science teaching programmes prepared in recent decades. These, however, present marked differences with regard to general and specific objectives. As it is impossible to present a general overall view which takes into account the diversity of declared objectives in the projects examined by Gadsen, Becht and Dawson, it would seem useful to draw the attention of teachers to a particularly complete reference model presented in one of the didactic units contained in the English project "Science 5–13", *With objectives in mind* (3), and aimed at the elementary school level, although at the same time it could also be applied at the Middle School level.

**Integration principles**

We could easily be encouraged to think of content as the main integrating principle: topics such as for example, water, air, the environment are by their very nature interdisciplinary.

Content, however, does not constitute the only possible integrating element.

The same function can be carried out in fact by:

a) common pedagogical objectives, like the acquisition of the capacity to analyse phenomena in science, in mathematics, in history;

b) the adoption of a common methodology, based for example on the acquisition of concepts and the activation of procedures that are basic to experimental sciences. The most important scientific procedures and concepts according to an elaboration by the American Association for Advancement of Science (AAAS) are indicated as follows (Tab. 1, 2).

Table 1 – Procedures followed in science (American Association for Advancement of Science – AAAS)

| | |
|---|---|
| **Observation:** use of the senses to describe objects and phenomena<br>**Classification:** to choose, group and order on the basis of particular criteria<br>**Numerical relationships:** to identify quantitative relationships existing in nature<br>**Measurements:** to measure various sizes; collection of data, evaluation, precision<br>**Time – space relationship:** description of spatial relationships and their variation in time<br>**Communication:** oral, pictorial and written<br>**Inference:** simple and plausible explanations of an observation<br>**Prevision:** to make previsions of the type: „what would happen if …..” | **Formulation of a hypothesis:** the use of observation, inference, prevision, etc. to suggest explanations of wider generalizations<br>**Produce operative definitions:** to define terms and objects in the context of a certain experience<br>**Identify and control variables:** to consider all variables but vary only one at a time in order to identify univocally the relationships with the system<br>**Experiment:** to formulate hypotheses, control variables, invent procedures, communicate<br>**Interpret data:** what do the data mean? What generalizations are possible? What further experiments are necessary? |

Table 2 – Some of the principal concepts in science (AAAS)

| | |
|---|---|
| Cause – effect | Organism |
| Equilibrium | Population |
| Force | Cycle |
| Matter – energy | Evolution |
| Space – time | Interaction |
| Entropy | Model |
| Field | Probability |
| Order | Scale |
| Symmetry | System |

**Dimensions of integration**

Among the various dimensions that characterise integrated science teaching programmes, are amplitude and intensity.

Amplitude depends on the number of disciplines that come into play in the integration process. A scale of growing amplitudes can be established for example:

a) within the scope of one of the natural sciences: for example in biology between zoology and botany;
b) between two closely related exact sciences: for example between physics and mathematics;
c) between natural sciences and social sciences.

Intensity, on the other hand, expresses the effective degree of integration between the disciplines considered.

At the Varna Conference the distinction existing between a complete integration process and one of simple coordination between disciplines was already clear. Today a much finer distinction between coordination, combination and synthesis (or complete integration) is proposed. (4)

The term coordination means the simultaneous teaching of independent programmes under the direction of a common organ, for example a coordination committee.

Instead, a combined programme includes didactic units that are programmed around large-scale themes referring to different disciplines. In a programme of synthesis, finally, a problem of interdisciplinary nature constitutes the unifying idea at the level of didactic unit or section. In order to determine the degree of integration characteristic of a certain programme, use is generally made of an integration matrix defined in terms of the dimensions of amplitude and intensity.

## THE RENEWAL OF ELEMENTARY SCIENCE EDUCATION IN 60s AND 70s

**The 60s and 70s were very important for the renewal of scientific education at all scholastic levels**.

**In those years numerous science teaching projects were developed in the United States and in the United Kingdom (Table 3)**.

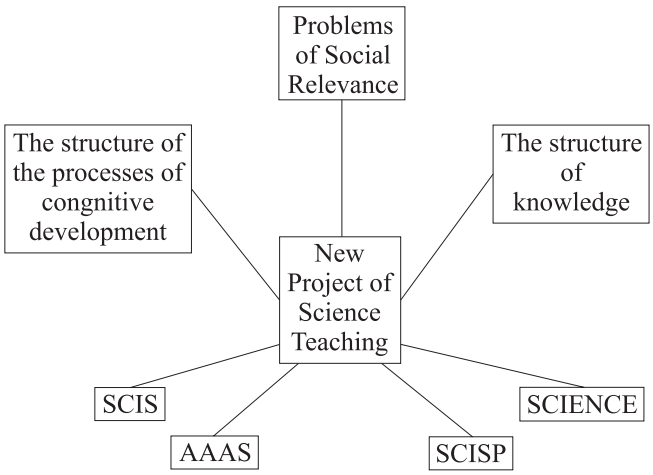
Table 3 – Some important projects of science teaching developed in the United States and in the United Kingdom during 60s and 70s

| Title of the Project | Structured or not | Publisher |
|---|---|---|
| Unites States (60s) | | |
| Science – A Process Approach (SAPA) | Struct. | Xerox Education Division, N. Y., 1967 |
| Science Curriculum Improvement Study (SCIS) | Struct. | Rand McNally, Chiago, 1967 |
| Elementary Science Study (ESS) | Not struct. | McGraw – Hill Book Co., N.Y., 1966 |
| Conceptually Oriented Program in Elementary Science (COPES) | Struct. | The Centre for Fielf Research and School Services, New York University, 1971 |
| Minnesota Mathematics and Science Teaching Project (Minnemast) | Not struct. | Minnesota University, 1967 |
| Unites States (70s) | | |
| Concepts in Science | Struct. | Harcourt Brace Jovanovich inc., N.Y., 1975 |
| Learning Science | Struct. | Benziger Bruce and Glencoe inc., Encino, 1977 |
| Elementary School Sciences Program (ESSP) | Struct. | J.B. Lippincott Company, Philaderlphia, 1977 |
| Exploring Science | Struct. | Laidlaw Brothers Illinois, 1976 |
| Science: People, Concepts, Processes | Struct. | McGraw Hill Book Co., N.Y., 1974 |
| Science – Understanding your Environment | Struct. | Silver Burdett Company, New Jersey, 1972 |
| United Kingdom | | |
| Nuffield Junior Science Project | Not struct. | Collins, London, 1967 |
| Science 5 – 13 | Not struct. | Macdonald Educational, London, 1973 |
| Teaching Primary Science | Not struct. | Macdonald Educational, London, 1978 |

**Most of these projects were structured and based on the development of scientific concepts or processes**.

**The development of these projects was deeply influenced by different factors of epistemological**, **technological**, **social and curricular nature (Sheme 1)**.

Scheme 1 – The influence of different factors on some projects of science teaching




## INNOVATION IN SCIENCE EDUCATION AT COMPULSORY SCHOOL LEVEL IN ITALY

### 1) An experience in the 70s inspired by the S.C.I.S. project

**The Science Curriculum Improvement Study** (S.C.I.S.) (5) is a research project developed during the eleven years, from 1963 to 1974, at University of California, Berkeley, directed by Prof. R. Karplus and financed by the National Science Foundation.

It is engaged in trying to find out how science can be taught to children in the elementary grades in such a way that the children will learn the fundamental concepts of both the physical and biological sciences.

**The teaching strategy** is as follows. (6)

Selected materials are brought into the classroom.

They may be nonliving objects or living organisms.

The children are allowed to observe or manipulate the material, sometimes freely in any way they wish and sometimes under the guidance of the teacher. The nature of the material and the objectives of the experiences determine to what degree the children's activity will be guided.

As a result of these preliminary explorations, the children have a new experience, a direct physical and mental contact with the natural world. This experience is essential if something more than behavior is to be learned.

At the next step, the teacher introduces the scientific concept that describes or explains what the children have observed.

This is called the "invention" lesson.

It is considered necessary because one cannot expect children to produce out of their own minds the concepts that have been invented by the scientific "greats" of the past. Following the

invention lesson, other experiences are provided that present further examples of the concept. These are called "discovery" lessons.

Through this procedure the child is expected to recognize that the new concept has applications to situations other than the initial example. In other words, the discovery experiences reinforce, refine, and enlarge upon the content of the concept.

The units of the S.C.I.S. program fall into a physical science sequence and a life science sequence, as illustrated in the following scheme.

S.C.I.S. Program Overview

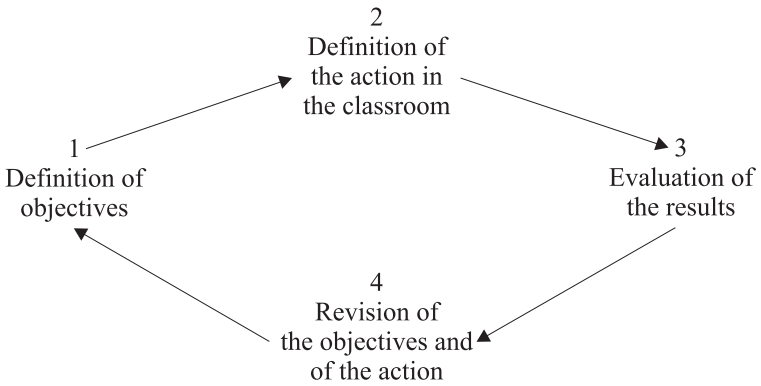
| PHYSICAL SCIENCE SEQUENCE | LIFE SCIENCE SEQUENCE |
|---|---|
| **Beginnings** | |
| Material Objects | Organisms |
| Interaction and Systems | Life Cycles |
| Subsystems and Variables | Populations |
| Relative Position and Motion | Environments |
| Energy Sources | Communities |
| Models: Electric and Magnetic Interactions | Ecosystems |

**During the 70s we effected a series of experiences in an elementary school in Leghorn in which we followed the same strategy suggested in the SCIS program, but with a modified content. (7)**

In this context the developed contents concerning chemical conceptual areas were those relative to interaction and systems, environments and ecosystems.

The teaching method was defined as guided-discovery method.

The approach model we followed with teachers may be represented as follows:




**The steps followed in preparing teachers to effect the activities with children were the following:**

a) Planning the activities.
b) Preparation of materials and organisms.
c) Experimentation of the various activities by pairs of teachers.

d) Revision of the activities.
e) "Transfer" of the various activities into the classroom.

The activities and the strategies followed during the realisation of this project had a great importance for children and teachers.

Children were involved in a large variety of stimulating activities which improved their knowledge of basic scientific concepts and processes, and their intellectual abilities.

Also the level of their capabilities of communicating improved greatly.

The teachers were invited to prepare material and organisms, to experiment the various activities and to discuss critically the results of their experiences, before effecting them in the classroom with children.

Most of them considered this kind of experience as a valid example of inservice teacher training, specially from the methodological point of view.

**2) Experiences of innovation in 80s and 90s**

In these years the chemistry and integrated science didactics research group of the University of Pisa continued its research, experimentation and retraining activities in collaboration with IRRSAE (Istituto Regionale di Ricerca, Sperimentazione e Aggiornamento Educativi), Tuscany. (8)

***(i) Activities at the elementary school level***

In Italy new programmes were introduced into elementary schools in September 1987 and science teaching, for the first time in the history of our schools, now plays an autonomous role. The new science programme is based on the following five themes:

1) physical and chemical phenomena;
2) the environment and natural cycles;
3) organisms: plants, animals and man;
4) man and nature;
5) the man-made world.

References to the chemistry content are present mainly in the first of these themes, but also in the others.

Starting from these programmes, in the pluriennial in-service training programme for elementary school teachers we tried to attain the following objectives and to develop the following contents:

*Objectives*

(a) Acquisition of a minimum, but correct, level of chemical language.
(b) Acquisition of some basic chemical concepts, in relation to childre»s congnictive development.
(c) Acquisition of some chemical processes.
(d) Acquisition of a first level of awareness of the importance that chemical knowledge plays in the relationships between people, society and the environment.

*Contents*

**(a)** Contents relative to the structure of chemistry:
(1) Physical states of matter;
(2) Changes of state;
(3) Systems (mixtures and solutions);
(4) Chemical substances (with particular reference to their danger and toxicity);
(5) Chemical interaction;
(6) Acids and bases.

**(b)** Relevant contents of chemistry.

These contents were relative to the relationships between chemistry, society and the environment, and concerned the great problems of contemporary society: health, the environment, food, energy resources, etc.

***(ii) Activities at middle school level***

At this age-level (pupils 11–14 years old) the experimental sciences and mathematics are taught together. The experimental science programme is based on the following five themes:

1) matter and physical and chemical phenomena;
2) the earth in the solar system;
3) structure, function and evolution of living things;
4) man and environment;
6) scientific progress and society.

**In relation to this program and in accordance with Ausubel's theory the following six units of instruction were prepared and experimented in some Italian middle schools:**

1) The physical states of matter;
2) Changes of state;
3) Solutions;
4) Elements and compounds;
5) Chemical interaction;
6) Acids and bases.

**Educational strategies**

Chemical activities are carried out experimentally, children working in pairs. The classroom is organized with low-cost, flexible and safe materials.

One of the most important aspects of the teacher's rôle is to stimulate curiosity and discovery by pupils.

An important starting point for each activity should be a knowledge of the children's preconceptions.

Concerning the activities at middle school level, it is evident, from the results obtained, that at the end of this level some confusion about diversified conceptual areas is still present in the pupils' minds. With the aim of helping pupils overcome the difficulties encountered, a constructivist learning model of teaching was developed.

## THE PRESENT SITUATION: PERSPECTIVES, ACTIVITIES AND PROBLEMS

Following all the activities developed in the last decades, what are the present-day prospects for the future? What are the main activities in progress in the Universities of Tuscany? And finally what are the main problems?

**Prospects**

Our present Italian scholastic system is articulated as follows: five years of elementary school, three years of middle school, five years of secondary school.

For the near future the most important prospect concerns the reform of our scholastic system, which is in progress. On the basis of this reform the future structure of our scholastic system will be articulated in two levels: primary and secondary levels.

The primary school will have a duration of seven years and will start after one year of preparatory school; it will be divided into three cycles of two years each, followed by one year of transition to the secondary school. The secondary school, will have a duration of five years.

**Activities in progress**

There are several activities in progress, organized by different bodies and organisations; the most important of these activities is the school of specialisation for preparing middle and high school teachers in all disciplinary sectors. In fact this 2-year postgraduate course started in March 2000 and in the three Tuscan Universities (Florence, Pisa and Siena) we had about 80 science student – teachers. For this academic year (2000–2001) we'll have students of two courses.

The contents necessary for the preparation of science teachers involve didactic activities and relative passes in the following areas (9):

***Area 1: training as a teacher***

This includes didactic activities aimed at the acquisition of necessary attitudes and competence in the science of education as well as in other aspects relative to the position of teacher. (200 hours for two years).

***Area 2: subject-specific training***

This includes didactic activities aimed at the acquisition of attitudes and competence relative to subject methodology, with particular attention to the logical aspects, the genesis, historical development, epistemological implications, practical meaning and social functions of each branch of knowledge. (1° year: 150 hours; 2° year: 60 hours)

***Area 3: laboratory*** with specific reference to the formative contents of various subjects. (1° year: 120 hours; 2° year: 80 hours)

***Area 4: teaching practice***. (160 hours)

**Profile of a mathematics and science teacher for middle school**

In relation to the present-day organization of the middle school, it is held that the most suitable profile for a mathematics and science teacher is that of a single teacher who has specific training in five subjects involved in the present ministerial programnmes: 1) mathematics with elements of computer sciences; 2) biology; 3) physics; 4) chemistry; 5) earth sciences.

For students who are not graduates in mathematics, physics or chemistry, one of the two subjects must necessarily be mathematics. The relative preparation will require an increased length of time for theoretical studies, laboratory activities and teaching practice.

**Problems**

During all pre-service training activities organized at the University of Pisa before the start of the school of specialisation and also during the first year of this school, the most important problem we had was really the realisation of coordinated or integrated teaching between the various disciplines. In fact, each group of University professors did their teaching separately from the others.

We need to overcome this kind of teaching and find a more coordinated and integrated model of teaching.

**CONCLUSIONS**

For many years in different countries the problem of integrated science teaching has been discussed and some suggestions for solving the problem have been advanced.

Neverthless, several trials conducted in recent decades in Italy at various school levels in the aim of integrating different subjects, show that this problem is not easy to solve in practice and raises the following questions for discussion:

1) Is the hypothesis for science teacher training at compulsory school level planned for Tuscany comparable to training models followed in other European countries? If not, what are the basic differences?

2) At this scholastic level, is it correct to train future teachers in the science area in 2–3 different subjects and then attempt subject integration or would it be better to research a unified science model on which to train teachers?
3) Integration techniques used up to now for the curricular development of integrated sciences are based on the following points of view:
   i) scientific (concepts, scientific processes and the nature of science)
   ii) practical (applied for example to industry, the environment, the family)
   iii) social (historical, technological, social problems)

**Today, which of these points can be held to have prevailed over the others in the European context?**

**In Europe today, are there new programmes allowing for a more efficient level of integration between the various subjects followed?**

## References

1) Conseil International des Unions Scientifiques (CIES): Congres sur l'integration des enseignements scientifiques, Droujba (Bulgaria), 11–19 September, 1968, CIES, Boulevard Pasteur 3, Paris XV.
2) T. GADSDEN, P. Becht, G. Dawson, The design and content of integrated science courses, in "New trends in integrated science teaching", vol. V, Unesco, Paris, 1979, p. 41.
3) Science. 5–13 series, Mcdonald Educational, London, 1972–75.
4) A. BLUM, Vers une théorie de l'enseignement intégré des sciences, in "Tendances nouvelles de l'enseignement intégré des sciences", vol. II, Unesco, Paris, 1975, p. 40

   A. BARGELLINI, S.Fedi, Il contributo delle scienze all'educazione ambientale, in Inserto redazionale a "Scuola e Didattica" n. 16, anno XXXV, Editrice La Scuola – Brescia, 15 May 1990.
5) Science Curriculum Improvement Study, Rand McNally & Company, P.O.Box 7600 Chicago, Illinois 60680.
6) C.A. LAWSON, So little done, so much to do, Science, Curriculum Improvement Study, Lawrence Hall of Science, University of California, Berkeley, California 94720.
7) A. BARGELLINI, C. Roncaglia, Osservo, Cerco, Scopro, esperienze di educazione scientifica nella scuola elementare, Quaderni di Corea, quinta serie, Libreria Editrice Fiorentina, Firenze 1973–74

   A. Bargellini, Voglia di scoprire, esperienze di educazione scientifica nella scuola elementare, Quaderni di Corea, sesta serie, Libreria Editrice Fiorentina, Firenze 1975–76.
8) A. BARGELLINI, Studio di un caso: il modulo di scienze, in Acts of the International Seminar organized by IRRSAE Tuscany in collaboration with A.T.E.E. on the theme "Innovation in primary education in Italy, planning and training", Florence, 1991, p. 147

   BARGELLINI, L. Lardicci, G. Raspi, P. Riani, The renewal of chemistry teaching at compulsory school level in Italy: the contribution of Pisa University, Acts of the International Newsletter on Chemical Education. IUPAC-December 1989, n.32, p. 3

   BARGELLINI, P. Riani, Children's conceptions in chemistry at elementary school level and some implications for inservice training of teachers. European Journal of Teacher Education, 1991, 14,9

# Interdisciplinary Education Within the Framework for Science Education in Germany

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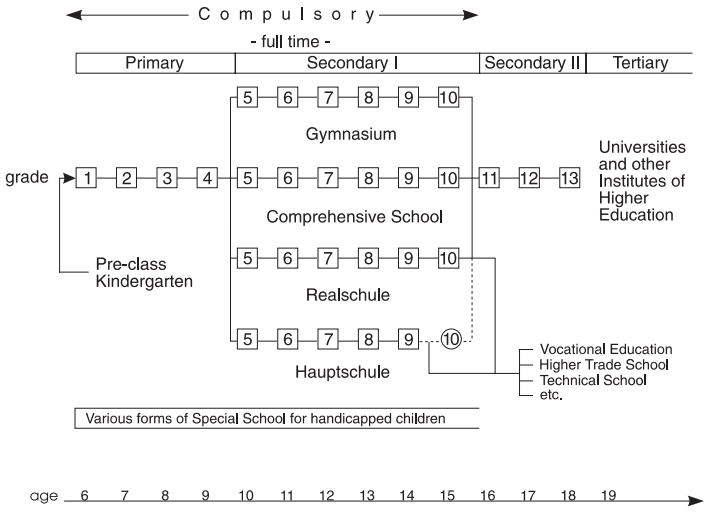
## 1. Background Information

After unification in 1990, the Federal Republic of Germany comprises sixteen Laender (states). Areas of government jurisdiction are divided between the federal government and the states. Education for compulsory schooling falls into the exclusive jurisdiction of the states. Authoritative control includes regulation of the curriculum, time schedules, professional requirements, teachers, school buildings, equipment and recruitment of teachers. Only about four to five percent of the children attend private schools, which are financially supported and supervised by state authorities too.

On the other hand, the federal constitution guarantees equal opportunities to everyone. Therefore, although independent in the educational sphere, the Laender have to coordinate their domain; and they have a long tradition in doing so as Germany has always been federal. There is a high degree of accepted benchmarks, e.g. concerning which subjects are to be included in the core curriculum and to what extent they are to be taught. The Laender coordinate their educational policy through the institution of the Standing Conference of Laender Ministers of Education (KMK). Decisions have to be taken unanimously, becoming legally binding through promulgation in the form of state laws, decrees or regulations by Laender authorities.

To make things more complicated: Germany is a federal state. Generally speaking, compulsory schooling commences at the age of six and finishes at eighteen. Nine (or ten) of these years have to be spent in full-time schooling; the following years either in full-time schooling or part-time vocational schools, e.g. in connection with an apprenticeship. The structure of the school system is given in the following figure.

Figure 1: Structure of the School System in the Federal Republic of Germany[1]



**Pre-school:** The Kindergarten for three to six year-olds is not directly linked to the education system and attendance is voluntary.

**Primary:** The Primary School (Grundschule) is the lowest level of the educational system attended by all pupils. It comprises grades 1 to 4 (6 to 10 years-old pupils).

**Lower Secondary Level** (10 to 16 year-old pupils) offers differentiated teaching in accordance with young people's ability, talent and inclination and includes:

– the **Hauptschule** (grades 5 – 9/10)
– The **Realschule** (grades 5 or 7 – 10)
– the **Gymnasium** (grades 5 – 10)

and as a school experiment in all Laender and as a normal form of school in some Laender

– the Integrated and the Cooperative **Comprehensive School**.

According to the special task of the types of school one finds many differences in the time-schedule and even in the subjects.

In 1997, the distribution of the 14/15 year old pupils (grade 8) is as follows:

| | |
|---|---|
| Hauptschule | 27.8% |
| Realschule | 28.8% |
| Gymnasium | 30.2% |
| Comprehensive Schools (including Waldorf schools) | 9.2% |
| Special Schools | 4.0% |

**Upper Secondary Level** (16 to 19 year-old pupils) offers a three year course, which leads to university entrance qualification (Abitur). Since the mid 1970's the course is no longer organized in terms of types of Gymnasium (classical, modern languages, mathematics and science), but is replaced by a system of basic and specialized courses as well as compulsory and optional ones.

Upper Secondary Level also encompasses full-time or part-time vocational education. The West German "dual system" of vocational education involves cooperative apprenticeships at two learning sites: the school and the workplace. Enterprise-based vocational training then has two sponsors: the Laender governments establishing and financing vocational schools, together with enterprises themselves financing and providing apprenticeships. Correspondingly, responsibility in enterprise-based vocational education is also split. The authority shared between the Laender Ministers of Education, the Federal Minister of Education and Science, the Federal Institute for Vocational Training and representatives of industry, commerce, the skilled trades and trade unions.

**Handicapped children** attend various forms of Special Schools.

The schools are financed in three ways:

a) The personnel costs (= teachers) are paid by the states. The teachers (who are usually state civil servants) are assigned to the schools according to the number of pupils enrolled.
b) The non-personnel costs (such as building maintenance, equipment, laboratories, libraries, etc.) are paid by the county, whereby the state contributes to new construction and larger investments.
c) In some states parents have to pay for textbooks and learning materials. In others states the costs are mainly covered by the county (b).

**Teacher training** for teachers at all kinds of schools – with the exception of those at pre-schools/kindergartens, and the technical instructors at general and vocational schools – takes place at univer-

[1] All data concerning the school system has been taken from Riquarts Wadewitz, 2nd ed., 1999.
The figure shows the main system. There are three major differences:
(1) In some states, grade 10 of Hauptschule is compulsory.
(2) In two states, grades 5 and 6 belong to Primary; in one state they form a separate type of school.
(3) In four states (of former East Germany) Upper Secondary Level has grades 11 and 12 only.

sities and institutes of higher education. Admission to training depends on possession of the Abitur (school leaving certificate/university entrance examination). Two training phases can be distinguished.

a) **Academic studies** – i.e. scholarly training in educational and social studies, but mainly in the two subjects to be taught in school later. This concludes with Part I of the degree examinations.
b) The introduction to **school practice** (on-the-job training) takes between one and three years depending on the job involved. This phase comprises practical involvement in schools and complementary training at seminars. This concludes with Part II of the degree examinations.

**2. The Locus of Science Education in the Overall Curriculum**

In Primary School a five or six day school week is divided up into 20 or 25 class periods (45 minutes each), of which Sachunterricht (could be translated as "teaching about things" or "teaching about real objects") covers 3 or 4 periods per week on the average – where usually one third is devoted to science-related topics.

On **lower secondary level** a six or five day school week is divided up into 30 to 35 class periods (45 minutes each). Taught are the subjects biology, chemistry, physics and to some extent in some Laender – technical science. The extent to which science is taught varies according to the different type of school as well as between the Laender; increasing differentiation of teaching in terms of subject-specialization is another characteristic for the secondary education course.

The main differences between the Laender are:

(a) Grade in which science education starts:
Biology starts in grade 5, physics in grades 5 to 8, chemistry in grades 5 to 9.
(b) Interruption in science education:
The interruption phase for each of the three subjects lasts up to one year; the earlier natural science teaching is begun, the more likely it is that there will be an interruption.
(c) Total amount of science education at lower secondary level.
The overall time devoted to science during grades 5 to 10 differs from 14 to 30 periods per week, which means 2 to 6 periods per week per year. In those states with few compulsory science lessons half of the time is usually devoted to biology; when more time is available for science, it is for the benefit of physics and – to a lesser extent – of chemistry.
(d) Science syllabi:
Each state has its own official curriculum or syllabus which differs for each type of school (16 states times 4 types of schools at lower secondary level equals 64 syllabi for biology, 64 for physics, etc.). The main differences are not to be found in the topics to be taught, but rather in the delegation of the contents to varying class levels and in the varying didactical conceptions.

After completion of full-time compulsory schooling, about 30% of the age group goes on to full-time upper secondary level schools, about 60% start their vocational training in the dual system described above.

At **upper secondary level** – full-time schooling – (grades 11 to 13) science is compulsory on a basic level for at least two years. But the students still have a choice of the subject – biology, chemistry, physics. On the average, biology is chosen twice as often as physics and chemistry. At upper secondary level the students have to choose two specialized 2-year courses. On the average of all Laender, 40% of the students take biology, 16% physics, 13% chemistry. Optional courses may be chosen, e.g. in astronomy, technology, statistics, data processing.

**Upper secondary vocational training/schooling** operates in a dual system involving on-the-job training and part-time attendance at a vocational school. Responsibility for supervising the former lies with the federal government and for the latter with the Laender. This apprenticeship system is financed by the Laender (by financing the vocational schools) and by the enterprises

(offering youngsters jobs and paying them an apprentice salary). At the moment schooling is one day a week and will gradually be extended to two days within the coming years. The subjects are (a) core ones, e.g. German, Mathematics and Social Sciences, and (b) specialized classes for specific jobs. Figures clearly show gender differences: the male apprentices prefer applied science jobs, whereas the female apprentices tend to prefer clerical professions such as consulting room assistants and "helping" professions such as doctor's assistants.

## 3. Starting Points for Interdisciplinary Science Education

From what was said about the school organization, the structure of the curriculum and of teacher training, it is obvious that all instruction is based on the content of a single subject.

Looking into European educational history since the early 19th century, nothing in schooling and society seems to be so stable and unchanged as the school subjects and the resulting categories in the school canon which – at the same time – are correspondingly connected to the university reference disciplines: in Germany at least up to now, the single school subject is the frame of reference and action (Hopmann & Riquarts 1999, p. 7).

The international discussion concerning interdisciplinarity in general and about interdisciplinary instruction in school has, of course, been brought up in Germany. The point of origin is the argument that the school subject stands as the archetype of the division and fragmentation of knowledge within our societies (e.g. Kliebard 1986, Haft & Hopmann 1990).

Following the specialization of university research areas, educational policy set the frame for state schooling: structuring the teaching according to the academic disciplines necessarily leads at once to fragmentation of knowledge within subject boundaries. Giving primacy to the school subject in the resourcing of schooling therefore means giving the way free to promoting a narrowing of a broader discourse about schooling.

Seeing these needs, most syllabus commissions in Germany try to overcome this restriction with regard to a single subject approach. They take into account the shortcomes of teacher training with respect to interdisciplinary approaches.

In the following, four types of approaches to the recognized necessities of interdisciplinarity are stated – all of which start from the single subject as the frame for the guiding curriculum.

### 3.1. Opening the Single Subject to Related Content Areas

Nowadays numerous syllabi try to overcome the problematic fragmentation of knowledge – due to the single subject structure of the syllabi – by introducing some topics in the subjects which overlap and showing how these topics could be integrated in the lessons of the various subjects in question. To give an example:

The syllabus for the state of Baden-Wuerttemberg (KM Baden-Württemberg 1994) indicates five interdisciplinary topics for each grade. The theoretical aspects of these topics refer to the compulsory contents in the subjects concerned. At least one of these interdisciplinary topics is mandatory. The following gives a concrete example of what is meant:

Grade 8 designates the following five themes:

| Themes | Related subject and Unit |
|---|---|
| 1 The World of Islam | Protestant religious instruction Unit 8.10 |
| | Catholic religious instruction Unit 8.3 |
| | Geography Unit 8.5 |
| | History Unit 8.3 |
| | Ethics Unit 8.2 |
| 2 The Forest as an Eco-System | Geography Unit 8.4 |
| | Biology Unit 8.3 |

| | |
|---|---|
| 3 From Waves to Sound | Physics Unit 8.1 |
| | Music Unit 8.1 |
| 4 The Opening up of America | Geography Unit 8.3 |
| | History Unit 8.4 |
| | English (language) Unit 8.2 |
| | Music Unit 8.2 |
| 5 Opera and Drama | German (language) Unit 8.1 and 8.2 |
| | Music Unit 8.3 |

This kind of interdisciplinary approach is nothing new to someone whose profession is first and foremost 'teacher' – he or she always made links to related areas. What is new here is for teachers at a Gymnasium – that they are asked to teach something which is not part of their studied background: it is beyond their professional domain and they are forced to teach it.

### 3.2. Profile Development Through Optional Courses

There is a long tradition of having various different types of Gymnasiums in Germany (e.g. profiles in the languages, the sciences, the arts or sports). At lower secondary level this kind of specialization amounts to four to six periods a week: when two numbers are given, the lower is the minimum for all students, the higher is for Gymnasiums with a science profile). In a Gymnasium with a language profile, these weekly periods are used for a third foreign language, in a Gymnasium with a science profile for more science lessons.

In the Realschule, the second foreign language is not compulsory. Those students not taking a second foreign language are offered a variety of optional courses, e.g. informatics, economics, technology or arts. These optional courses are usually not organized in such a way that one could identify a school's profile.

A recent development in the state of Lower Saxony (KM Niedersachsen 1997a+b) is remarkable in this connection. Based on the KMK Agreement of 1993, it was possible to also apply the curriculum guidelines in the Hauptschule and the Realschule, thus making profile development feasible. Using 'more autonomy for the individual school' as a catchword, they began to set down the minimum number of hours for the separate disciplines according to the KMK Agreement as well as the maximum number to which the individual areas of study could be expanded. This holds true (similar to the guidelines for the Gymnasiums) for the sciences, social science, arts, technology/economics and sport. A conference made up of teachers and parents is responsible for deciding on a school's profile, i.e. in which area an emphasis is to be placed. In order to enable interdisciplinary project teaching, it is possible to enmesh two subject fields, e.g. science and technology/economics.

### 3.3. The Subject 'Physics-Chemistry'

In nearly half of the German states, you find the subject 'physics/chemistry' in the time schedule for the Hauptschule. This subject description leads one to believe that two subjects are taught in conjunction two periods a week. A glance at the corresponding syllabus, in this case from Bavaria, shows the following topics:

grade 6: aggregate conditions
- temperature change causes volume change
- how heat travels
- characteristics of materials
- metals
- distribution and reflexion of light
- development and distribution of sound waves

grade 7: electrical circuits
electric power
permanent and electromagnets
movement
gravity
combustion as a chemical reaction
acids and bases
grade 8: using machines to conserve energy
work and energy
voltage
resistance
work and achievement
structure of materials
salts as an important connection
grade 9: petroleum and coal
creating tension by induction
structure and mechanics of a transformer
electricity in the home
radioactivity
production of electricity in power plants
electronic components

The first impression of this topic survey is not misleading: inspite of the course designation it is not a coordinated one, but a physics course with some chemistry units. This is mainly due to the fact that there are hardly any teachers who studied both topics, whereby competency in chemistry is more seldom. Or, to put it frankly, as Schleip (1994) said, "the ministers of education should honestly admit that students at a Hauptschule learn nothing about the world of the elements that surround them in their daily lives and are so important for their live quality" (author's translations, p. 59).

### 3.4. Integrating the Sciences

In the seventies, the discussion about American, Australian and English developments in integrated science education also lead to discussion in Germany about how such teaching could be structured and made functional with regard to common educational purposes (see Buck 1992). No new curriculum, based on the theoretical discussion of an integrated syllalbus with an interdisciplinary foundation, was created. Individual materials using the three natural sciences as a basis, were, however, developed (see Imberg, May 1976).

The failure of this development can mainly be explained by two reasons:

a. Based on the structure of teacher training, there are no teachers available for this kind of teaching; just as the teacher trainers were unable to sufficiently mediate these new didactic concepts.
b. The top-down development model of curriculum development gave those concerned – as in the Anglo-Saxon countries – little support once the materials were prepared in using the innovation in everyday teaching.

Contrary to the threefold school system in traditional secondary education, the comprehensive schools founded in the seventies were interested in integration, but the practical side of organizing the lessons (theme centered approach) as coordinated science teaching can be so termed, i.e. in the sense of the Nuffield Combined Science Curriculum.

A new approach for integrating the sciences was started in 1990 by the comprehensive school teachers in the state of Schleswig-Holstein. They were dissatisfied with the status quo, i.e. with the effects of science teaching in terms of students' success and motivation. The project which arose was

called PING – Practicing Integration in Science Education (see Projektkerngruppe PING 1996). The new approach was to take into account the students' interests, pre-conceptions, learning abilities and special needs with regard to instruction as well as shift to more pupil – centered teaching and learning strategies which take students' demands more seriously. Three types of goals should be achieved:

- **Integration**, seen as a process leading to new ways of thinking and knowledge in students' minds, conceptualized and practiced by means of exploring common human experience and decision-making, of researching manifest relationships of man and nature, of using methodology and processes of science and of learning central concepts and principles.
- **Promoting student action** in a non-destructive approach to nature by recognizing and respecting fundamental human needs and rights for all people, which include safeguarding nature's development, allowing each person his or her self-realization which fully respecting the needs, rights and chances of others, avoiding harm and practicing responsibility towards others, nature and self, and striving for knowledge and capability.
- **Development of values** based on humane and democratic education for all, including ideas of equality, freedom and solidarity, and, thus, e.g. satisfying needs and interests of girls.

PING materials have been or are being developed for grades 5 to 10, based on the relationship of man to nature: how it is, how it has developed and how it could be.

At present, teachers from some 50 schools in twelve of the sixteen states are working with the PING materials. The schools are mainly comprehensive ones, but an increasing number of schools from the traditional threefold system are joining in because they would like to offer integrated science education as well.

Knowing the problems with earlier integrated science approaches, viz. to overcome the reasons for their failure, a concerted action of teachers, researchers, in-service trainers and administrators was set up to establish a communicative and participating system of collaboration. The teachers are seen as playing the key role in the innovated process, then the other agencies (e.g. researchers and in-service trainers) play a strictly supportive function, vital for the whole innovation, as most of the teachers involved had neither training in all three of the sciences, nor in integrated approaches. Measures taken in the PING project include the establishment of a coordination center for organization, revision and consultation for information exchange (preferably through electronic media), for organizational development and for revision of existing materials and their distribution, as well as a flexible in-service structure matching the specific needs of teachers on short notice (for details see Riquarts, Hansen 1998).

## 4. Concluding Remarks

In overcoming the fragmentation of knowledge for the learners due to organizing school subjects according to university disciplines, different steps have been widely discussed in education and didactics during the last decades (e.g. Saez & Riquarts 1999):

– integrating the sciences
– including technological and societal aspects in the curriculum (STS approach)
– Science for All initiatives (changing the goal of schooling)
– widening the educational context by including the idea of scientific culture
– obtaining a global perspective of educational aims in using the concept of Sustainable Development, thus introducing the economic perspective into the curriculum.

These theories – known from discussions in education, especially in Scandinavia and the Anglo-Saxon countries and from school practice – have not – yet? – prevailed in Germany.

Following the primacy of a single approach under the constraints of the increased specialization of knowledge (Andersson 1995) leads German syllabus commissions to look for ways to bridge the gap in the student's understanding of a global reality to gain access to the world and to

participate in it. The approaches mentioned might be regarded as marginal, but one can consider them cautious as they neither take into consideration the single teacher's education, nor his/her socialization and professional self-concept, nor – of course – students' problems in connecting the bits of knowledge from various subject disciplines.[2]

The four types of interdisciplinarity mentioned found by 'looking' across the border in the various syllabi in Germany are a way of opening the view in neighboring areas – and even unfamiliar contents – without losing the basic frame of the familiar structure: the single school subject. This reference to the familiar is valid for both students and teachers alike.

Assuming the goal of interdisciplinarity is the right way to achieve the desirable educational aims of today, the forces hindering this achievement can be stated as follows:

Following the 19th century based structure of education, the German school systems follow a division of subjects oriented towards the university division of knowledge and the, thus, connected fragmentation of knowledge. On the other hand it has given the teaching profession greater academic value: Teachers are primarily specialists in their (subject) area, at the same level with certified physicists, chemists, etc. (also regarding pay), and no mere agents who communicate knowledge for the purpose of educating individuals.

In order to attain the goal of interdisciplinarity it is necessary to separate teacher training from subject-oriented education and to direct teacher training towards what is to be achieved in school: generally speaking, away from what is the (university) subject to what is needed in school.

Whether such a restructuring (and the thus resulting professional downgrading in the eyes of the teachers concerned) can be carried out is doubtful – as stated earlier, it is only desirable when the interdisciplinarity goal to be attained can clearly be seen as the best way to achieve an appropriate education in this century.

## 5. Literature

ANDERSSON, B. (1995). On knowing through integration. Paper presented at the conference "A debate on European action for scientific culture in education". Lisbon, European Commission and Gulbenkiane Foundation.

BUCK, P. (1991). Didaktik integrierten naturwissenschaftlichen Unterrichts. (Didactics of integrated science teaching). In K. Riquarts et al. (eds.), *Naturwissenchaftliche Bildung in der Bundesrepublik Deutschland, Bd. 3.* (Science Education in the Federal Republic of Germany, Vol. III). Kiel: IPN, pp. 159–189.

GOODSON, I., Hopmann, S. & Riquarts, K. (eds.) (1999). *Das Schulfach als Handlungsrahmen* (The School Subject as Frame for Action). Köln: Böhlau.

HAFT, H. & Hopmann, S. (eds.) (1990). *Case Studies in Curriculum Administration History*. New York: Falmer Press.

HOPMANN, S. (1999). Lehrplanarbeit und Reformpädagogik. Anmerkungen zu einem schwierigen Verhältnis (The Work of Syllabus Commissions and Reform Pedagogy). In: Oelkers, J. & Osterwalter, F. (eds.): *Die neue Erziehung. Beiträge zur Internationalität der Reformpädagogik*. Bern: Lang.

HOPMANN, S. & Riquarts, K. (1999). Das Schulfach als Handlungsrahmen – Traditionen und Perspektiven der Forschung (The School Subject as a Frame for Action). In: Ivor F. Goodson et al. (eds.) *Das Schulfach als Handlungsrahmen*. Köln: Böhlau, pp. 7–28.

[2] These basic conditions set the limits for the experiments so popular in the 90's which were to overcome – or at least – 'soften' the subject borders, either by means of 'interdisciplinary instruction' or by topic oriented project lessons which are taken from the quasi-natural undisciplinarity of the out-of-school problems. One could look for reasons why these forms of teaching appear and disappear in cycles (cf. Hopmann 1999), or why they have proven to be less productive for poorer learners (cf. Weinert 1996).

IMBERG, K., May, R. (1976). *Unterrichtsmaterialien zum integrierten Curriculum Naturwissenschaft*. (Teaching Materials for the Integrated Science Curriculum.) Kiel: IPN (IPN-Arbeitsberichte 29).

KLIEBARD, H. (1986). *The struggle for the American curriculum 1893–1953*. London: Routledge and Kegan Paul.

KMK (Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (1993). *Vereinbarung über die Schularten und Bildungsgänge im Sekundarbereich I*. Beschluß vom 3.12.1993. (Agreement About the Types of Schools and Courses of Instruction at Secondary Level I.) Resolution of 3 December 1993.

Kultusministerium Baden-Württemberg (1994). Bildungsplan für das Gymnasium. Erlaß v. 4. Februar 1994. In: Kultus und Unterricht. Baden-Württemberg Lehrplanheft 4/1994.

Kultusministerium Niedersachsen (1997a). *Die Arbeit in der Hauptschule*. Erlaß v. 25. März 1997. (Work in the Hauptschule. Regulation of 25 March 1997.) In Schulverwaltungsblatt Niedersachsen 4/1997, pp. 110–117.

Kultusministerium Niedersachsen (1997b). *Die Arbeit in der Realschule*. Erlaß v. 25. März 1997. (Work in the Realschule. Regulation of 25 March 1997.) In Schulverwaltungsblatt Niedersachsen 4/1997, pp. 118–125.

Projektkerngruppe 'Praxis integrierter naturwissenschaftlicher Grundbildung' (PING) (Juli 1996). *Was ist PING?* Kurz-Informationen zu Status – Konzeption – Entwicklung. (What is PING? Short Information About its Status – Conception – Development.) Kiel: IPN.

RIQUARTS, K. et al. (eds.) (1990–1994). *Naturwissenschaftliche Bildung in der Bundesrepublik Deutschland*, 4 Bände. (Science Education in the Federal Republic of Germany, 4 volumes). Kiel: IPN.

Band 1 (1990). *Bedingungen und Einflußgrößen naturwissenschaftlich-technischer Bildung*. (Conditions of Influences on Science and Technology Education). Kiel: IPN.

Band 2 (1994). *Naturwissenschaftliche Bildung in öffentlichen und privaten Institutionen* (Science Education in Public and Private Institutions). Kiel: IPN.

Band 3 (1991). *Didaktiken naturwissenschaftlicher Fächer und naturwissenschaftsbezogener Lernbereiche.* (Didactics in Science Subjects and Science Related Areas of Learning). Kiel: IPN.

Band 4 (1992). *Aktuelle Entwicklung und fachdidaktische Fragestellungen in der naturwissenschaftlichen Bildung* (Current Developments and Subject-Oriented Questions Concerning Science Education). Kiel: IPN.

RIQUARTS, K., Hansen, K.-H. (1998). Colloboration among teachers, researchers and in-service trainers to develop an integrated science curriculum. *Journal of Curriculum Studies, 30* (6), 661–676.

RIQUARTS, K. & Wadewitz, C. (1999). Framework for Science Education in Germany. 2nd revised edition. Kiel: IPN.

SAEZ, M. & Riquarts, K. (1999). Sustainable Development as a Topic of Integration Science Curriculum. In: Keogh, M. & Naidoo, S. (eds.) *Proceedings of the 9th Symposium of the International Organization for Science and Technology Education*. Durban: University of Westville, pp. 564–568.

SCHLEIP, A. (1994). Chemieunterricht in Hauptschulen. (Chemistry Instruction in Hauptschulen.) In K. Riquarts et al. (Eds.), *Naturwissenschaftliche Bildung in der Bundesrepublik Deutschland, Bd. II*. (Science Education in the Federal Republic of Germany, Vol. II). Kiel: IPN, pp. 57–72.

WEINERT, F.E. (1996). Lerntheorien und Instruktionsmodelle (Theories of learning and models of instruction). In: Weinert, F.E. (ed.). Psychologie des Lernens und der Interaktion. Enzyklpädie der Psychologie, Bd. 2. Göttingen: Hogrefe, pp. 1–48.

# Teaching Natural Science in Primary Schools in Poland

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Natural science began to be taught at schools already before World War II. At that time the integrated subject, combining information from biology, mineralogy, geography, physics and chemistry, was first introduced to schools. The aim of this action was to evoke the pupils' interest in the natural environment, to train them in the ability to make observations, find cause-and-effect relations and formulate conclusions in a precise and accurate manner. The emphasis was no longer put on merely memorising data, but rather on discovering information about life in the process of the pupil's own work.

Unfortunately after World War II the idea of teaching subjects related to the natural environment was changed and separate subjects of biology, geography, physics and chemistry were introduced to the teaching programme at the beginning of the fourth year of primary school. During their first three years of school pupils still had a subject called 'the environment', however it was only distantly related to the pre-war 'natural science'. Not long ago the subject came back, which was connected with the reform of the educational system that was introduced to schools on September 1st, 1999.

The reform brought many changes, both in the teaching programme and the structure of the educational system. Greatest changes affected the organisation of teaching process. Instead of the eight-year primary school and four-year general secondary school (*liceum*), there appeared the six-year primary school, the three-year post-primary school (*gimnazjum*) and the three-year profiled secondary school.

Obviously, changes in the structure of the education system are closely bound with a new approach to information and teaching. It would be very difficult to present here all the changes, even very briefly. The most noticeable ones affected the primary school, where education is now integrated during the first three years, and grouped in thematic areas in years 4 to 6.

One of these groups is natural science. It contains elements taught so far during four separate subjects: biology, geography, physics and chemistry.

The assumptions and objectives of the new subject were included in the outline of teaching programme issued by the Ministry of Education. According to the document, the most important objectives of teaching natural science at school are as follows:

- To develop the pupils' interest in the world surrounding them
- To present the unity of nature and the co-relations between the animate and inanimate nature
- To make the pupils aware of the basic phenomena and changes in the surrounding environment
- To make the pupils aware of the most important principles that govern the processes happening in nature
- To develop the ability to make simple experiments
- To develop the ability to understand relations in the natural environment and the consequences of imbalance in nature
- To develop environment-oriented sensitivity by making the pupils aware of the co-relations between man and the surrounding environment
- To communicate the basic knowledge necessary for the future learning process in the post-primary school

Several programmes of teaching natural science in primary schools have already been developed. Unfortunately, the majority of them have a tendency to maintain the traditional division of content between separate subjects: biology, geography, physics and chemistry. They also do not include any detailed guidelines how and to what extent particular topics should be covered.

Natural science should be an integrated subject, presenting the world as an entity, the elements of which are closely bound and depend on one another. Obviously, this does not mean that every lesson of natural science should necessarily contain elements of physics, chemistry, biology and geography. There have to be lessons, or even whole sections, devoted to only to one of these sciences. The real point is to show their co-relations wherever it is possible.

Taking this into consideration, the team of authors (...) has prepared a programme for teaching natural science in primary school. The titles of particular thematic sections, divided between particular school years, are as follows:

| | | |
|---|---|---|
| | 1. YEAR 4 | |
| Section 1: | WE LEARN NATURAL SCIENCE | – 24 lessons |
| Section 2: | THE EARTH | – 23 lessons |
| Section 3: | WATER | – 20 lessons |
| Section 4: | THE AIR | – 16 lessons |
| Section 5: | ENERGY | – 10 lessons |
| | 2. YEAR 5 | |
| Section 1: | WE ORGANISE THE INANIMATE WORLD | – 16 lessons |
| Section 2: | THE WORLD OF LIVING ORGANISMS | – 34 lessons |
| Section 3: | JOURNEY ON THE MAP OF POLAND | – 21 lessons |
| Section 4: | HOW DOES THE WORLD WORK? – MOVEMENT AND FORCES | – 19 lessons |
| | 3. YEAR 6 | |
| Section 1: | THE UNSEEN WORLD OF ATOMS AND MOLECULES | – 14 lessons |
| Section 2: | THE HUMAN BEING | – 22 lessons |
| Section 3: | LANDSCAPES OF THE EARTH | – 26 lessons |
| Section 4: | THE AMAZING NATURAL PHENOMENA | – 22 lessons |

A programme, even a most carefully prepared one, is only a collection of phrases and does not contain detailed information about the taught material. The programme we have prepared, apart from information divided into particular sections, also contains a commentary – suggestions of experiments, practical exercises, as well as detailed suggestions how and to what extent particular sections should be taught.

Now I will try to present briefly the contents of our programme. We start with the section "We learn natural sciences", the aim of which, briefly speaking, is to introduce the new subject to pupils. The actual teaching programme for year 4 contains four sections: the Earth, Water, the Air and Energy. These sections were designed as separate entities, each of them containing basic information about a given subject, taken from various natural sciences. We tried to limit the content to the most essential topics and to present as comprehensible and interesting to pupils. As an example I will discuss one of the sections prepared for year 4, which deals with water as the leading topic.

*Year 4, Section 3:* WATER – 20 lessons

1. Characteristic properties of water:
   - Physical properties of water
   - Water as liquid
   - Water as solvent

- Water – three states of matter
- Melting, evaporation, precipitation, solidification

2. Water on Earth
   - Reservoirs of fresh water (lakes, rivers)
   - Reservoirs of salt water (oceans, seas)
   - Water as solid (glaciers)
   - groundwater
3. Water – an element of all living organisms
4. The natural water cycle
5. Water as habitat
   - Living conditions in water
   - Plants – adaptation to life in water
   - Animals – adaptation to life in water
   - Plants and animals living in fresh and salt water
6. The role of water
   - The role of water to plants and animals
   - The role of water to the human being
7. Water pollution and protection

We start with a description of water. The successively covered topics are as follows: the physical properties of water, the three states of matter and changes to which water is subjected as temperature changes. The next lessons are devoted to water on the Earth. Their aim is to make the pupils aware of the fact that our planet is composed mostly of water, and to discuss briefly the reservoirs of salt water (seas and oceans), fresh water (rivers lakes) and groundwater. The programme also mentions water in glaciers. The successive lessons discuss water as habitat, the basic species of plants and animals living in water and their adaptation to life in this environment. The last topics deal with the role of water to all living organisms, as well as the causes of water pollution and methods of protecting water on Earth.

During year 5 and 6 pupils learn the actual basis of natural sciences. Topics covered, or rather mentioned, in year 4 are later presented and discussed in greater detail in the successive years. Here the division of particular sciences becomes much more noticeable. As I have already said, this cannot be avoided when particular topics are discussed. In order to look for co-relations among natural phenomena, we need to have at least a minimal knowledge of biology, geography, physics and chemistry. So we need to discuss the necessary basic knowledge first. Additionally, there are topics like e.g. finding bearings or the composition of organisms, where the lack of an elementary knowledge would make it impossible to find natural connections with other sciences, and trying to look for them without the basic knowledge could only result in confusion.

This problem can be avoided by preparing special repetitive lessons to sum up the particular portions of material – the pupils, who already have acquired a certain portion of knowledge, can themselves find the relations between the discussed topics belonging to various natural sciences.

# 2. Interdisciplinary education at EU and Polish universities

## Interdisciplinarity at the University of Aveiro Brief description

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The University of Aveiro is 27 years old. It belongs to a new generation of Universities that brought higher education outside the traditional University Cities: Lisbon, Porto and Coimbra.Now the University has ca 8500 students, 7000 being undergraduates. In recent years pos-graduate studies (in Portuguese Mestrado and Doutoramanto) have developed and currently there is about 1500 students in these degrees.

The main scientific areas are:

– Sciences
– Engineering
– Teacher Training
– Management
– Humanities
– Arts

The University Rector is elected and the Senate is the executive collegial body. The University has 15 Departments that cover the different areas of the University. So there are 4 in Sciences, 6 in Engineering, 2 in teacher training and 1 in each of the other areas.

As consultative bodies there is a Scientific Council (all PhD professors) and the Pedagogical Council (Degree Directors and One Student per degree). Recently coordination bodies have been introduced with responsibilities by function: Research, Undergraduate Studies, Pos graduate studies. These bodies are essential in coordinating the respective areas.

The University awards the graduate degree of Licenciatura (4 or 5 year degree) and pos graduate degrees: Mestrado (1–2 years degree with course units and a thesis) and Doutoramento (PhD) that requires at least a 3 year research program.

**Interdisciplinarity**

There is a strong effort to achieve interdisciplinarity, both in study programs and in research.

i –*Undergraduate degrees*

Each Department is responsible for teaching its own area for every degree that requires a component of that subject. Even if a degree has a dominant participation of one Department, all degrees have courses thought in other departments (20–25% minimum). To ensure the coherence of study programs coordinating bodies are essential. Thus, the degree Directors of an area, as Sciences and Engineering, or Teacher Training, have regular meetings to discuss curriculum de-

velopment. Basic core programs are agreed upon, even if the Professor in charge has liberty to develop the teaching process as he whishes.

Besides unidisciplinary Departments, as Mathematics, Physics and Mechanical Engineering, some of them, mainly those in new areas are already interdisciplinary, gathering staff from different specialities, as Environment and Planning, Management and Industrial Engineering and Communication and Art.

ii – *Example of interdisciplinary degrees*

Teacher training, environmental Engineering, Management and Industrial Engineering and New Communication Technologies are examples of interdisciplinary degrees

4 year degree (licenciatura) in New Communication Technologies

| Areas | ECTS credits |
|---|---|
| Communication | 35 |
| New Communication technologies | 100 |
| Linguistics | 35 |
| Human Sciences | 14 |
| Management | 26 |
| Project, others | 25 |

5 year degree (licenciatura) in Management and Industrial Engineering

| Year of study | Areas | ECTS credits |
|---|---|---|
| 1st | Math, Phys. Chem. Informatics, English | 60 |
| 2nd – 4th | Management | 86 |
| | Technology | 64 |
| | Economics | 14 |
| | Law | 16 |
| 5th | Options and Project | 60 |

iii – *Other interdisciplinarity experiences*

At course unit there are examples of a course given by professors of two different areas. One example is Physics and Technology of Metals, where basic physical characteristics and models are presented by a Physics Professor, followed by technological preparation and applications in charge of a Mechanical Engineering Professor.

Also in the final year project interdisciplinary themes are common, as Physics and Chemistry, Physics and Electronics, Physics and Geology.

iv – *Interdisciplinarity in pos graduation and research*

There are several mestrados with strong components of different Departments. For example the Mestrado in Coastal Regions gathers areas as Physics, Chemistry, Environment Biology and Geology.

Another mestrado in Science and Engineering of Materials gathers the areas of Chemistry, Physics and Materials Sciences.

This situation reflects also the growing joint research projects that are currently being developed at the University

## CONCLUSIONS

The Departmental organization of the University requires and promotes interdisciplinarity. This process was a natural one when the University was at an early stage, with few Professors and Students. More recently new interdisciplinary departments such as Management and Industrial Engineering and Communication and Art gather staff originating in former University Departments.

With the growth of the University it is apparent that some formal organization has to be put in place, so that the regular contacts among Departments and the necessary coordination is assured. This is why the different "Institutes" were created. This gives indeed a flexibility to develop new areas and new degrees. The advantages for students come from being exposed to an interdisciplinary environment, that is considered essential for the development of transversal competencies and adaptation for a fast changing world where professionals are expected to change often their field of work.

# Interdisciplinary Education in Science at the Polish Universities

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## Trends and Changes in National Education System

Dynamic changes transforming the economy and lifestyle of the Polish society in the late of the 1980. have had an essential impact on education, first of all on the higher education (Lonc, 1999). New rules of financing universities, substantial budget cuts, increasing number of students, particularly part-time (financial support provided exclusively by the Ministry of National Education is much more dependent on the number of students) and growing international co-operation were the most important factors influencing a new environment in academic institutions. These new trends in higher education can be illustrated by:

- the creation of non-state higher schools which educate students mainly up to the level equivalent the B.Sc., and first of all in the field of economy, marketing and management. [Students of non-state schools form about 12% of the whole number of students of Polish HE institutions.]
- change of traditional uniform five-years study into a three year bachelor programme, followed by a two-years masters programme and four Ph.D. study.
- development of ECTS and self-evaluation procedure (very often within the framework of TEMPUS programme) as the obligatory conditions in accreditation procedure (LONC and MISIEWICZ 1998). The University Accreditation Commission was set up on the basis of Agreement of Polish Universities for the Quality of Education in 1997 ( http://main.amu.edu.pl/ects/uka/uka.html);
- rapid move towards the massive higher education (this path of development was undergone by Western countries in 1960s/1970s): in the last decade the number of students doubled, and education ratio increased from 9.8% (in 1990) to 22.2% (in 1997).

## System of Higher Education in Poland

Educational reforms (started in 1990) were finally accepted by Parliament only in 1998. The changes and trends at the level of elementary and secondary schools as well as higher education are illustrated by the diagram (Fig.). The most important change is replacing obligatory 8–year elementary school by an obligatory 6–year elementary school plus 3–year gymnasium school. [At elementary school and gymnasium the discipline teaching is replaced by the so-called blocks (module teaching), e.g. mature including physics, chemistry, biology and geography.] The state certificate exam (=Abitur) previously conducted at secondary school, is going to replace by the exam conducted by special state commissions. One of the consequences will be resigne the admission exams for universities and higher professionals schools because of the uniform qualifications of candidates.

Conditions for **higher education** (HE) have been established by two laws adopted in 1990, i.e. **The Act on Higher Education** and **the Act on Academic Degrees (both Acts from 12 th September 1990)** as well as **The Act on Higher Professional Schools from 13 th 1997**. In the Polish HE system two organs perform accrediting functions, i.e. **The General Council of Higher**

**Education** (= Rada Główna Szkolnictwa Wyższego) which makes up a list of study curricula (= field of study), undergraduate and graduate and decides on staff requirements) as well as **the State Commission for Scientific Title and Degrees** (= Centralna Komisja Do Spraw Tytułu Naukowego i Stopni Naukowych). In Poland there are: professional titles, scientific degrees and a scientific title. Two professional titles are: *licencjat*, being equivalent in general to B.Sc. in the British or American system and *magister* (*mgr*) – M.Sc. (or M. A); other versions of these titles are *inżynier* (= engineer) and *magister inżynier, mgr inż.* (= M.Sc.in engineering) after technical studies. Alumni of medical or veterinary 6 years studies obtain the title of *lekarz medycyny* or *lekarz weterynarii* (= physician). Scientific degrees *doktor (dr)* (= Ph.D.) can be awarded after 4 years Ph.D. studies (on the basis of a thesis and exams) and *doktor habilitowany* (*dr hab.)* ("habilitated doctor") after habilitation procedure which is similar to that in Germany and France. The scientific title of *profesor* (= professor) is given by the President of the Sate. *Profesor nadzwyczajny* (= extraordinary professor) means also academic position, so-called *profesor uniwersytecki* (= university professor, = associate professor in USA or reader in UK).

Poland has ca. 246 higher education institutions: 95 are state schools supervised by the Ministry of National Education (56 of them) and some other ministries (for instance: Ministry of Health supervising 11 Academies of Medicine), Ministry of Internal Affairs supervising the Central Higher Fire-Protection School, Ministry of Culture supervising Academies of Music and Academies of Arts, etc.). [The name "academy" (*akademia*) mentioned above is used in our terminology for university level schools of several more specific types: there are academies of economics, medicine, agriculture, arts and music.] 12 universities (*sensu stricto*) are teaching and doing research in the classical disciplines. Another group of HE institutions formed technical universities, in Polish terminology the traditional name for that schools is *Politechnika* (similar to the British name – polytechnics, but having in fact different meaning); among them there is the Academy of Mining and Metallurgy in Kraków. A new trend is environmental education realised by some out of 100 private ("non-state") educating mainly up to the level equivalent the B.Sc. or B.A.

**Interdisciplinary education at universities**

In Poland, the tendency to expand and/or implement new version of interdisciplinary education has received in the 1990' an impetus at all levels of primary and secondary schools, universities and post-diploma studies. Two types of interdisciplinarity have been developed to the greatest extent in university education: interdisciplinary education in the field of environmental protection and broader interdisciplinary education in science.

**Environmental education**

New Constitution passed in 1997 basing also on the Ecological Policy of Poland (1991) obliged the State to solve the problems of environmental protection in regard with the principles of "sustainable development". **The education** has the first place among the 8 main methods of implementation the Polish policy of sustainable development. [Document is available in English: <http:www.mos.gov.pl/mos/publikac/environment.html>. It is centred around achieving ecological effects in the field of environmental protection as a result of a reconstruction of these branches of economy, which pose the biggest threat for the environment, i.e. power generation industry, transportation, heavy industry, as well as a wide implementation of eco-development rules for mining, agriculture, and forestry, which are directly connected the exploitation of various natural resources.]

New attitudes emerging in our society in the end of 1980' are also perception of existing limits to the use of natural resources as well as higher consciousness of environmental risks and deeper ecological awareness. According to sociological studies, the percentage of people accepting, e.g.

the role of local governments in solving environmental problems increased from 63 to 67% in the years 1992–1997; number of organisations involved in environmental activity is about 1200. From the other side, the society is slowly beginning to feel the taste of market economy and this creates new social, economic and also environmental problems (KASSENBERG and KAMIENIECKI, 1998). Some symptoms of excessive and unbalanced consumption are already present, e.g. the growing amounts of wastes and automobile emissions, especially in large cities. At present, in Poland the poorest social strata acquire new cars at the fastest rate what is unique world-wide (given the financial capabilities of Poland's inhabitants the index of new car purchases should be 2–3 times lower). There is lack of critical reflection over consumption effects in terms of environment, energy, space as well as the lack of promotion of different value and behaviour patterns leading to a lower impact on the environment.

It seems that education will be a key tool for choice between the building highly developed and over consuming society or taking an advantage of our underdevelopment in searching for alternative solutions and creating bases for a society of "sustainable development". Evidence indicating the education as a useful tool for environmental protection is a group of potential supporters of sustainable development solutions i.e. about 1/3 of the society – better educated and younger persons, residents of cities (LONC el. al. 2000).

In the field of environmental protection annually several hundreds of candidates apply for the course of environmental protection at the each university but only ca. 60 can be accepted. Since 1999 environmental education is as a **separate module/subject (*edukacja ekologiczna* EE = ecological education)** in the new core curriculum for pupils of primary and secondary schools. The degree course in "*ochrona środowiska*" programme (= field of study) Environment Protection consists usually of a three-year programme resulting in the licentiate diploma (B. Sc.) or environmental protection engineering (inżynier ochrony środowiska), and two – year graduate studies with the aim of completing a thesis based on laboratory (or field) project for *magister* degree (diploma) – M.Sc. in environmental protection (or M.Sc. eng. – mgr inż.). Unfortunately, there is no possibility to obtain doctorate in the environmental sciences; graduates from the environmental protection are Ph.D. students in the related fields of biological sciences or earth sciences, agricultural or technical sciences;

A new trend is environmental education realised by private schools ("non-state" – student pay registration fee) educating mainly up to the level equivalent the B.Sc. or B.A. Out of more than 100 private schools (students pay registration fee) there are 3 non-state Higher Schools for Environmental Protection in Bydgoszcz, Radom, and Warszawa as well as three faculties of environmental sciences at the non-state Higher Schools in Pułtusk, Olecko and Skierniewice;

Within our Universities like in some European Universities (ARESTA 1998) two different tendencies were applied, i.e. the implementation of environmental contents into already existing curricula of biology, chemistry, geography, geology, engineering, farming and developing new courses of environmental protection with strong multi– and interdisciplinary character. The new, more or less interdisciplinary environmental study programmes has received the name "environmental protection" ("ochrona środowiska") in accordance with the list accepted by the High Education National Council in 1990. Those two different educational approaches shaped different professional skills. In the first case, a specialist is formed, in the second case (environmental protection) a scientist more skilled to investigate environmental facts using "a systemic approach". The enclosed list (appendix according FRANKOWICZ and STOBIECKA, 1998) of studies related to environmental sciences offered by the Polish higher education (***12 Universities sensu stricto*** *in Białystok, Gdańsk, Kraków, Lublin, Łódź, Opole, Poznań, Szczecin, Toruń, Warszawa and Wrocław; Academy of Catholic Theology in Warszawa; Academy of Mining and Metallurgy in Kraków*, ***5 Academies of Agriculture*** *in Kraków, Lublin. Poznań, Wrocław, Warszawa;* ***2 Acade-***

***mies of Economics*** *in Poznań and Wrocław;* ***16 Politechnics*** *in Białystok, Częstochowa, Gdańsk, Gliwice, Kielce, Koszalin, Kraków, Lublin, Łódź, Poznań, Radom, Rzeszów, Szczecin, Wrocław, Warszawa, Zielona Góra****; 4 Higher Schools of Pedagogy*** *in Częstochowa, Kielce, Słupsk and Zielona Góra; Higher Scool of Agriculture and Pedagogy in Siedlce; Technical-Agricultural Academy in Bydgoszcz and Olsztyn*,) includes mural (regular) and extra-mural (B.Sc and/or M.Sc.) multi– and/or interdisciplinary study programmes in:

1. **environmental protection** with specializations:
   - analysis of pollution of environment,
   - analysis of state and hazards of environment,
   - biology of environment, biotechnology,
   - chemical systems of environmental protection,
   - ecology,
   - ecology and protection of water,
   - farming environment protection,
   - ergonomics and safety,
   - fundamental problems of technology in environment protection,
   - geoecology,
   - landscape protection and planning,
   - planning and management of environment,
   - protection of water,
   - protection and management of the environment,
   - soil protection and waste recycling,
   - protection of soil,
   - protection of nature
2. **environment engineering** with specjalisations:
   - analysis techniques in environmental protection, air conditioning, atmosphere protection systems;
   - clean energy technologies, ecological problems in heat technology, heating and ventilation;
   - ecotechnology, exploratory and environment geophysics, engineering geology and water protection;
   - environment protection in industry, environment planning, environment planning in mining areas, environment protection engineering and equipment in chemical industry, environmental biotechnology, environment protection in energy plants and transportation;
   - environment resources management in rural areas, heating, ventilation and protection of atmosphere, protection of water, technology of water supply and wasterwater and solid waste disposal, soil protection and waste recycling;
   - gas engineering, geology of deposits and geochemistry of environment, hazards and safety in industry, heating, ventilation and dust removal technology;
   - heat technology, hydraulic engineering, heating and household installations; hydraulic and sanitation engineering of rural areas, hydraulic and land reclamation engineering, hydrology, industrial furnaces and environment protection;
   - land reclamation and planning of farming environment;
   - machinery and equipment in environment protection, marine environment engineering, municipal engineering;
   - petroleum geology and geothermal sources;
   - planning of farming environment proecological chemical technologies, protection of atmosphere and management of natural environment, rural environment protection and planning, sanitation engineering;

- sewage systems and household installations;
- systems of environment protection, sanitation equipment; systems for water, soils and landscape protection;
- water supply, water management; wastes and wastewater disposal;
- wastes management, technology of water supply, technology of environment protection;

Within "traditional" disciplinary study programmes there are specjalizations oriented in environmental topics:

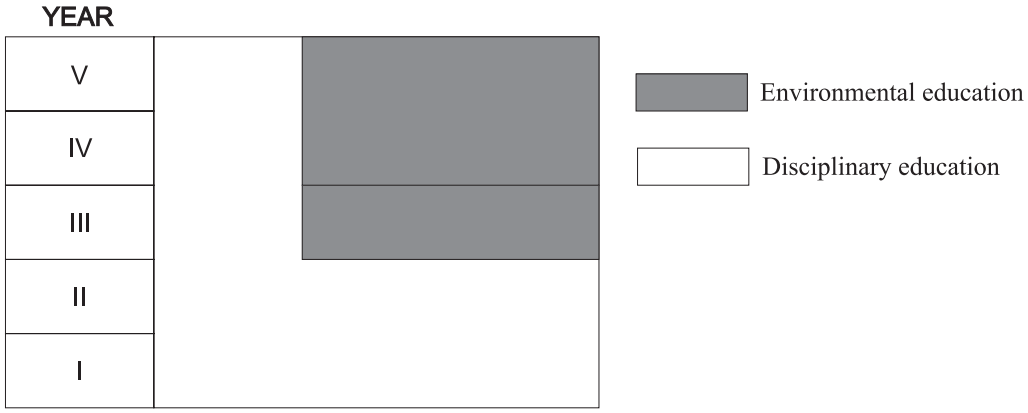
- **biology**, spec.: environmental biology, environmental protection;
- **biotechnology**, spec.: biotechnology in environment engineering;
- **chemistry**, spec.: environmental protection chemistry, chemistry of environment, pro-ecological chemical technology;
- **civil engineering**, spec.: hydraulic engineering and planning of the environment;
- **economy**, spec.: politics and environment protection management;
- **geography**, spec.: planning and protection of environment;
- **mechanics and machinery design**, spec.**:** environment protection equipment;
- **metallurgy**, spec.: heat technology, industrial furnaces and environmental protection;
- **farming**, spec.: ecological manufacturing;
- **physics**, spec.: environmental physics;
- **management and marketing**, spec.: management of urban areas and environment;
- **mining and geology**, spec.: environment protection in drill mining, petroleum and gas industries, exploratory and environmental geophysics, geology of deposits and geochemistry of environment;
- **technology of food and nutrition**, spec.: management and environment protection engineering);
- **zootechnology**, spec.**:** rural environment protection and planning.

The discussions during seven National Annual Conferences entitled "Environmental Protection at the University Level of Natural Sciences [The University of Wrocław (1993), Cracow (1994), Opole (1995), Warszawa (1996), Poznanń (1997), Gdańsk (1998), Lublin (1999)] showed rather theoretical attitude to environmental problems at the Polish Universities contrary to practical problem solution-oriented education, e.g. in the Netherlands (KANTOWICZ and LONC, 1999).

The above listed environmental education is realised according to few typical models:

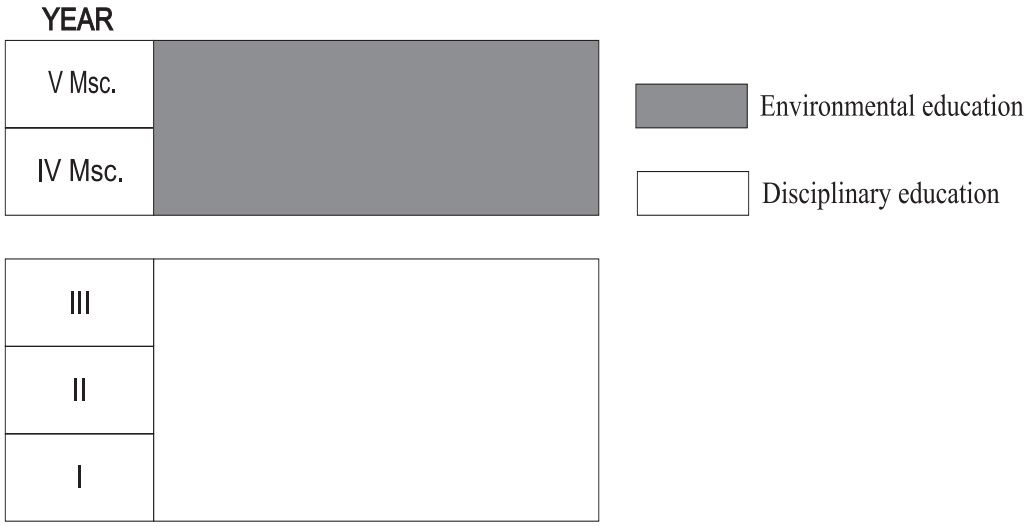
a) Specialist programme, within a "traditional" programme (e.g. biology) the student can choose a particular pathway in the later years of study – specialisation, and can continues disciplinary programme as well.

Model of specialiste programme



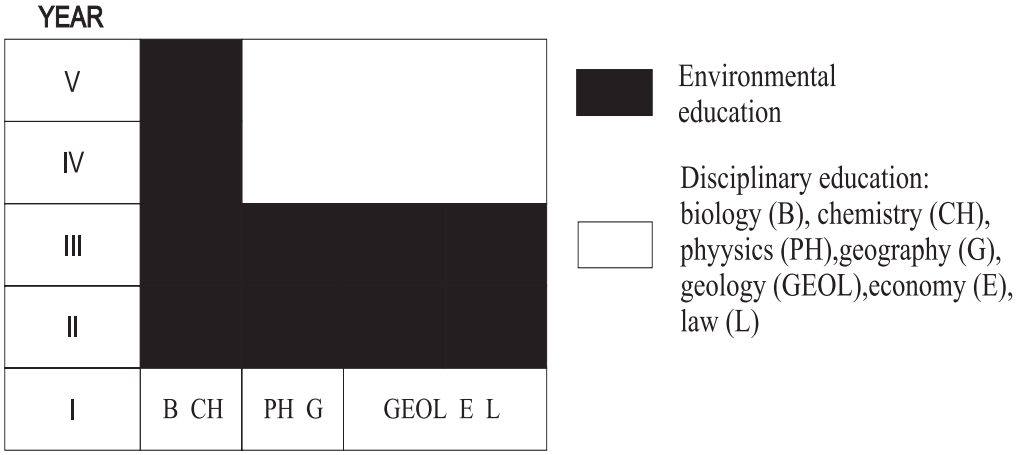
b) A degree followed by an environmental specjalisation at Master of Science level

Model of two level disciplinary/interdisciplinary environmental education

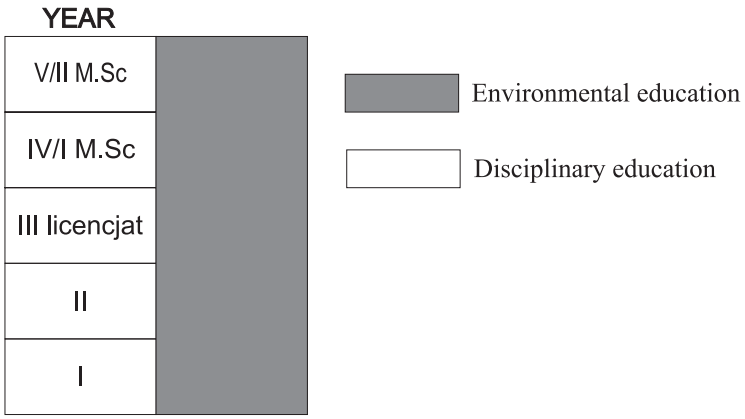



c) Model of broad pluri– or multidisciplinary foundation followed by interdisciplinary knowledge and formally interdisciplinary Msc degree, but students choose disciplinary courses connected with the master thesis prepared under the supervision of disciplinary specjalists. This is the model realized at the University of Warsaw.

General structure of the environmental education at the University of Warsaw



d) **Model of environmentl education (at two level studies) at the Wrocław University** can serve asan example of mixed two models (a and b).




**Interdisciplinary individual study programmes in science**

Several Universities introduced individual study programmes called "Międzywydziałowe Indywidualne Studia Matematyczno – Przyrodnicze" which means Individual Studies in Mathematics and Natural Science. The possibility of "licencjat" diploma in two disciplines, e.g. physics/chemistry, biology/chemistry or physics/informatics after three years of study is the model of such education. M.Sc. Degree can be obtained in one discipline only. This type of studies are adressed to the best student who have the scientific interests on cutting edge of traditional disciplines. They exist at Warsaw University and Jagiellonian University.

Another intredisciplinary model of education is connected with the needs of reforming secondary school education. The programmes of dual subjects teachers education (physics/geography UMCS, Lublin) and so called integrated science block teachers education (Przyroda, UAM, Poznan) were created at lower (licencjat) university level. Both forms of interdisciplinary education in science can be illustrated by the case of the University of Silesia

**Education and Research Policy**

**Education** has the first place among the 8 main methods of implementation the Polish policy of sustainable development. [The others are: elaboration of the new legal acts with the clear division of competences between state and local authorities, introducing the values of natural resources into cost – benefit analysis, creation of better clear financial mechanisms (environmental charges), physical planning in regard to the nature on the one hand, and the rational transportation on the other side, better use of soil potentiality to increase the food production, the growth of afforestation rate from the present 28 % to minimum 30 %, constant monitoring of environmental quality in respect to accepted by the Polish state environmental coefficients: afforestation rate, quality of surface waters, air pollution, arduous noise, abundance of protected species.]

It should be also noted that during the 1990s. the percentage of students in the whole population of people being 19–14 year old grew up rapidly. The total number of students is now about 800 000; the "education rate" is more than 22% (in 1991 was only 12.9%). Unfortunately, number of people studying above licenciate is lower and there is tendency to increase number of graduate students. Another very importanat goal of the educational policy is a change of the intellectual profile of alumni of practically all types of schools, and in particular of universities.

Interdisciplinary Education at the Faculty of Mathematics, Physics and Chemistry University of Silesia

| **Physics at Institute of Physics** | | | |
|---|---|---|---|
| **Specialisation** | **Type of study** | **Number of students (limits)** | **Inter-faculty and inter-university co-operation** |
| 1. Experimental Physics<br>2. Theoretical Physics | M. Sc. (5 years) | 180 | |
| 3. Geophysics | M. Sc. (5 years) | 40 | Institute of Geology<br>Faculty of Earth Science |
| 4. Physics and Chemistry<br>– dual subject teachers education<br>5. Physics and Computer Science<br>– dual subject teachers education | M. Sc. (5 years) | 40<br><br>40 | Institute of Chemistry |
| 6. Medical Physics | Licentiate (3 years)<br>+ M. Sc. (2 years) | 40 | Silesian Medical Academy<br>Silesian Technical University<br>Institute of Oncology |
| 7. Physics and Computer Science | Licentiate (3 years) | 90 | |
| 8. Econophysics | Licentiate (3 years) | 50 | School of Management<br>Academy of Economy |
| **Environmental Protection** | | | |
| 1. Physical and Chemical Methods of Environmental Protection | Licentiate (3 years) | 75 | Faculty of Mathematics, Physics and Chemistry |
| 2. Geoecology | | | Faculty of Earth Science |
| 3. Biological elements of environmental protection | | | Faculty of Biology |

In Poland, **research** is mainly carried out by the state-owned universities and institutes of the Polish Academy of Sciences (they are less or more oriented to basic sciences), additionally there are some scientific centers, which persue a more applied approach; state agencies collect and aggregate a huge amount of data, but the results not always reach a scientific level. The new system of the Polish **research policy** (organization and funding) operates under the Act of 12 January 1991 on the establishment of the State Committee for Scientific Research (the Polish acronym KBN). KBN was formed as a supreme governmental body responsible for the state S&T policy and for budgetary expenditures on R&D. It means that except for military research (partly financed by the Ministry of Defence) all governmental support is channelled entirely through

KBN. Budget outlays cover the following activities: statutory activities (core funding) of academic and research-developmental institutions (R&D), investment in the R&D infrastructure; research projects proposed by scientists or commissioned by the KBN, international scientific and technological co-operation from intergovernmental agreements, general technical assistance to R&D activities (e.g. information, library, promotion of science).

The Basic Research Commission consists of 34 members (28 persons elected by scientific community) who work in 6 groups: humanities, economic and law; mathematics, physics and astronomy; **biological sciences**, **earth sciences and environmental protection**, medical science as well as agricultural sciences and forestry. The Applied Research Commission consisting of 43 members (30 persons elected by scientific community) works in 6 groups: Architecture, Civil and General Engineering; Materials Sciences and Technologies; Chemistry, Chemical Technology and Chemical Engineering; Electrical Engineering and Power Generation; Telecommunication, Electronics, Control and Computer Engineering, Mining, Transport and Surveying.

[Recently, from those groups the special sections dealing exclusively with environmental issues were excluded, namely: Section for Protection of Natural Environment, Ecological Section, Section of Process Engineering and Environmental Protection, Section for Water Management, for Development of Agricultural and Forestry Environment.] Also half out of ca. other 70 specialised sections finance the projects which are less or more connected with biodiversity, environmental engineering and environmental protection.

In the years 1991–1997 ca. 10% of all commissioned and financed by the Committee for Scientific Research grants were connected with ecology and environmental questions, i. e.

2000 research projects proposed by scientists in the field of environmental problems (170 millions PLN), 60 goal-oriented projects (15 millions PLN) raised by environmental engineering and environmental protection as well as 50 ordered research projects served mainly environmental management, spatial planning.

**Evaluation**

A logical effect of environmental policy is the growing need for labour, first of all in the administration connected with environmental protection services, consulting, scientific research and education. Despite many initiatives in the field of environmental research and education the KBN have not yet decided to establish one Sector dealing with environment protection problems; ecological questions are spread into many groups and financial support is not comprehensive. Similarly, the State Commission for Scientific Degree have not supported idea of naming "environmental protection" as a separate field of scientific discipline. In practice, it means that university graduates from environmental sciences have to continue their Ph. D. study (and to receive scientific degrees) only in the related disciplines. It delays the process of trans-disciplinary research and education what is contrary to labour market demands.

The main constraint on educational reform and the process of environmental education deals with limited public funding. In Poland, the higher education budget is said to be reduced by about 45% in real terms since 1990, while the number of students rose dramatically, so that the budget per student even decreased by about 67% in real terms; the participation rate the Polish young generation in HE is rising rapidly, but has by far not yet reached Western European levels (percentage of the Polish youth learning at higher level is only 22%, 32% in Italy, and 37% in Germany). Also low salaries in public educational sector have to be blamed, because they make it is impossible to have sufficient highly qualified staff [majority of academics who stay with university have another jobs or engagements at other institutions (also private schools) that takes them out of their teaching and research activities in maternal university).

**There is a clear trend to enhance interdisciplinarity of environmental research and education**. However, interdisciplinarity seems in many cases a useful catchword. In principle, the structure of Polish universities is sectoral, and many of discipline relevant for environmental protection still trend to a basic discipline scientific (not practical) orientation. [Moreover, doing interdisciplinarity work is not rewarded in the scientific career, now in Poland it is based mainly on the number of publications according the index citation.] Any attempt to integrate the environmental studies within university than in the separate departments are opposed by conservative part of academics who have enough power to dominate the faculty councils. They are sometimes very large body (e.g. Faculty of Natural Sciences at the University of Wrocław has 120 members). Because faculty council has to make decisions on only strategic but also operational ones it is very difficult to establish effective management of study. Under this collective management there is a strong pressure to follow egalitarian rules: to pay the same salaries and to preserve all privileges.

Because of inadequate state financing and managerial problems of universities the help of foreign sponsors conducting environmental projects featuring research and training in Poland has significant meaning and it is very much appreciated. Since 1990s Poland was the prime beneficiary of external aid for environmental management training from EC PHARE programme. Environmental protection was one of priority areas of TEMPUS designated to promote the development of the HE systems in the countries of Central/Eastern Europe. TEMPUS provided excellent opportunity for developing a credit transfer system. It made easier for students to build their programmes of study flexible by combining courses of environmental protection from different faculties.

## References

ARESTA, M. 1998. Environmental education and formation: state of art and perspectives at some EU Universities. In: Environmental Education at Universities. State of Art for Poland and Some EU Countries. Output of "DEPES" TEMPUS CME–96–2520, pp. 5–15.

CHEŁKOWSKI, A., RATUSZNA, A., 2000, Interdisciplinary education at the Faculty of Mathematics, Physics and Chemistry, University of Silesia, Katowice, Poland (not published)

FRANKOWICZ, M., STOBIECKA, E. 1998. Environmental Education and Formation: State of Art and Perspectives at Polish Universities. In: Environmental Education at Universities. State Of Art. For Poland And Some EU Countries. Output of "DEPES" TEMPUS CME–96–2520, pp. 41–82.

KANTOWICZ E., LONC E. Environmental Studies and Professional Perspectives of the Graduates in Poland. 5th Conference on Environmental Education, Zurich, Switzerland, April 15–17, 1999. Volume of Abstracts, pp.112.

KASSENBERG A., KAMIENIECKI K. 1998. The Strengthening of European Integration Through Sustainable Development. Ministry of Environmental Protection, Natural Resources and Forestry. Environmental Economy and Natural Resources Foundation in Białystok, Warsaw May 1998, pp. 36.

LONC E. 1999. National report Poland [http://www./vsnu.nl/essence/our products]

LONC E., LUBOCKA J., KANTOWICZ E., OKULEWICZ A. 2000. Social Attitude to Environmental Problems (Questionnaire Results 2000). Abstract for EURO-ECO, Cracow 15–16 Sep.

LONC E., MISIEWICZ M. 1998. Evaluation in Environmental Protection. In: Environmental Education at Universities. State Of Art. For Poland And Some EU Countries. Output of "DEPES" TEMPUS CME–96–2520, pp. 111–123.

# Interdisciplinary Education at the College of Science Warsaw, Poland

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The College of Science (Szkola Nauk Scislych) is a very young university if compared with the most famous Polish ones as it was established in 1993. The College of Science is based on a few Institutes of the Polish Academy of Sciences and the main part of its educational activity is carried at the Institutes of Physical Chemistry, Physics and Mathematics and at the Center for Theoretical Physics.

Like in the other countries of Eastern Europe the Polish Academy of Sciences was an important scientific institution during the communist time. Its institutes maintain a high standard of research.The Institutes of the Polish Academy of Sciences were always involved in the education at the post-graduate level. In seventies and eighties there were many graduates of Polish universities who were willing to join the graduate schools of the Polish Academy of Sciences and there work on their doctors dissertations. However, the transformations of Polish political life changed the situation.Young people discovered that it is easier to get a good and well paid job after graduating a business school rather than physics or chemistry. Thus the number and quality of newcomers to the university departments of natural sciences decreased significantly. Moreover, only a small percentage of graduates of departments of mathematics, physics or chemistry look for future academic carrier in research because the salaries are much lower than those offered by banking or industry. Most of them are employed by the universities they graduated. As the result inflow of young people who decided to join graduate schools on physics or chemistry of the Polish Academy of Sciences has dropped significantly.

One of the solutions which would help to encourage more young people to do research at the Polish Academy of Sciences was to organize its own university, the best graduate of which would join the research groups. However, there is no room for the undergraduate education within the present structure of the Polish Academy of Sciences. In order to solv the problem a group of leading scientists representing the Institutes of Mathematics, Physics, Physical Chemistry and the Center of Theoretical Physics formed the Stanislaw Ulam Foundation which founded the College of Science – a new university oriented on education in mathematics and natural sciences. The College of Science is considered as a ”private” university which means that it receives no financial support from the state. However, unlike most of Polish private universities, it is not oriented on profits. The tuition (about 700$\$$ a year) is much lower than the yearly fee of a typical private playschool in Warsaw. We can keep tuition at such a low level because the participating institutes of the Polish Academy of Sciences (Institute of Mathematics, Institute of Physics,Center for Theoretical Physics Institute of Physical Chemistry, Institute of Fundamental Problems of Technology and industrial Institute of Electronic Technology) guarantee the access to their laboratories and the technical assistance without any charges. Most of the lecturers work at the institutes mentioned above and they do not receive regular salary for their work with students. The tuition just covers the cost of administration, laboratory equipment and materials and foreign languages (it should be said that our students have twice as many hours of languages if compared with the Polish state universities and moreover, the native speakers are employed as a tutors at the College of Science).

Many students ask the question:

why should we pay for education at the College of Science when the deparments of physics or chemistry of state universities are willing to accept all graduates of high schools without any tuition? I personally believe College of Science is able to offer a more modern and flexible program of education. The curriculum is divided into two stages. After first three years of education the students graduate with the "licencjat" degree (similar to the bachelor degree in the British/American system). Next they continue their education for two years more and graduate with the master of science degree. It should be said that we are one of the first universities in Poland which introduced such a system. Traditional university education is 5 years long and ends with master of science degree. Our system gives students more freedom; some of them leave the College after B.Sc. and start working, some come from the other universities to do their M.Sc with us.

The basic assumption of our curriculum was to make it as interdisciplinary as possible.We do not like to produce a specialist with a narrow range of knowledge, but a person with a wide view on natural sciences who can specialize in future. Traditionally, newcomer at the Polish universities signs for mathematics, physics or chemistry just at the beginning of the study and it is not easy to change later the direction of studies. At the College of Science all students have the same interdisciplinary curriculum during the first two years of education and choose the area of specialization at the third year. Our students can learn a lot on the character of research in chemistry, mathematics and physics during the first two years, so they can make more mature decision about their future profession. At the first year the education is focused on mathematics as the language of natural sciences and on practical use of computers. Students have 150 hours of calculus, 120 hours of the algebra and 60 hours of computer laboratories. Moreover students have courses on introduction to physics and chemistry (120 hours each) and both physical and chemical laboratories (each 60 hours a year). During the second year the number of hours reserved for mathematics is slightly reduced (120 hours for the advanced calculus and 60 hours of probability) if compared with the first year. On the other hand the number of lectures and laboratories related to physics and chemistry is increased: there are 120 hours of lectures and 80 hours of laboratories on both physics and chemistry. In my opinion the curriculum of the first two years of the College of Science offers a good balance between chemistry, mathematics and physics. Even the future mathematicians have a basic knowledge of experimental physics and chemistry. More precise information on our curriculum can be found on the web page http://snsinfo.ifpan.edu.pl. Of course, our novel curriculum faces the constraints introduced by the Polish Ministry of Education. The College of Science can give the bachelor degree within so called macrodirection "physics, mathematics and chemistry" and this gives some flexibility in preparing an interdisciplinary program. I would also like to focus your attention on the lecture on mathematical problems of insurance given at the third year. Our students find it very interesting because it links the "academic" knowledge of mathematics and statistics with the world of business and REAL money. The Polish regulations for the master of science title are quite precise and at the third year of education our students have to decide if they prefer mathematics, physics or chemistry and start their specialization. At the moment we offer the bachelor degree in the following interdisciplinary areas:

– physics and chemistry of the new materials,
– modern experimental techniques of physics and chemistry,
– interdisciplinary teaching of natural sciences,
– computer and mathematical modeling of nature and society.

Each of these specialization is related to specific courses and laboratories. In the case of teaching the students have lectures of psychology, pedagogy and practice in the schools instead of the advance experimental projects. I would like to point out that an interdisciplinary education of

teachers is very important for the country. The schools have been recently reformed in Poland. Instead of 8 years long elementary school and 4 years long high school we have 6 years long elementary school +3 years long junior high school +3 years long senior high school. According to the present regulations a person with "licencjat" can teach in a junior high school and our graduates have enough knowledge and pedagogical experience to become teachers of mathematics and physics and chemistry there. A new specialization namely "practical computer science" will be added to the set of bachelor degree specializations of College of Science in the near future. We have found that many research groups need a person who will develop the strategy of calculations, automatic data aquisition and data processing, who will do the administrative work on a small cluster and who will help in visualization of results in a multimedia form. On the other hand many of our students are very interested in learning such skills. We are going to incorporate thus new specialization into our interdisciplinary curriculum thinking that a computer specialist with some knowledge of physics and chemistry can more fruitfully contribute to team's work than a pure computer scientist.

At the moment the Polish Ministry of Education does not allow to grant master of sciences title in interdisciplinary disciplines and our students should get M.Sc. in mathematics or physics or chemistry. During two last years of education the courses are fully specialized in order to fulfill the present regulation. However, we encourage our students to choose an interdisciplinary subject for their master thesis. I believe that the eight years long education activity of the College of Science is succesful. The best graduates joined the Academy of Sciences as young research fellows and are continuing their education. Many of graduate started promising careers in industry or economy and the motto of the College of Science: "Our interdisciplinary curriculum prepares graduates who can learn everything" is a gateway to their success.

# Interfacultive Individual Studies of Mathematical and Natural Science at Warsaw University

**Andrzej Hannel**

*Warsaw University*

Warsaw University has initiated the new form of studies called Interfacultive Individual Studies of Mathematical and Natural science, starting from academic year 1992/93. It happened the first time in Poland.

Seven faculties of the University, such as: Faculty of Biology, Faculty of Chemistry, Faculty of Physics, Faculty of Geography and Local Studies, Faculty of Geology, Faculty of Mathematics, Informatics and Mechanics (only mathematics specialization) and Faculty of Psychology, take part in this programme.

Interfacultive Individual Studies of Mathematical and Natural Science are regular studies. Evening and part-time studies are not provided. Students of Interfacultive Individual Studies of Mathematical and Natural Science formally belong to every mentioned faculty simultaneously. Every student is under control of a professor or lecturer who represents the specialization which is the closest to ones interest. Students with their patrons set their own individual plan of studies which are composed of the subjects from the mentioned faculties and some supplementary courses from the other faculties of the University. One is not obliged to choose from every faculties creating Interfacultive Individual Studies of Mathematical and Natural Science.

Individual studies are interesting and difficult in the same time because they demand responsibility from the students. They can be recommended both when the person has precised interests or difficulties in choosing the future specialization. The perfect candidate for Interfacultive Individual Studies of Mathematical and Natural Science is the one of wide mathematically-natural interests.

Warsaw University currently gives two kinds of diploma. Every faculty after five years of studies finished with presentation of Master thesis grants Master's degree. Some of the faculties after three years of studies finished with Bachelor's thesis grant Bachelor's degree.

Bachelor's degree is the intermediate diploma suitable for people who want to reach a Master degree. It is also the diploma which finishes university studies for those who study at other Universities. It is convenient because two faculties are time-consuming.

In 1998 Senate of Warsaw University after a long discussion took the final decision concerning diploma for the students of interfacultive studies. Bachelor's and Master's degrees are issued only by Warsaw University faculties with the information of completing Interfacultive Individual Studies of Mathematical and Natural Science.

The first important decision of every student of Interfacultive Individual Studies of Mathematical and Natural Science is the choice of the patron's specialization. There are about hundred patrons at Warsaw University, every third is the professor. The students have to choose the subjects from different faculties they are interested in, some of them decide on taking higher year's courses, the others opt for studies at one faculty. In any time they can change it.

Many students manage to create two or three faculty plans. The most popular interfacultive sets are the courses: biology-chemistry (mainly those interested in genetics), mathematics-phys-

ics and biology-psychology, there are also: biology-mathematics, biology-geology, physics-chemistry, geographical-mathematics, chemistry-mathematics, physics-psychology etc.

Statistical student divides his time between the faculties of the University in such a way:

21% Faculty of Biology
12% Faculty of Chemistry
19% Faculty of Physics
7% Faculty of Geography and Local Studies
2% Faculty of Geology
22% Faculty of Mathematics, Informatics and Mechanics
16% Faculty of Psychology
1% Interfacultive Studies of Protection of Environment

Finishing every academic year student of Interfacultive Individual Studies of Mathematical and Natural Science can move at one of the Warsaw University faculty with the agreement of the dean.

This course is so popular that every year there are about 500-600 candidates among whom 20 are the winners of the contests. Nowadays there are 350 students at Interfacultive Individual Studies of Mathematical and Natural Science.

# Interdisciplinary Education at the Adam Mickiewicz University in Poznań

**Maria Kaczmarek**

*Institute of Anthropology, Adam Mickiewicz University, Poznań. Poland*

**I. Background**

Adam Mickiewicz University (AMU) was founded in 1919 in Poznań, the capital of Great Poland (North-West part of Poland). At present it is the largest higher school in Poznań and one of the most eminent universities in Poland. It currently employs 4,100 employees, including 259 full professors, 247 University professors and 689 senior lecturers. Over 40,000 students can choose between 150 specialities for study proposed by twelve faculties. Current system of study comprises a three-stage model of education: three-year undergraduate level (licentiate study with bachelor's degree), followed by two-year graduate level (terminated with master's degree) and post-graduate level (doctoral study terminated with Ph.D.). Students are taught in two ways: a traditional method of learning focusing on the subject and learning by disciplines and a modern system, focusing on problems and learning by multidisciplinary approach.

**II. Interdisciplinary Study in Sciences (ISS)**

Education through multiple disciplines is a modern method of acquiring a comprehensive knowledge about surrounding world. This system of study is addressed to very skilled students whose interests in sciences exceed a curriculum proposed by one faculty.

Objectives:

The aims of Interdisciplinary Study in Sciences (ISS) are to:

promote the ability to solve some problems in sciences in a complex and multidisciplinary way,

provide students with the ability to communicate effectively in a scientific context.

Learning Strategies:

Students may choose:

regular courses offered by various faculties and composed into one comprehensive entirety (**Interfacultative System of Study – IFSS**),

individual modules of study (**Individual System of Study – ISS**).

Students' work is overseen by a tutor who guides through their work providing help and advise throughout the study and the totality of its assessment.

**Interfacultative studies in natural sciences:**

At the A.Mickiewicz University in Poznań following regular courses in sciences are proposed to students:

1. **Protection of Environment (undergraduate and graduate full-time study)**.
2. **Ecology and Management of Natural Resources (undergraduate full-time study)**.
3. **Medical Physics (graduate full-time study)**.
4. **Surrounding Nature (post graduate extra-mural study)**
5. **Education to Life in Family (post graduate extra-mural study)**

**Protection of Environment (MSc)**

***The structure*:** Following faculties are involved in the organisation of this study: Faculties of Biology, Chemistry, Geography and Geology.

The staff consists of academic teachers of the faculties.

Individual management is dealt by deans of the Faculty of Biology and the Faculty of Geographical and Geological Sciences. Collective management is dealt by the Programmed Committee composed of representatives of the Faculties. Legal base consists of the Senate Resolution.

A two-stage system of study: three-year undergraduate level (licentiate study with bachelor's degree), followed by two-year graduate level (terminated with master's degree).

**The organization and proceeding:**

There are two enrollment procedures:

for the first stage of the study – a written test,

for the Master's degree study: mean marks higher than 3.75 and an interview.

Number of candidates exceeds number of places available. There are 100 candidate per 60 places available for full-time licentiate's study, and 24 candidates per 24 places available for full-time Master's degree study.

The diploma:

1. Licentiate in the Protection of Environment
2. The degree of Master of the Protection of Environment

**Three-year licenciate study:**

Obligatory vs optional subjects: 1st year of the study – 100%
2nd and 3rd years of the study 80% vs 20%

The Tutor: university teacher possessing at least Ph.D. degree

The choice of the topic of Licentiate Work – 5th semester.

**Two-year Master's degree study:**

Obligatory vs optionalsubjects: 90% vs 10%

The Tutor: university teacher possessing the degree of habilitated doctor

The choice of the topic of Master's Thesis – 1st semester.

***Curriculum***

| **Three-year undergraduate study:** | **1st year** | |
|---|---|---|
| Elements of inorganic chemistry * | L 30h E | P 60+15h |
| Knowledge of Litho– and Pedosphere ** | L 60h E | P 45h |
| Organic Chemistry * | L 45h E | |
| Botany of Environment *** | L 30h E | P 45h |
| Selected Topics in Physics **** | L 30h E | P 60h |
| Biology of Environment *** | L 45h E | |
| Zoology of Environment *** | L 30h E | P 45h |
| Bio– and Geo Diversity (field work)** *** | 48 h | |
| Foreign Language | 60 h | |
| Sports | 60 h | |

* the Faculty of Chemistry
** the Faculty of Geographical & Geological Sciences
*** the Faculty of Biology
**** the Faculty of Physics

**Assessment:** E – exam

***Curriculum***

| **Three-year undergraduate study:** | **2nd year** | |
|---|---|---|
| Chemical Analysis * | L 30h E | P 60+15h |
| Abiotic Natural Subsystem ** | L 30h E | P 30 +15h |

| | | |
|---|---|---|
| Cartography** | L 15h | P 15h |
| Chemistry of Environment * | L 15h | P 15h |
| Fundamentals of Ecology*** | L 30h E | P 15h |
| Microbiology *** | L 15h E | P 30h |
| Pollution and Protection of Atmosphere*** | L 30h E | |
| Protection of Water; Water– Sewage Economy*** | L 45h E | P 45h |
| Monitoring of the Natural Environment*** | L 45h E | P 45h |
| Ecophilosophy***** | L 30h E | P 30h |
| Protection of Human Natural Environment*** | L 30h | P 30h |
| Structure, Control and Protection of Environment (field work) | 48 h | |
| Computer Workshop Classes | 30 h | |
| Foreign Language | 60 h | |
| Sports | 60 h | |

* the Faculty of Chemistry
** the Faculty of Geographical & Geological Sciences
*** the Faculty of Biology
**** the Faculty of Physics
***** the Faculty of Social Sciences

**Assessment:** E – exam

***Curriculum***

**Two-year graduate study in Biology:** **1st year**

| | | |
|---|---|---|
| Biodiversity and its Protection | L 20h E | P 60+10h |
| Geobotanical Research Methods | L 15h E | P 30h |
| Hydrobotanical Research Methods | L 15h E | P 30h |
| Methods in Experimental Biology | L 15h C | |
| Ecological Methods in Zoology | L 15h E | P 30h |
| Computer Workshop Classes | | 45h |
| Biodiversity and its Protection (field work) | | 32h |

**Assessment:** E – exam CT – credit on test basis

***Curriculum***

**Two-year graduate study in Biology:** **2nd year**

| | | |
|---|---|---|
| Ecological Basis of Land-Use Planning | L 15h E | P 15h |
| Planning of Preserved Natural Objects | L 15h E | P 15h |
| Environmental Impact Assessment | L 15h E | P 15h |

**Assessment:** E – exam

**Ecology and Management of Natural Resources**

***The structure*:** Following faculties are involved in the organisation of this study: Faculties of Biology, Chemistry, Geographical and Geological Sciences (UAM) and Faculty of Economy (Academy of Economics).

The staff consists of academic teachers of the faculties.

Individual management is dealt by dean of the Faculty of Biology. Collective management is dealt by the Faculty Council. Legal base consists of the Senate Resolution.

Three-year undergraduate level (licentiate study with bachelor's degree).

The organization and proceeding:

Enrollment procedure is based on an oral exam in Biology.

Number of candidates exceeds number of places available. There are 150 candidate for 36 places available for full-time licentiate's study.

The diploma:

Licentiate in Biology (specialization in the Ecology and management of Natural Resources)

***Curriculum***

Abbreviations:

| | |
|---|---|
| FCh | the Faculty of Chemistry |
| FGGSc | the Faculty of Geographical & Geological Sciences |
| FB | the Faculty of Biology |
| FF | the Faculty of Physics |
| FM | the Faculty of Mathematics and Computer Science |
| FE | the Faculty of Economy |
| FL | the Faculty of Law |

| **Three-year undergraduate study:** | **1st year** | |
|---|---|---|
| Physical-Chemical Basis of Life[FCh &FF] | L 30h E | P 60h |
| Biostatistics and Informatics[FM] | L 60h E | P 45h |
| Organization of Life[FB] | L 30h E | |
| Chemistry of Biosphere[FCh] | L 30h E | P 60h |
| Diversity of Plants and Fungi[FB] | L 30h E | P 30h |
| Diversity of Animals[FB] | L 30h E | P 45h |
| Foreign Language | 60 h | |
| Sports | 60 h | |

**Assessment:** E – exam

***Curriculum***

| **Three-year undergraduate study:** | **2nd year** | |
|---|---|---|
| Economy, management and Marketing[FE] | L 45h E | P 45h |
| Life on Molecular Level[FB] | L 30h E | P 45h |
| Cell Biology. Cell Reaction on Environmental Stress[FB] | L 30h E | P 45h |
| Genetics: General and Ecological[FB] | L 30h E | P 45h |
| Methods in Ecological Studies[FB] | L 30h E | P 60h |
| Ecology of Organism and Population | L 30h E | P 60h |
| Foreign Language | 60 h | |
| Sports | 60 h | |

**Assessment:** E – exam

***Curriculum***

| **Three-year undergraduate study:** | **3rd year** | |
|---|---|---|
| Geological and Hydrological Basis of Biosphere[FGG] | L 30h E | P 60h |
| Vital Functions[FB] | L 30h E | P 60h |
| General and Environmental Microbiology[FB] | L 30hE | P 50h |
| Biocenology[FB,FGG] | L30h E | P 45h |
| Natural Resources and their Protection[FB] | L 45hE | P 30h |
| Legal-Economical Basis of Environmental Management[FL,FE] | L 15h E | P 30h |

| | | |
|---|---|---|
| Use of Ecology[FB] | | P 45h |
| Foreign Language | 60 h | |

**Assessment:** E – exam

**Medical Physics (MSc)**

***The structure*:** Following faculties are involved in the organisation of this study: Faculty of Physics, Mathematics and Computer Science (AMU) and Medical Academy.

The staff consists of academic teachers of the AMU and MA.

Individual management is dealt by the dean of the Faculty of Physics.

Collective management is dealt by the Faculty Council.

Legal base consists of the Senate Resolution.

This specialisation offers five-year Master's degree courses exclusively.

The organization and proceeding:

Enrollment procedure is the same as for the physics: an entrance examination.

Number of candidates exceeds number of places available. There are 100 candidate per 60 places available for full-time licentiate's study, and 24 candidates per 24 places available for full-time Master's degree study.

The diploma:

The degree of Master of Physics (with a specialisation of Medical Physics)

***Curriculum***

| **Five-year graduate study:** | **1st year** | |
|---|---|---|
| Algebra * | L 30h E | P 30h |
| Mathematical Analysis 1* | L 60h E | P 60h |
| Elementary Mathematics * | L 45h | |
| Mechanics** | L 60h E | P 30h |
| Physical Laboratory** | 60h | P 60h |
| Computer Laboratory* | 75h | |
| Introduction to Computer Science* | 30h T | |
| Introduction to Physics** | L30h | |
| Mathematical Analysis 2* | L 60h E | P 60h |
| Heat** | L 30h E | P 15h |
| Electronics** | L30h E | |
| Electricity and Magnetism** | L 30h E | P 15h |
| Physical Laboratory 1** | 60h | |
| Foreign Language | 60 h | |
| Sports | 60 h | |

* the Faculty of Mathematics and Computer Science

** the Faculty of Physics

**Assessment:** E – exam T – test

| | **2nd year** | |
|---|---|---|
| Mathematical Analysis 3* | L 60h E | P 60h |
| Anatomic and Molecular Physics** | L 30 E,T | P 15h |
| Nuclear Physics and Elementary Particles** | L 30h E | P 15h |
| Physical Laboratory 1** | 45h | |
| Optics** | L 30h E,T | P 30h |
| Electrodynamics** | L 30h E,T | P 30h |

| | | |
|---|---|---|
| Electronics Laboratory** | 60 h | |
| Elements of Human Anatomy**** | L 30h E | |
| Classical Mechanics** | L 30h E | P 30h |
| Fundamentals of General Chemistry with Elements of Biochemistry*** | L 30h E | P 30h |
| Probability Calculus and Statistical Mathematics* | L 30h E | P 30h |
| Foreign Language | 60 h | |
| Sports | 60 h | |

* the Faculty of Mathematics and Computer Science
** the Faculty of Physics
*** the Faculty of Chemistry
**** Medical Academy

**Assessment:** E – exam T – test

**3rd year**

| | | |
|---|---|---|
| Condensed Phase Physics** | L 30h E | P 30h |
| Quantum Mechanics** | L 30 E | P 30h |
| Fundamentals of Human Physiology**** | L 30h E | P 30h |
| Physical Laboratory 2** | 105h | |
| Medical Statistics* | L 15h E | P 30h |
| Thermodynamics of Biological Systems** | L 30h E | |
| Introduction to Medical Physics** | L 30 h E | |
| Biochemistry***** | L 30h E | |
| Elements of Bioenergetics** | L 30h T | |
| The Influence of Physical Factors on Man** | L 30h E | |
| Foreign Language | 60 h | |

* the Faculty of Mathematics and Computer Science
** the Faculty of Physics
*** the Faculty of Chemistry
**** Medical Academy
***** the Faculty of Biology

**Assessment:** E – exam T – test

**4th year**

| | | |
|---|---|---|
| Analysis of Signals and Images** | L 30h E | P 30h |
| Diagnostic and Clinic Therapy**** | 90 h | |
| Master Laboratory | 120h | |
| Radiative Therapy**** | L 30h E | |
| Computer Tomography and NMR** | L 30h E | |
| Laser in Medicine** | | L 30h E |
| Fundamentals of Human Pathophysiology**** | L 30h T | |
| Master Laboratory | 150h | |

** the Faculty of Physics
**** Medical Academy

**Assessment:** E – exam T – test

**5th year**

| | |
|---|---|
| Elements of Ethics in Medicine: Palliative Care**** | L 15h E |
| Master Laboratory** | 210h |
| Master Seminar** | 30h |

Monographic Lecture 1:

| | |
|---|---|
| Fundamentals of Magnetic Resonances** | L 30+30h E |
| Fundamentals of Molecular Spectroscopy** | L30+30h E |

** the Faculty of Physics

**** Medical Academy

**Assessment:** E – exam

**Surrounding Nature (post extramural study)**

**Education to Life in Family (post graduate extramural study)**

***The structure:*** Both proposals are addressed to post graduate students of biology, pedagogy or other disciplines who are teachers in primary schools teaching interdisciplinary the Nature. The study is affiliated at the Faculty of Biology, and individual management is dealt by the Dean of the Faculty of Biology. The Ministry of National Education grant financially supports this proposal.

The objective of the study is to provide students with qualification to teach interdisciplinary the module the Nature. Students receive the diploma of qualifying them to teach the Nature in classes IV to VI of the primary school in Poland.

***The organisation and proceedings:*** The number of candidates proceeds three times the number of places available (180 candidates per 60 places).

***Programme of the study:*** All subjects are obligatory and set into seven modules:

Unity and diversity of the nature.

Man in natural environment.

Methods of observation and description of the natural phenomena and planning designing and executing experiments.

Principles and methods of classifying the objects and natural phenomena.

Methodology of teaching the Nature.

The personality of the teacher of the Nature.

The use of computer technology in the teaching the Nature.

**Within-facultative system of studying Mathematics and Computer Science:**

Faculty offers to intra-mural undergraduate an graduate students of Mathematics and Computer Science many ways of the combining of both specialities as well as possibility of achieving admission to teaching profession both in Mathematics and Computer Science in primary school, secondary school (gimnazjum) and high school (liceum).

Moreover there exists **postgraduate extramural study:**

**Mathematics with Computer Science**

***The structure:*** Proposal is addressed to candidates having master's degree in any speciality.

The aim of study is making candidates eligible for admission to teaching profession in primary school both in Mathematics and in Computer Science.

***The organisation and proceedings:***

Number of candidates does not exceed number of places available. There are 22 (first year) and 19 (second year) students.

***Programme of the two-year study:***

| | |
|---|---|
| Mathematical Analysis 1 | 30h E |
| Mathematical Analysis 2 | 40h T |
| Algebra 1 | 15h T |
| Algebra 2 | 20h T |
| Geometry 1 | 15h T |
| Geometry 2 | 20h T |

| | |
|---|---|
| Introduction to Probability Theory | 20h T |
| Introduction to Computer Science | 15h E |
| Computer Tools | 45h T |
| Introduction to Programming Languages | 15h T |
| Programming Languages | 45h T |
| Applications of Computers in Education | 40h T |
| Foundations of Didactics | 30h E |
| School Mathematics | 30h T |
| Methodics of Mathematics | 15h T |
| Methodics of Mathematical Analysis | 20h T |
| Methodics of Algebra | 10h T |
| Methodics of Geometry | 10h T |
| Methodics of Probability Theory | 10h T |
| Application of Computer Science in teaching | 45h T |
| School Computer Science Laboratory | 45h T |
| Psychology | 20h T |
| Pedagogy | 20h T |

**Assessment:** E– exam, T– test.

**Individual System of Study – ISS**

Individual system of study enables students to choose the module of study adapted to their individual interests in sciences. Individual curriculum is planned by matching various subjects offered by Faculties or various institutions. In general assumptions the proposal of IIS at the AMU is linked to experiences of other Polish universities.

***The structure*:**

The Individual System of Study in Natural Science is proposed to full-time (intra-mural) students.

This system is a three-stage system of study: undergraduate, graduate and postgraduate.

Student gets Master's degree of the discipline in which he/she completed his/her Master's Theses. IIS system of study enables to obtain the degree of Master of two disciplines.

In the organization of Individual Study in Natural Science following units of the AMU are engaged: Faculties of Biology, Chemistry, Physics, Mathematics and Computer Science, Geography and Geology.

Individual management is dealt by the Dean and Dean's office of the proper Faculties.

Collective management concerning the structure of study, programmes, curricula is dealt by Interfacultative Group for Individual Inter-Facultative Study and Individual System of Study in Natural Science.

The organization and proceeding:

Enrollment procedure: there is no special enrollment procedure. Candidates are chosen from among full-time students of biology and biotechnology, chemistry, physics, astronomy, mathematics, informatics, geography, geology, nature protection and psychology.

Student may study individual curriculum from the beginning or may apply for this during the first year of the study. As ISNS is addressed to very skilled students it is the Dean of the home Faculty who undertake the final decision. Although there is no a special enrollment procedure following things are taken into account: attainments in the Scientific Olimpiades and Competitions, results of the enrollment procedure, results during studies. It is the Dean who accepts the programme and project of study for given academic year prepared by student and his/her tutor.

***Programme of the study:*** The basis for ISNs is individual programme and education proposed under proper advice of the Tutor

The tutor may be professors or adjuncts affiliated at the UAM. It is possible to have more than one tutors.

The basis for acceptance the programme of the individual study is the statement that there are taken into account subjects essential for getting the Master's degree. It is proposed that student is obliged to credit the basic course which constitute 70% of the whole programme of the study and in the frame of 30% realized chosen subjects in other disciplines.

***Assessment procedures:*** The method of the assessment of the particular semester and year of the study follows those used by particular discipline. Semesters and years are assessed by the Dean of the home Faculty.

# Medical Physics Education at the University of Silesia

**Z. Drzazga**

*Department of Medical Physics, Institute of Physics, University of Silesia,*
*40–007 Katowice, Uniwersytecka 4*
*drzazga@edu.us.pl*

Interdisciplinary education on medical physics at licence level was organised by the Institute of Physics, University of Silesia in co-operation with the Silesian Medical Academy in Katowice and the Oncology Centre in Gliwice in 1995. Three years later we started with education at higher level ending with the MSc diploma.

The medical physics discipline was organised in order to educate qualified personnel possessing necessary skills for the application of modern physical methods in medical diagnosis and therapy. Because of the very specific regional request for these specialists they would be educated mainly in the subject of radiotheraphy, radiodiagnostics, X-ray tomography and magnetic resonanse imaging, nuclear and resonanse spectroscopy in medicine. Recently one may observe new diagnostic and theraphy techniques like photodynamic laser theraphy of cancer, microwaves, fibroscopes, laser surgery or biomagnetic stimulation that will lead to the even greater request for graduates in medical physics.

The structure, organisation, legal basis, financial aspects and programme of interdisciplinary study have been discussed and confirmed by ***Scientific Committee on Medical Physics*** including professors of the Institute of Physics, University of Silesia, the Silesian Medical Academy in Katowice and the Oncology Centre in Gliwice.

Interdisciplinary education was regulated by the ***special arrangement between the University of Silesia and Silesian Medical Academy in Katowice***.

The programme of medical physics covers general education in physics and mathematics some selected subjects of medicine and computer and information science applications. The general outline of the teaching programme is presented in the Fig.1 and is briefly listed bellow:

a) *essential scope (basic subject specification)*
   - fundamentals and principles of physics (experimental and theoretical physics, introduction to modern physics)
   - laboratory exercises (first and second level practical physics laboratory, nuclear physics laboratory)
   - electronics (electronics for physicists with the elements of knowledge about the medical electronic apparatus)
   - principles of higher mathematics (mathematic analysis, analytical geometry, higher algebra)
   - statistical methods in experimental data processing

b) *medical science subjects specification*
   - human anatomy
   - principles of physiology and physiopathology
   - diagnosis and therapy methods of radiology
   - an outline of diagnosis and therapy in oncology

c) *medical physics subjects group specification*
   - application of physical methods in medicine and biology

Fig. 1 Interdisciplinary Education at the Faculty of Mathematics, Physics and Chemistry
University of Silesia, 40-007 Katowice, Uniwersytecka 4

| **Physics at Institute of Physics** | | | |
|---|---|---|---|
| Specialisation | Type of study | Number of students (limits) | Inter-faculty and inter-university co-operation |
| 1. Experimental Physics<br>2. Theoretical Physics | M. Sc. (5 years) | 180 | |
| 3. Geophysics | M. Sc. (5 years) | 40 | Institute of Geology<br>Faculty of Earth Science |
| 4. Physics and Chemistry<br>– dual subject teachers education<br>5. Physics and Computer Science<br>– dual subject teachers education | M. Sc. (5 years) | 40 | Institute of Chemistry |
| 6. Medical Physics | Licentiate (3 years) + M. Sc. (2 years) | 40 | SilesianMedical Academy<br>Silesian Technical University<br>Institute of Oncology |
| 7. Physics and Computer Science | Licentiate (3 years) | 90 | |
| 8. Econophysics | Licentiate 3 years | 50 | School of Management<br>Academy of Economy |
| **Environmental Protection** | | | |
| 1. Physical and Chemical Methods for Environmental Protection | Licentiate (3 years) | 75 | Faculty of Mathematics, Physics and Chemistry |
| 2. Geoecology | | | Faculty of Earth Science |
| 3. Biological elements of environmental protection | | | Faculty of Biology |

– principles of the modern biochemistry and biophysics
– medical physics laboratory and application of medical apparatus laboratory
– materials engineering in medicine
– clinical accumulative dosimetry

d) *computer science subjects group specification*
– principles of computer science (computer systems, numerical methods)
– computer applications in medicine (mathematic simulation and modelling in medicine, statistical methods in medicine, data base processing, imaging)
– computer network laboratory

e) *auxiliary and some additional subject*
   - an intensive course of English language
   - philosophy of nature
   - courses of some subjects related to the specialisation and the theme of the final thesis, consultations on final thesis

f) *holiday season training in some policlinics*
   Students gain practical abilities in the Central Clinic Hospital in Katowice, in the Oncology Centre in Gliwice.
   *Detailed programme is available at*: **http://usctoux1.us.edu.pl/licfmed**

The CATS system (Credit Accumulation and Transfer System, according to European Credit Transfer System ECTS) has been introduced since 1998/1999.

Currently we offer two stages education of medical physics:

1. Three-year professional studies, ending with the licence diploma.
2. Two-year university studies for licentiates (fulfilling required criteria for continuation of studies), ending with M. Sc. Diploma.

The School offers highly qualified staff who is proficient in various methods applied in medical diagnosis and therapy. We hope that our graduates will be employed at Hospitals, Oncology Centres, in the public and private health service, as well as, in research institutions.

# Interdisciplinary Education at the Faculty of Mathematics, Physics and Chemistry, University of Silesia, Katowice, Poland

**Alicja Ratuszna, A. Chełkowski**

*Institute of Physics, 40–007 Katowice, Uniwersytecka 4*

**Physics**

Our Institute is interested in producing smart and motivated graduates who can adjust to challenges of the social demands in a constantly changing job market. To make the studies in physics more attractive and make the job finding easier we additionally broaden our offer by creating **new optional specialization courses**.

The Institute of Physics offers the following regular **graduate 5 year M. Sc. study in physics: experimental and theoretical physics**.

Students who complete these studies are prepared to conduct basic research in scientific institutions, as well as, to teach physics in all kinds of schools.

The following new special options were created:

| **Physics at Institute of Physics** | | | |
|---|---|---|---|
| Specialisation | Type of study | Number of students (limits) | Inter-faculty and inter-university co-operation |
| 1. Experimental Physics<br>2. Theoretical Physics | M. Sc. (5 years) | 180 | |
| 3. Geophysics | M. Sc. (5 years) | 40 | Institute of Geology<br>Faculty of Earth Science |
| 4. Physics and Chemistry<br>– dual subject teachers education<br>5. Physics and Computer Science<br>– dual subject teachers education | M. Sc. (5 years) | 40<br><br>40 | Institute of Chemistry |
| 6. Medical Physics | Licentiate (3 years) + M. Sc. (2 years) | 40 | Silesian Medical Academy<br>Silesian Technical University<br>Institute of Oncology |
| 7. Physics and Computer Science | Licentiate (3 years) | 90 | |
| 8. Econophysics | Licentiate (3 years) | 50 | School of Management<br>Academy of Economy |
| **Environmental Protection** | | | |
| 1. Physical and Chemical Methods of Environmental Protection | Licentiate (3 years) | 75 | Faculty of Mathematics, Physics and Chemistry |
| 2. Geoecology | | | Faculty of Earth Science |
| 3. Biological elements of environmental protection | | | Faculty of Biology |

**Geophysics**

This specialisation is offered jointly with the Institute of Geology of the Faculty of Earth Sciences (5 year system). Students learn subjects in mathematics and physics, according to physics and geology majors. They additionally conduct field works in geology and geophysics. After completing the third year of studies students select M. Sc. thesis in physics or geology. Finally they receive a M. Sc. degree in physics or geology with a specialisation in geophysics. Students who finish their thesis in the Institute of Physics are also encouraged to additionally study didactic subjects. This entitles them to teach physics in school.

**Study in Physics and Chemistry for Teachers** (5 year system)

These studies are offered jointly with the Institute of Chemistry of our Faculty and prepare teachers who can teach physics and chemistry in all kinds of schools. Students are required to learn mathematics, physics and chemistry according to the minimal requirements for physics and chemistry.

After the 3rd year of studies they could decide about selecting their master thesis in physics or chemistry. They receive a M. Sc. title in physics with a teaching speciality which additionally entitle them to teach chemistry. Alternatively, they receive a M. Sc. title in chemistry and additionally they can teach physics. They also are required to complete specialised courses in didactic and methodology of teaching in physics and chemistry and attend practical classes in school where they teach physics and chemistry.

**Study for Teachers of Physics and Computer Science**

The students learn mathematics and physics according to requirements of the program of physics studies. Additionally they study computer science, same as for physics and computer science licentiate. They study didactic of physics and computer science and take classes of teaching physics and computer science in schools. They receive a degree of M. Sc. in physics with a specialisation of a teacher prepared to teach computer science.

**Medical Physics** (3 year + 2 year system). These studies are conducted jointly with the Silesian Medical Academy and the Institute of Oncology (some examples of the courses, a characteristic of the graduate and chances for the employment will be presented by prof. Z. Drzazga).

**Physics and Computer Science** (3 year + 2 year system). Students are obliged to complete physics, mathematics and electronic courses according to the minimal requirements. They also attend lectures and laboratory classes in computer science. On completing special didactic courses they are prepared to teach computer science in school.

Recently, jointly with the Academy of Economy and the University of Silesia School of Management, we propose **econophysics** as a new special option in academic year 2001/02.

A rapid development in economy, interrelations between financial markets, stock functioning requires proper description, analysis and prediction of the economic trends of a financial market using mathematical and physical methods.

Physicists are often employed in banking where after completing additional courses they are employed as high rank staff due to their ability to use statistical tools and physical methods for predicting global economic laws and market modelling.

Thus, we are interested in preparing such students of physics who are able to work in this rapidly growing financial market. The students will learn during 3 year study subjects in mathematics, physics, statistics, statistical physics, computer science, as well as, micro– and macroeconomics, elements of management, econophysics, physical models in economy, etc.

The above described study programs are offered according to ECTS (European Credit Transfer System) mark system. Students can choose a program from those offered by ECTS 2000/01 (**http://www.us.edu.pl**)

# Interdisciplinary Education in the Field of Forensic Chemistry

**Paweł Kościelniak**

*Department of Analytical Chemistry, Jagiellonian University, Cracow, Poland*

For the last few years the efforts are made at the Faculty of Chemistry of the Jagiellonian University to create, establish and develop the educational student courses in the field of forensic chemistry. This action is based on the long standing collaboration between the Faculty of Chemistry and the Institute of Forensic Research (IFR), Cracow.

IFR is an institution of a very high reputation and of a long tradition (since 1929) in the forensic activity. The main role of the IFR staff is to provide expertise for courts and public prosecutors. Besides, they regularly offer the educational trainings targeted towards the professional groups (prosecutors, judges, border guards) in various forensic areas and they carry out own research projects in cooperation with numerous scientific centers in Poland and over the world. Due to the highly professional activity in all above scopes IFR is a unique center of the forensic branch in Poland.

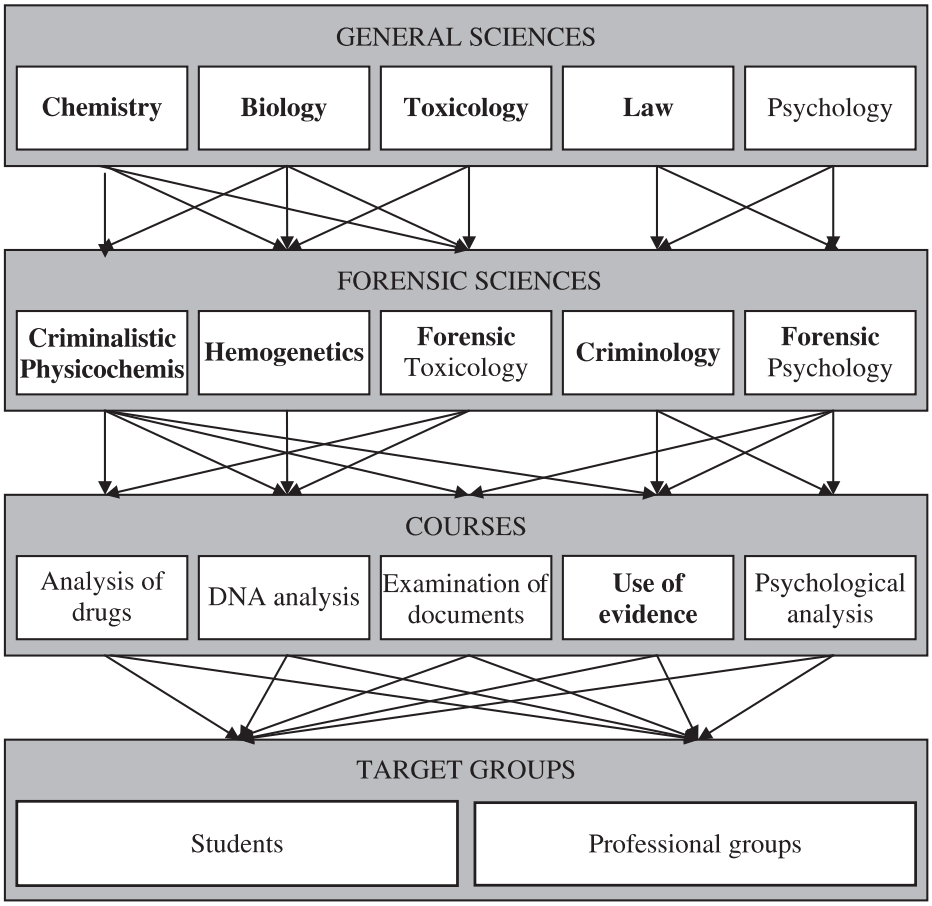
The educational and scientific connections between the Jagiellonian University and IFR are very strong. The JU staff represents those general scientific disciplines (law, chemistry, biology, pharmacy, toxicology, psychology) which can serve to especially great extent to the examination of crime and its consequences. These disciplines are the basis of the forensic sciences. The IFR staff consists mainly of the specialists in examination and solving of strictly forensic problems with the use of above general disciplines. Although the experience and expertness of both teaching groups are greatly common, they are complemented as well. As a consequence, both groups, when collaborating together, have a great chance to prepare and perform the interdisciplinary curricula in the field of forensic sciences.

The examples of some forensic courses, resulting from the mutual relations between the general and forensic scientific disciplines represented by both institutions, are presented in Fig. 1. The courses could be offered to different target groups, including both graduate and postgraduate students of various units of the Jagiellonian University.

In years 1998 – 2001 the Faculty of Chemistry of the Jagiellonian University and IFR developed and realized two international projects, both granted by the TEMPUS PHARE program, namely project JEP 12236–97 titled "Transformation of University Chemistry Studies at the Jagiellonian University" (TRUCS) and project JEP 13514/98 titled "National Training Program for Forensic Science Experts" (NATFOSE). As the partner foreign institutions, the high schools and forensic institutes from Italy, Austria, Portugal, Great Britain, the Netherlands, Sweden, and Germany contributed to the projects. The wide-scale collaboration and financial support ensured by both projects made the educational activities more efficient and essentially richer.

In the first stage of the realization of the TEPMUS projects the specialization called "forensic chemistry" has been established at the Faculty of Chemistry. Among the general sciences the chemistry has a special contribution to the forensic sciences. Regarding extreme variety of the crime traces the knowledge of chemical and physicochemical properties of various materials is essential (e.g. documents, markers, plastics, metals, fibers etc.). Credible identification and accurate quantitative determination of the components in an evidence can be a crucial factor in police and judicial investigations. In order to determine substances in trace and micro-trace amounts one has to have a profound knowledge of various methods of instrumental analysis, the skill to operate sophisticated equipment and the ability to interpret properly the results. Toxicology constitutes the separate field of chemical investigations.

Fig. 1. The concept of creation of the interdisciplinary courses in the field of forensic science basing on the collaboration between the Jagiellonian University and the Institute of Forensic Research



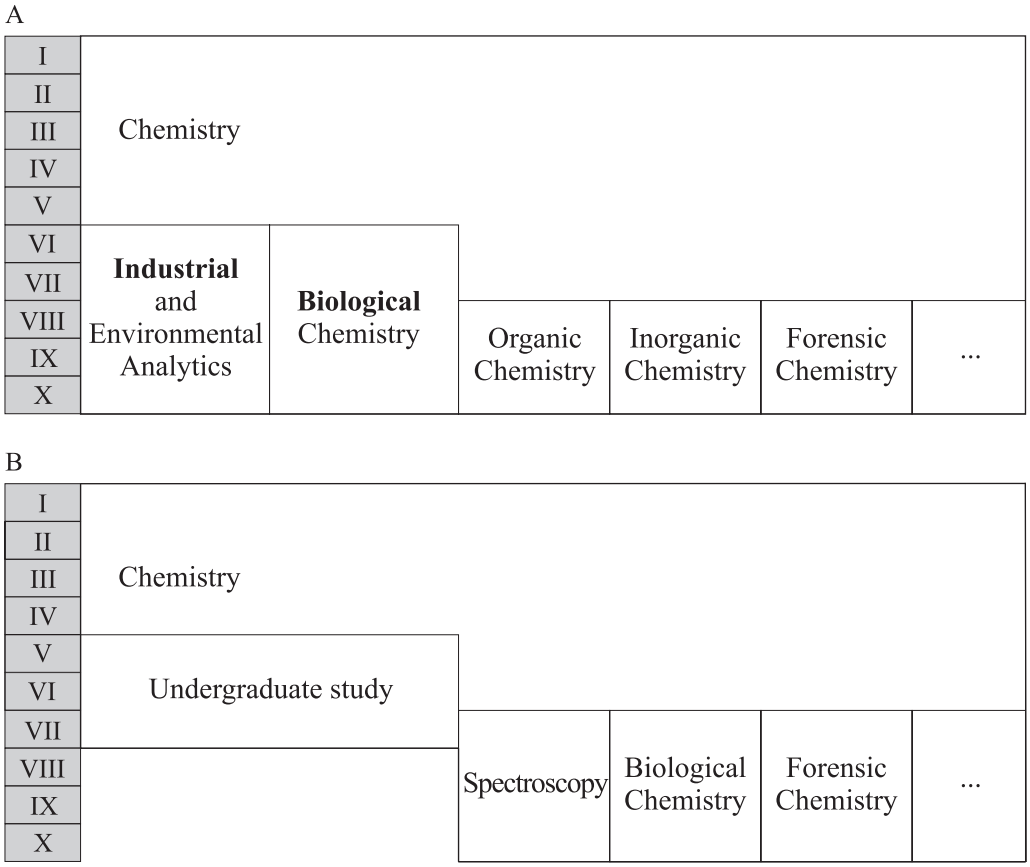

The problems existing in this filed are not only to detect the poisons and apply appropriate methods for their determination, but also to recognize their chemical structure and properties.

The "forensic chemistry" specialization is actually offered to the students of three last semesters of their chemical study. The module is equivalent to other "small" specialization lines which are commonly arranged in particular departments of the Faculty of Chemistry and deal with typical chemical subjects. The position of the "forensic chemistry" specialization in the present structure of the chemical study is shown in Fig. 2A.

Because of a great interest of the student in the forensic issues, from among all candidates a group of six students is selected every year by means of a qualification discussion. The main subjects taking into account for the qualification are the analytical chemistry and toxicology. Most of the dedicated lectures, seminars and laboratory classes are provided as yet by the IFR staff with the use of equipment and space of this institution. During the last year of chemical study the students have the opportunity to participate in the research topics solved currently in IFR and to prepare their master theses on this basis. The present curriculum of the "forensic chemistry" specialization is shown in Table 1.

Another initiative undertaken in the frame of the TEMPUS projects is the establishment of the Laboratory for Forensic Chemistry. It was founded in 2000 at the Faculty of Chemistry as the

Fig. 2. Structural scheme of the chemical study at the Faculty of Chemistry, which is valid hitherto (A) and developed according to the novel curriculum (B)




first laboratory of the forensic profile in Polish high schools. The main role of this laboratory is to introduce the permanent, still upgraded forensic education into chemical study of the Jagiellonian University on the basis of close collaboration with IFR and other European forensic centers. The other task is to develop the new research methods and procedures in those criminalistic and toxicological issues which are currently of especially great forensic importance.

The Laboratory for Forensic Chemistry is equipped with advanced audiovisual facilities (e.g. video projector, cameras, video recorder etc.), all purchased for educational purposes. Moreover, the instrumental systems for atomic fluorescence spectrometry and capillary electrophoresis have been installed that allow the preparation and analytical examination of different samples of complex composition. At present, the procedure of analysis of biological samples (i.e. human tissues, hair, body fluids, plants) is developed with respect to the determination of trace amounts of such toxic elements as mercury, antimony, cadmium, selenium, arsenic, and lead. In the frame of other research line the chemical composition of inks extracted from paper is examined as a part of question document forensic investigations.

According to novel curriculum of the chemical study at the Faculty of Chemistry the structure of specialization study is to be changed (see Fig. 2B). In general, all modules are intended to be started not later then from the seventh semester and consequently to be expanded in terms of number and kind of courses. The assumption is also made that the courses should compose more

Table 1. Present curriculum of the "forensic chemistry" specialization

| Semester | Course | Title | Size (h) |
|---|---|---|---|
| VII | lecture | Toxicology | 30 |
| VIII | lecture | Criminalistic physicochemistry | 15 |
| VIII | lecture | Legal aspects of expert work | 15 |
| VIII | seminar | Chemical aspects of forensic sciences | 15 |
| VIII | lab. class | Volatile organic solvents. Determination by GC method | 8 |
| VIII | lab. class | Examination of ethanol in body fluids and breath | 8 |
| VIII | lab. class | Separation of inorganic poisons from biological materials | 8 |
| VIII | lab. class | Determination of heavy metals in body tissues | 8 |
| VIII | lab. class | Chemical examination of drugs and medicines | 8 |
| VIII | lab. class | Chemical examination of oils | 8 |
| VIII | lab. class | Chemical examination of car paints | 8 |
| VIII | lab. class | Chemical examination of fibers | 8 |
| VIII | lab. class | Chemical examination of ink materials | 8 |
| VIII | lab. class | Chemical examination of gun-shot residues | 8 |
| IX, X | seminar | General problems of forensic sciences | 30 |
| IX, X | monographic lectures | | 60 |
| IX, X | graduate's laboratory | | |

topical modules based on different chemical disciplines (in fact it is actually characteristic for the "forensic chemistry" specialization).

In above situation a novel curriculum in forensic chemistry is intended to be developed in near future as well as some of new courses are expected to be provided at the Faculty of Chemistry by the staff of the Laboratory of Forensic Research. For this purpose the lecture and seminar dealing with the forensic analytics is prepared. The new laboratory classes are also arranged with use of the instruments for atomic fluorescence spectrometry and capillary electrophoresis. Some other classes are planned to be presented with the aid of audiovisual system (e.g. DNA analysis, chemical examination of fingerprints) and of computer programs (e.g. profiling of amphetamine). At last, the research subjects currently performed in the Laboratory will be offered to the students of the "forensic chemistry" specialization as the basis for their master's and doctoral theses.

Certainly, the further intentions dealing with the forensic education will be able to be realized on the basis of collaboration between the Faculty of Chemistry, Jagiellonian University, and the Institute of Forensic Research. From among those ideas which are possible to be brought into practice very soon is the concept of the postgraduate studies in the field of forensic science. However, the common activities have a chance to based not only on the mutual relationships between both institutions (as shown in Fig. 1) but also on both the experiences gathered during the realization of two TEMPUS projects mentioned above and the support from foreign forensic centers participating in both projects.

# Two-subject Studies: Biology and Geography

**Jan Kozłowski**

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An environmental science is a relatively new interdisciplinary subject, not fully falling into classic disciplines, such as biology or geography. Because of human population explosion accompanied by rapid technological development, environment is strongly endangered and its protection is now one of key issues in social policy. Environmental protection is undoubtedly mainly technical and economical problem, but our experience in other technical disciplines teaches us that practical solutions are safer and more efficient if based on a solid scientific foundation. Because environment consists of animated and unanimated components working in unity, it is difficult to understand basic principles having training in either biology or geography separately. This is a rationale to develop two-subject studies, preparing to work in a broad range of environment-objected jobs, as well as to teaching science in school. Strong background in environmental sciences, not achieved separately in biology or geography, as well as knowledge of monitoring, environmental evaluation, nature conservation, environmental protection, landscape planning, etc., make a graduate a good candidate to work in public administration, environmental agencies, national parks and landscape protection parks, laboratories, and small business, especially environment-oriented one.

The idea of the studies is as follows. During five years students obtain two degrees: B.Sc. in biology and M.Sc. in geography, or B.Sc. in geography and M.Sc. in biology. It is also possible to resign of M.Sc. and to obtain two B.Sc. in both disciplines, possible in a shorter period of four years. To be permitted to teach, it is necessary to take additional pedagogical courses provided by our University.

First three years, about 2100 class hours, comprise of:

- basic courses:
  - foreign language, mathematics & statistics, computer sciences, physics, chemistry
  - zoology, botany, biochemistry, physiology, cell biology, genetics, microbiology & immunlogy, human anatomy, evolutionary theory, ecology, biogeography, environmental protection
  - astronomy, geology, geomorphology, hydrology & oceanography, meteorology & climatology, physical geology, social & economical geography, GIS, cartography & topography, soil sciences, teledetection
  - field courses
- optional courses
- B.Sc. thesis in a complementary subject to the subject chosen for M.Sc.

For those chosing biology as a final subject, last two years comprise of:

- 1380 hours (including seminars and M.Sc. thesis preparation)
- Compulsory, common to all students (47%)
  - environmental chemistry, ecosystem ecology, evolutionary ecology, methodology of science (including advanced statistics), biodiversity, environmental protection (advanced), techniques of visualization and communication
- Optional blocks (22%)

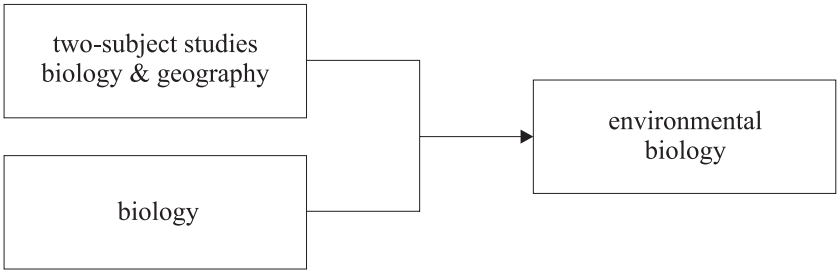
- land ecosystems or hydrobiology
- biology of selected systematic groups: plants or animals or water organisms
- field studies in plant biology or zoology or hydrobiology
- nature conservation or technologies of environmental protection or resource management

– Other optional courses (5%)
– Seminars, M.Sc. thesis (26%)

For those chosing geography as a final subject, last two years comprise of:

– About 1300 hours (including seminars and M.Sc. thesis preparation)
– Compulsory, common to all students (38%)
– Optional blocks (25%)
  - geomorphology & soil geography
  - hydrology & climatology
  - geo-ecology
– Other optional blocks (7%)
– Seminars, M.Sc. thesis (30%)

Two-subject biology & geography studies will start in the autumn 2001. Predicted enrollment is 60 students per year. At the same time reform of classical biology studies and geography studies starts. These reforms take into account better coordination with two-subject studies, and the possibility of student mobility between subjects within our Faculty. For example, environmental biology specialization is expected in new biology study system to be similar to the one within biology & geography studies. This means that two ways to graduate in environmental biology will coexist:




This way the number of students specializing in environmental biology will increase, which will make possible to enrich the offer. Similar flexible system is expected for physical geography, with possible specialization either through two-subject biology & geography studies or classical geography studies. Because the two-subject studies are organized within the ECTS system, we hope also for student mobility in Europe.

# Studies Of Mathematical and Natural Sciences (SMP) at the Jagiellonian University in Kraków

**Jerzy Szwed**

*Faculty of Mathematics and Physics, Jagiellonian University*

The program of SMP started in the academic year 1993/94. It is a new way of studying at 3 faculties of the Jagiellonian University: Faculty of Mathematics and Physics, Faculty of Chemistry and Faculty of Biology and Earth Sciences. It includes programs of 10 regular study fields: astronomy, mathematics, physics, biology, biochemistry, chemistry, geography, geology, environmental protection and computer science. After test exams (mathematics and one of four fields: physics, biology, chemistry or geography) students choose individual tutors and with their help compose their own study program. The only common and special to0 SMP activities are: computer science (semester 1–2), seminars given by faculty members (semester 1–4) and seminars given by the students themselves (semester 5–6). At the end of the 4$^{th}$ semester students choose the leading field (one of 10) in which they prepare their M.Sc. theses.

SMP has nearly no administration. The SMP Program Council (chairman, secretary and representatives of 10 fields) takes care of the whole educational process. The Students Secretariat of the Institute of Physics does the whole administration for the first 4 semesters including entrance examinations. The Institute of Physics also administrates finances. This has been accepted because of limited number of students. Each year 30 students enter SMP with about 3 times more candidates.

The experience after 7 years shows that SMP is a successful initiative. SMP students are very active reaching often-outstanding results in their work. For their achievements they win numerous awards and scholarships. Just to give an example, each year they receive about 10 scholarships from the Ministry of Education. This means that being less then 1% of the student population they receive more than 20% of all these scholarships coming to our University.

More information about SMP can be found on the WWW page under the address: http://www.if.uj.edu.pl/SMP/smp.html

# III
# Organisation, structure and curricula for interdisciplinary subjects teachers education

## Assessing the Progress of Student Science Teachers

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**Introduction**

Since 1997–8 student teachers in the UK have been required to meet a demanding new set of nationally imposed standards before they can be awarded Qualified Teacher Status (Department for Education and Employment, 1997). This paper considers the framework in which this can be achieved, the support that student teachers receive from collaborating university and school staff and the problems and advantages of this system. The nature of the Standards, including references to interdisciplinary issues, will be outlined. All of this will be addressed in the context of assessing the progress of student science teachers.

The majority of secondary science teachers in the UK enter the profession by completing a one year postgraduate training (Post-graduate Certificate in Education, PGCE) after graduating in a science discipline, e.g. Biology, Physics, Chemistry or related subject such as Medical Science or Engineering. These are usually thirty eight week courses with a substantial component of school-based practical experience. Most courses prepare students to teach science to the 11–18 years age range. The course offered by the University of Warwick is typical, with students spending most of the course in schools (68%) and with two periods of full time school based practicals of six and fifteen weeks duration. The students are prepared to teach all of the science national curriculum to 11–14 year olds, at least their specialism (Biology, Chemistry or Physics) to 14–16 year olds and normally Biology, Chemistry or Physics to 16–18 year olds. They are expected to become competent at teaching the full ability range normally found in mainstream schools.

With students spending so much of their time in schools, they require good support from successful science teachers as well as from University tutors. The University works in partnership with a large number of schools in the region. Certain staff in each school are trained by the University to act as mentors to the student teachers.

**Teachers as mentors**

A science student is formally supported by two teacher-mentors during a school-based practical experience. One of the mentors, the Professional Mentor, is a senior teacher within the school, perhaps a deputy head teacher, while the other is a science specialist. In both cases they will be experienced and successful teachers who have received initial training in their role by university tutors and other mentors. However, teacher-mentors also receive on-going training as the nature of their role develops and opportunities to share good practice arise. Science mentors are expected to meet formally with their students at least once a week to discuss the student's progress and to review and set targets. Thus the mentor plays an important part in the formative development of the student as a competent new teacher. However, they also have a key contribution to make in the summative assessment of the student. This may be the most important factor in determining whether the student ultimately achieves qualified teacher status. In practice, many students also receive additional useful support and guidance from other teachers whom they work alongside in the partnership schools.

**Assessment against the Standards**

The success of student teachers in the UK is measured against the Standards for Qualified Teacher Status (hereafter known as "The Standards"), as required by the Department for Education and Employment. These were first introduced for students completing courses in 1998 and represented a significantly more demanding set of requirements than any applied to preceding courses. Students have to meet all of the eighty six standards, as well as additional requirements specifying their level of subject knowledge, numeracy, literacy and ICT competence. Most of the Standards can only be reached when the student demonstrates competence during the school-based phases. Competence must be demonstrated in a consistent manner, it is not enough for the student to show their ability to perform acceptably against one of the Standards on one occasion. All of this means that the student and mentor need to build up a thorough base of evidence against the Standards and be able to justify judgements of standards met or not met. As the person best positioned to judge a student's performance, the Science Mentor is expected to coordinate the school-based assessment of a student. In this task they will be supported by the Professional Mentor and by a visiting University tutor who will liaise with the school and observe the student teaching. Assessment is carried out using a four point scale:

Level 1 Area of strength
Level 2 Area of competence
Level 3 Acceptable, but needing improvement
Level 4 Area needing further sustained effort to achieve competence

Students must achieve levels 1–3 in all standards by the end of the course.

The Standards are detailed and divided into four sections:

- Knowledge and Understanding
- Planning, Teaching and Classroom Management
- Monitoring, Assessment, Recording, Reporting and Accountability
- Other Professional Requirements

The Standards are widely regarded as demanding. When first introduced, most experienced teachers expressed considerable doubt as to whether they met the Standards themselves. Certainly, the Standards should be seen as part of a wider, political drive to raise standards generally within education in the UK.

Despite the large number of individual standards set out, many require considerable interpretation and are therefore liable to be interpreted differently by different individuals or institutions. As far as interdisciplinary education is concerned, there are relatively few references, perhaps reflecting the emphasis that has been placed on relatively narrow subject based approaches to the

curriculum in recent times. However, there are standards that are relevant to the growing attention being paid to the importance of developing children's wider life skills through subject studies. Thus we find standards that include the following statements:

Those to be awarded Qualified Teacher Status must, when assessed, demonstrate that they:

*... understand the contribution that their specialist subject makes to the development of key skills.*

*... plan opportunities to contribute to pupils' personal, spiritual, moral, social and cultural development.*

*Use teaching methods which sustain the momentum of pupils' work and keep all pupils engaged through:*

*... exploiting opportunities to improve pupils' basic skills in literacy, numeracy, IT and the individual and collaborative study skills needed for effective learning, including information retrieval from libraries, texts or other sources.*

*... providing opportunities to develop pupils' wider understanding by relating their learning to real and work related examples.*

**Interpreting the Standards**

Most of the Standards set quite high demands that are basically achieved or not achieved. In order to help students learn and progress, it is important that a system is used that allows them to plot their progress as a formative experience. To this end, university tutors and school mentors have worked to produce a series of level descriptors for each of the Standards, so that a student may know whether he/she has been adjudged to have just attained a standard or whether they are secure against that particular standard.

Level descriptors for standards relating to the student's ability to contribute to a pupils' wider development are:

Level 1 contributes to a pupils' wider development as a matter of course
Level 2 has often created or taken opportunities which arise for contributing to pupils' wider development
Level 3 has, on occasion contributed to pupils' wider development

Note that the basic standard of competence required of the new teacher is set so high, that it is difficult to differentiate between different levels of performance. This is not the only problem with the use of standards for assessing student teachers.

**Problems assessing against the Standards**

As already mentioned, the Standards require interpretation. The interpretation that is placed upon a particular standard by a mentor will be influenced by their own teaching experiences, the nature of the school in which they teach and the nature of the pupils with whom they work. The mentor's own level of competence as a teacher will inevitably influence their interpretations and judgements. This is one reason why the University tutor's role is so important in the assessment process, because they possess a wider perspective, having seen the work of many more student teachers than the mentor and being familiar with a much greater range of schools in many different localities influenced by different socio-economic factors.

Another problem with the Standards is the necessity to develop a comprehensive evidence base to support the judgements made during assessment. This places a great pressure upon the

student to maintain a comprehensive and well organized paper-trail of all their planning, preparation and other activities. This requirement is quite challenging for some students, many of whom may show considerable promise as dynamic and even inspirational teachers, yet have difficulty organising paper work. There is a real risk that some potential new teachers my be deterred from their chosen path early on in their career by the apparently buracratic nature of the training process. It also places a considerable burden upon mentors, who also have to maintain comprehensive paper records in the relatively modest amount of time they are allocated for working with student teachers.

Finally, a problem with the Standards is that they only refer to the measurable. The true worth of a new teacher may not be captured by a set of figures pertaining to the Standards. Some individual students will be undervalued by a standards only profile while others may appear more proficient than they really are.

**Benefits of assessment against the Standards**

Despite all the problems, there are also benefits to a standards-based assessment of student teachers. The Standards have made it clearer than ever before what is expected of newly qualified teachers. This makes it easier for student teachers, and also those responsible for their training, to feel secure about the aims of the course. The Standards can be used to generate regular feedback to students of an open nature based upon transparent criteria. They can also be adapted, in the ways described, to provide students with a structured system of targets during the course so that they can be motivated by a sense of progress. The reaction of experienced teachers to the introduction of the Standards reflects the fact that they do represent an attempt to spell out clearly what good teaching is about. In this respect, it can be argued that the Standards have promoted good teaching in all areas, some of which may previously have been neglected or paid insufficient attention. Certainly, both mentors and students have found the Standards-based assessment of their progress useful in some ways. An experienced Science Mentor in a Coventry school said:

"...working with student teachers really helps me reflect upon my own practice. Becoming a mentor has made me a better science teacher."

Student teachers appreciate and benefit from the mentoring system in schools:

"My science mentor provided invaluable help. It was really useful to be able to discuss my progress and targets with someone who knew the kids I was teaching".

**Reference**

Department for Education and Employment (1997) *Standards for the Award of Qualified Teacher Status.* Circular 4/98.

*This document may be downloaded from a website:*
*http://www.canteach.gov.uk/info/itt/requirements/index.htm*

# The Structure and Organisation of the Reformed Teacher Training Programme at Karlstad University

**Mariana Hagberg**

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Teacher education is under discussion in Sweden; it is being rethought and reconstructed. In Karlstad University we give a lot of thought to the reconstruction of our science teachers education as well as the teacher education in general. The Commission on Teacher Education has finished its work and the final report was presented to the Swedish government. By now the government has accepted the suggested reconstruction and they have given their directives to the Swedish universities. I will here give a background and report on the structure and organisation of the teacher education programme and its implementation at our university.
The following issues will be reported on:

- The conditions for a new task as a science teacher – the roll of the future science teacher.
- Desirable qualities and competencies of the future science teacher.
- Our approach to learning and knowledge
- The new structure and organisation of the future science teacher education.
- Our ways to create interdisciplinary subjects.

## Background

### The conditions for a new task as a teacher – the roll of the future science teacher

From different sources in society we are meet by the message that education, competence and capacity to handle information are decisive for a democratic society and economic increase. So we understand it that the society must educate individuals to have the desire and the capacity to searching independently for knowledge and for solving problems. We need to educate children, young people and adults to be able to in an independent way ask questions, find answers and to test different understandings of facts and experiences. Historically the roll of the teacher has been to talk at the pupils and direct the teaching. Today's society presents the future teachers with a new task and correspondingly we teacher educators are also faced with a new task, to educate these new teachers for their future profession. The future teachers will meet a new generation, which asks new questions. He/she must acquire competence in assisting pupils to select relevant and reliable information from the information overload of IT society. One task is to help pupils to make their own critical analyses and discover connections. We believe that knowledge can't be find in a box ready to be handed over to the pupil, but that it is something that the individual himself must acquire. The teacher can offer information but only through reflection by the individual can knowledge be created. As a teacher one therefor must be able to place information into a context and create knowledge together with the pupils. It follows that an important task of the future teacher is to create good learning situations and to stimulate a process where the individual learns in the best possible way. We believe that in the future the teacher must be a partner whose authority will stem from mutual trust, awareness and ethical awareness. This is in contrast to the

former roll of the teacher whose authority was given by definition. The teacher was the teacher – and he was not to be contradicted!

At another level we are presented with the new situation that new and different types of information technology create. Learning may take place outside or beyond the classroom and it will no longer be necessary always to meet in the classrooms of the schools. New possibilities for teaching are thus opening up carrying with it demands of new creative teaching methods and didactics.

**Desirable qualities and competencies for the future science teacher**

Considering our ideas, presented above, about the future science teacher profession we are of the opinion that the teacher training as well as the science teacher training must be organised in order to develop certain qualities and competencies in the intended teachers. We all agree that the future teacher should be creative and have initiative while he/she at the same time should have adaptability to change. Responsibility and commitment are important attributes as well. Further competencies of a more general character, which the science teacher students should develop during their education, are:

- Ability to listening and empathy grounded in caring for others.
- Ability and wish for co-operation and conflict handling.
- Leadership specially focused towards leading other peoples learning.
- Ability to critical reflection, especially around own and others experiences in the teaching profession.
- A will and a capability to a continuos learning.
- To critically analyse the connection between change in society, the formulation of the curriculum and the school's understanding of its social function.

The following competencies have a more special character related to the different subject matters:

- Well-grounded and relevant subject theory knowledge as well as competence in subject matter didactics. The competence in subject matter didactics includes the ability to follow independently the development within the subject theory. It also includes being able to put the subject theory into a historical perspective and being able to reflect around the scientific core of the respective subject theory. It also includes ability to relate the subject to other subjects as well as to the present understandings about the world of the learner. This with the intention to ease the pupil's understanding of an interdisciplinary reality.
- Well-grounded knowledge in learning theory. Competence to lead the learning of others from a developmental and social-psychological perspective.

  Our approach to learning and knowledge.

We believe that the science teacher education must itself serve as a model. The education should be a practice of the ideas and principles about learning theory that we teach and are to be practised at the compulsory school later by the apprentice teachers themselves. That is to say, the student should be able to use the ways of teaching, as they have experienced them during their own education, in their own future work as teachers.

The responsibility and influence of the students must be obvious in the science teacher education. Interactive ways of working should be dominating. The learning process should be investigative and rooted in the questions and beliefs of the students. Such questions might arise during their teaching practice at school, which is integrated in their subject theory studies. For instance a student may experience a need for more knowledge in the area of human physiology. She will then be given the opportunity for advanced study in human physiology. Or another student feels the need for putting the theory of the origin of species in its historical setting. Then the opportunity for such studies will be given. In this way we create interplay between the theoretical and the practical experiences which we believe is fruitful for learning.

The guiding of the science teacher students is other a field that must be developed. Guiding must be of a more clear and specific nature in order to develop the skill of the students in reflecting over the experience you make when you practise teaching. It will also help in theorising the practical experience.

At Karlstad University we also discuss incorporating the aesthetic dimension into the various parts of the science teacher education programme to a greater extent then is done today.

The reformed teacher educationprogramme will have a closer linkage to research. One purpose is that a scientific way of thinking should be reflected in al teaching. When teacher students are encouraged to learn a scientific attitude and are in contact with research the new generation of teachers will be more open to examining academic research with an analytical frame of mind. The Science teacher education programme is suggested as an entry to doctoral studies.

## The structure and organisation of the reformed science teacher training programme

**The structure and organisation of the future science teacher education**.

The reformed science teacher training programme will have the following structure and organisation. It will consist of three well-integrated course categories: 1) a general course block, 2) a focus block and 3) a specialisation block. The courses, which belong to the focus and the specialisation blocks, will be organised in order to be useful also for in-service teacher-training.

The teacher-training programme contains a presentation of a paper. This paper will focus the training of the ability of the science teacher student to reflect over his/her knowledge and relate it to his/her teaching in his future profession

The exams within the science teacher education programme consists of totally either 140 credits (3,5 years of study) directed toward teaching at pre– and primary school or 180 credits (4,5 years of study) directed towards teaching at secondary and upper secondary school.

**The general course block**, **60p**

The general course block extends to 60 credits and is made up by two different parts

A) areas of knowledge, which are central for the teaching profession
B) Interdisciplinary, thematic studies.

Of the totally 60 credits ten will be situated at the field of the activities i.e. at schools.

Part A consists of courses in learning theory, didactics, pedagogics, in socialisation, and in common value grounds in society.

Part B is made up by central interdisciplinary subject studies. These courses in part B will contribute to the advancement in the subject theory knowledge of the students but at the same time the courses will pay attention to different ways of organising and acquiring knowledge. Another aim of these courses is to give different perspectives on the existence and life of man. The different courses of part B should give the students an understanding of interdisciplinary work procedures as well. Thus the teacher students should be prepared for the school situation where co-operation between teachers with different subjects is necessary in order to meet the questions of the pupils in a fruitful way. An example of such a thematic, interdisciplinary course may be "Man and his environment" where subjects like biology, chemistry and civics can meet.

**The focus block**

The different courses within the focus bloc have each a credit score of minimum 40 credits. They will later constitute the school subjects of the future teacher and corresponds to the former subject theory studies. The courses are be built of new or traditional school or university disci-

plines. They may be interdisciplinary or thematic in content. At least 10 credit scores must be located to the schools where the practise is carried out.

**The specialisation block**

The specialisation block consists of different courses of 20 credits. They may include an advanced course in the subject theory, or may constitute a broader base to these courses. Such a course may be for instance philosophy or history of ideas. Alternatively they can give other a perspective on already acquired knowledge, for instance directed towards teaching the subject to a certain age group of pupils. The courses are connected to research and are individual or group courses. Some of them are distance education.

**Our way to find and create new interdisciplinary subjects**

When implementing and organising the reformed teacher education programme at Karlstad University we wanted a bottom up structure in opposite to a top down structure. Therefor the teachers at the university were invited to sketch suggestions of possible disciplinary and interdisciplinary 40p courses suitable for the courses within the focus bloc. This resulted in 70 different suggestions with titels like: Settings for survival, Physics and technology, The living landscape, The body and the soul, How to discover and learn concepts in mathematics, language and nature and Environmental history

The different suggestions were then clustered into groups of similar or related content. Out of these clusters the group responsible for the reform work at the university formed four fields which were named “knowledge-areas”. These were Language and culture, Aesthetics, media and communication, Nature and man and Co-existence and internationalism. This was used as a base. The persons who have given contributions are now together forming interdisciplinary courses within these knowledge areas. Of cause not al of the contributions could form a course of its own but parts of most of the ideas will be used in courses in different ways. Some of the ideas will be used in the thematic courses of the general course bloc and some will constitute good courses of the specialisation block. This is how far our work has proceeded by now. Our staff has showed a lot of competence and creativity when performing this work. The group responsible for the reform work at the university is confident that the work will result in a new, interesting teacher education programme. Still a lot of work remains before the reformed teacher education programme will start at 1 July 2001.

# A Physics and Chemistry Degree for Teachers – some aspects of an interdisciplinary course

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## Introduction

One of the former goals of the University of Aveiro was the improvement of teacher training courses for basic and secondary school levels. In the last 27 years we have developed a general model for this kind of undergraduate studies in which is included the professionalization.

## General Model for Teacher Training Degrees

The model that was intended to develop was an integrated model. This means that along with the course the student is gradually being acquainted with all the areas that will be necessary to acquire an adequate formation to become a future teacher of a specific domain at Basic[1] / Secondary school level. She/He finishes her/his degree after being succeed in a special training year at one public school and only after this she/he has the final diploma.

The main degrees that are performed at the University of Aveiro are:
Biology + Geology[2]; Physics + Chemistry; Electronics + Informatics;
Englisch + German; Portuguese + French; Portuguese + English; and
Portuguese + Latin + Greek.

More recently we have made some adjustments to the previous experience. These are concerned essentially with the implementation of a first year at the university common to all degrees in Science and Technology. The main objective was to develop with the students a common dimension in the basic sciences – Mathematics, Physics, Chemistry, Informatics and English, for all

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[1] As for Basic we intend especially the third level of Basic (it comprehends students from 13 to 15 years old). The second level of Basic can also have some of these teachers, usually those from Humanities. There are special degrees for those who will intend to be teachers at a primary level or even for teaching at kindergarten.

[2] The present curricula plans for the Training Teachers Degree of Biology and Chemistry and of Electronics and Informatics are the following:
**Biology Geology**: *1st Year / 1st semester* – Calculus I, Physics I, Chemistry I, Introduction to Informatics, English. / *2nd semester* – Calculus II, Physics II, Chemistry II, Programming and Structure of Data and Algorithms, English. *2nd Year / 1st semester* – Mineralogy, Cytology and Histology of Plants, Bio statistics, Bioorganic Chemistry / *2nd Year / 1st semester* – Cytology and Histology of Animals, General Botanic, Petrology, Palaeontology. *3rd Year / 1st semester* – General Zoology, Genetics, General Geology, Psychology of Development and Apprenticeship/ *2nd semester* – Animal Physiology, Microbiology, Cartography, Sociology of Education.*4th Year / 1st semester* – Man Biology, Ecology I, Energetic Mineral Resources, Educative Technology in Science, Specific Didactic A / *2nd semester* – Physiology of Plants, Ecology II, Geology of Portugal, Specific Didactic B. *5th Year* / Project and Teacher Training (annual).
As for **Electronics + Informatics**: *1st Year* – Identical to Biology Geology. *2nd Year / 1st semester* – Calculus III, Electromagnetism, Linear Algebra and Analytical Geometry, Programming of Systems and Software Engineering/ *2nd semester* – Waves, Applied Mathematics, Probability and Stochastically Processes, Circuit Analysis. *3rd Year / 1st semester* – Electronics I, Digital Systems, Systems Theory, Psychology of Development and Apprenticeship/ *2nd semester* – Electronics II, Introduction to the Architecture of Computers, Foundations of Telecommunications I, Sociology of Education. *4th Year / 1st semester* – Electronics III, Interfaces and Peripherals, Educative Technology in Science, Didactic of Electronics I/ *2nd semester* – Electronics IV, Option, School Organization and Curricular Development, Didactic of Electronics II. *5th Year* / Project and Teacher Training (annual).

those that want to perform a career in or with science in the future. The Engineering degrees were also within this measure that also affected the two existing science teacher degrees, that is, the degrees on Biology and Geology and the one on Physics and Chemistry. This experience has already seven years and more recently we are reflecting again on our degrees.

The main intention is now to evaluate what kind of competencies students present when they enter the university and what should be the capabilities they must acquire at last after a certain performance to get a degree.

In what concerns future teachers there has been an effort to identify main competencies in science, education, and communication, as they will become agents of education. In this aspect they should have a solid basis in the scientific subjects but also in science education, evaluation, psychology, as they will deal with 13 to 18 years old students with all the differences they can manifest. On the other hand, they must integrate themselves in the school milieu and be acquainted with family diversities too.

We are putting some emphasis on the model of two-cycle studies that is being now internationally discussed (Bologna Declaration). In this context, we are getting emphasis:

– on a first cycle of 2 years – the students should acquire competencies studying basic courses in physics, chemistry and mathematics that are requisites for a sound basis for any advanced course work;
– a second cycle – in the following two years study is divided between further courses in physics and chemistry (taken in common with physics and chemistry students) and courses on education (school psychology, school sociology and didactics)
– a 5$^{th}$ year – dedicated to teacher training at school and to complete a final year project.

The Physics and Chemistry Degree is coordinated jointly by the Physics Department, the Chemistry Department and the Didactics and Education Technology Department.

The present curriculum is the following one:

*1$^{st}$ Year / 1$^{st}$ semester* – Calculus I, Physics I, Chemistry I, Introduction to Informatics, English.

*1$^{st}$ Year / 2$^{nd}$ semester* – Calculus II, Physics II, Chemistry II, Programming and Structure of Data and Algorithms, English.

*2$^{nd}$ Year / 1$^{st}$ semester* – Calculus III, Electromagnetism, Thermodynamics and Physics of Fluids, Organic Chemistry.

*2$^{nd}$ Year / 2$^{nd}$ semester* – Mathematical Physics, Waves, Introduction to Quantum Physics and Statistic and Inorganic Chemistry.

*3$^{rd}$ Year / 1$^{st}$ semester* – Physical Chemistry, Chemical Analysis, Quantum Mechanics, Psychology of Development and Apprenticeship.

*3$^{rd}$ Year / 2nd semester* – Introduction to Biochemistry, Complementary Organic Chemistry, Solid State Physics I, Sociology of Education, Didactics of Sciences.

*4$^{th}$ Year / 1$^{st}$ semester* – Inorganic Chemistry and Environment, Option I, History and Theory of Education, Educative Technology in Science, Specific Didactic A.

*4$^{th}$ Year / 2$^{nd}$ semester* – Complementary Physical Chemistry, Option II, School Organization and Curricular Development, Specific Didactics B, History of Physics and Chemistry.

*5$^{th}$ Year* – Project (annual) and Teacher Training (annual).

In the last year the student goes to a public school and there she/he has committed to her/him two classes in the Basic School Course where she/he gives classes on Physics and Chemistry[3]. During this training year, a secondary school teacher supervises her/him. Two coordinators from

3 In our school system we have a common discipline where subjects of physics and chemistry are presented. It is only in the last year of secondary school, in the pre-university year, that the discipline is separated in Physics and in Chemistry.

the University staff are also accompanying her/his performance at school. She/He also gives some lessons in one of the classes of her/his school supervisor in order to acquire some experience in the domain of the Secondary School Course.

This last year is really an interdisciplinary one, where all the scientific and pedagogic subjects must be performed all together with the different actors that are intended to participate – teacher + supervisor + university coordinators + students of different levels.

During this last year she/he must develop a final project linking a topic of physics or chemistry with the teaching of that subject at the school level.

**Course Pedagogical Commission**

The university organization has paid attention to the necessity of creating discussion forums where students and teachers can exchange ideas and/or discuss problems concerned with scientific and pedagogic matters. It is at this forum that the main objectives of the curriculum are discussed as well as interdisciplinary problems. Attention is paid in order the subjects can be articulated in general without repetition of subjects.

This Commission is a consultative one and is constituted by a teacher staff representative of each Department involved in the course and a representative member of the students, one for each year of the course.

# Curriculum of the Interfaculty Postgraduate Study for Science Teachers

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Since 1945 there had been no natural science classes taken in Polish schools. It was introduced in 1999 for children at the age between 10 – 12. It was consequence of Education Reform.

Nowadays the levels of Polish Education System are: kindergarten, primary school, secondary school and high school (general, technical). Each level of education ends with the exam. The first three years at primary school is integral education, during next three years there are lessons: polish, history, foreign language, mathematics, art, physical exercise and science. Science includes elements of biology, geography, chemistry and physics. At secondary and high school there are separate subjects as polish, math, chemistry etc.

Science is introduced only at Primary school and as a subject is novelty for us.

Nowadays the teachers not properly qualified for this particular subject are teaching science. So far biologists, geographers, physicists and chemists have given the lessons. Recently, a problem of organising "the teacher training college" has appeared.

And here it is: The Interfaculty Postgraduate Study for Science Teachers.

We give prospects for science teachers to be, hitherto not available.

The programme of the studies aims at:

1. the complement of basic knowledge;
2. presentation of new trends in natural science;
3. presentation of nature integration and unity;
4. subjects correlation.

Taking into consideration the items mentioned we are trying to fulfil the programme of the studies by realisation of the following subjects:

| Subject | Materials range | Number of hours |
|---|---|---|
| Biology | Elements of general biology, botany, zoology, medical biology, ecology. | 80 |
| Geography | Basis of general and regional geography, elements of climatology. | 42 |
| Chemistry | New aspects of inorganic and organic chemistry, elements of physical chemistry. | 30 |
| Physics | Fundamental physical processes and rights. | 20 |
| Didactic | Science didactic.<br>Ecology in science education. | 30 |
| Historical, Philosophical, Psychological bases of science teaching. | Psychological bases of science teaching.<br>History of natural science.<br>"Between chemistry and physics" – series of lectures integrating chemistry and physics | 18 |
| Others | Scientific and posters sessions for teachers.<br>Individual consultations. | 30 |
| **The number of hours altogether** | | 250 |

**(X) The teachers present their achievements**

Relatively, the most frequent is biology and it is followed by geography, chemistry and physics. It is results from the science programme basis and from the fact that greatest numbers of our listeners are chemists. We are also trying our hardest to introduce components of basic instruction in science and usage of computers and multimedia that may be employed in the science classes. The study lasts 1 year.

The classes are organised in two forms: lectures and obligatory activities divided into laboratory classes and open – air activities. These open – air activities include two kinds if subjects botany and geography. Both are concentrated on individual, practical work and they both help to obtain good teaching results in the future. They educate participants on best didactic methods useful in practise.

During the course, listeners are obliged to write mid – year essays on particular topics in term time.

Exemplary topics are:

1. Parks and gardens neighbouring the school as a place of didactic activities.
2. The outline of science classes at schools.

The course ends with a thesis, which is conducted by a supervisor

Exemplary topics are:

1. Fractals in nature.
2. National Park of Babia Góra as a place of didactic activities for pupils.
3. The structure of human spine and its changes with age.
4. The Sun as the source of energy for the surface of the Earth and its atmosphere.
5. Lessons conspectuses for section “Water in nature”

On graduating the participants acquire rights to lecture science at primary schools.

The programme is modified yearly according to student’s education.

# Improvement of Educational Skills in the Science Knowledge Integration of Science Teachers During the Postgraduate Studies

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## Introduction

In the school year 1999/2000 the education reform was introduced in Poland. This is both syllabus and system reform accompanied by decentralization of the educational system to meet the expectations and requirements of the local environment.

Realization of assumptions and priority tasks of the new reform requires more individual work from teachers, skills to use the obtained autonomy in the procedure choice to reach the objectives concerning knowledge, skills and attitudes. Therefore there is an urgent need to improve the skills of teachers of all subjects and types of schools.

In the curriculum of science teachers training it is indispensable to include problems of correlation and integration of teaching contents of science subjects and to form teachers' skills in the area such attempts have been undertaken in the Faculty of Biology and Earth Sciences, Maria Curie-Sklodowska University in Lublin where there were opened the postgraduate studies for the teachers who taught biology or geography before the reform was introduced but now they teach the integrated subject "science" in the second stage of education (IV-VI forms of primary school). The studies can be carried out owing to the financial support by the Ministry of National Education (Education Grants 1999/2000, 2000/2001).

## Model of Integration of Science Contents in the Science Teachers Training Curriculum

Teachers get familiar with the problems of science knowledge integration and improve their professional skills during realization of the tasks included in the successive stages of the educational process. They will be discussed below.

1. Getting the teachers familiar with the science education models i.e. interdisciplinary and multidisciplinary models; drawing attention to the interdisciplinary character of science contents included in science curricula and handbooks.

*Educational tasks:* analysis of curriculum contents, establishing interdisciplinary problems, working out of the three-dimensional model of teaching contents taking into account the connections between educational aims, contents of teaching material and requirements from pupils (Niemierko 1999).

Works of teachers include such notions as water, energy, weather and substances in everyday life e.t.c. The contents are analyzed with respect to possible realization of accepted aims, consistency, arrangement, attractiveness for the pupils, maintaining the rule from the concrete to the abstract idea as well as possibility of forming key skills like planning, organizing and estimating learning; effective communication in different situations; effective collaboration in the group and problem solving in the creative way (arranging activities and favorable situations for their formation). Teachers prepare substantial commentary including a list of problems and skills connected with introducing a given curriculum notion and methodical commentary including suggestions for methods, form of work and teaching aids. Based on this the optimal educational style is worked out.

2. Integration of science contents within the cross-curricular paths: ecological path, health path
   A. Getting acquainted with the rules of constructing educational cross-curricular paths (Dereń et. al. 1999).
      *Educational tasks*: discussion of examples of science knowledge integration focused on structure-creating problems, concepts as well as skills, assigning objectives, contents and tasks connecting the integrated subject "science" with educational tracks.
   B. Method of the project and its role in the cross-curricular integration.
      *Educational tasks:* preparation of the educational project for realization within the cross-curricular path including a list of teaching contents and formed skills, instructions for the project realization with suggestions about educational solutions and tasks for pupils as well as ways of project presentation and evaluation.
3. Field activities and integration of science problems
   A. Discussion of educational qualities and methods of field activities carried out in the closest school surrounding, local environment and in the areas of special natural quality region
   B. Determination of the educational possibilities of the local environment in the background of region in the field of general natural and ecological education:
      – making use of methodical works including e.g. a series of methodical publications "green lessons at school and in the nursery schools" prepared in the Department of Biology Education M. Curie-Sklodowska University (Gajus-Lankamer 1998, Jarocka 1996, 1997, 1999, Pedryc-Wrona 1998, Samonek-Miciuk 1998, 2000, Wojcik 1998)
      – educational tracks in the region for school youths
      – curricula and methodical books for the ecological education in the field (Samonek-Miciuk, Gajus-Lankamer 1998, Samonek-Miciuk 1999)
      *Educational tasks:* review of methodical literature
   C. Participation of students in the field activities at the Bystrzyca River and in the Botanical Garden M.C.S. University (substantial and methodical character of activities)
      *Educational tasks:* natural observations; planning the ways for realization of various natural problems included in the curriculum base; working out the plan of field activities in the natural education including a list of trained pupils' competencies, styles of educational work, kinds of activities and tasks for pupils, teaching aids, project of work card as well suggested ways for evaluation of educational effects
   D. Participation of teachers in the field biological-geographical activities in Natural Roztocze Park and Kazimierz Landscape Park

These activities are of substantial character. They supplement natural knowledge and help notice connections and natural relations between phenomena and processes taking part in the environment (holistic vision of nature).

## CONCLUSIONS

The presented model of professional training of science teachers contributes to formation and improvement of their competence in the field:

– planning and designing observational tasks, natural experiments and measurements to be used in the field activities
– preparation of science education curricula in the interdisciplinary formulation
– determination of objectives for natural and environmental contents teaching
– selection of curriculum contents possible for realization during field activities and a list of tasks connected with teachers' and pupils' preparation for this type of activities
– designing work cards for pupils

– making use of methodical publications as well as planning own suggestions for educational tracks in the local environment and closest school surrounding
– planning and organizing activities of pupils in the field of the environmental protection

**References**

DEREŃ A. et al., 1999, Program Nowa Szkoła. Integracja międzyprzedmiotowa, CODN, Warszawa

GAJUŚ-Lankamer E., 1998, Skarby jesieni, Wyd. UMCS, Lublin

JAROCKA M., 1996, Zapachy roślin, Wyd. UMCS, Lublin

JAROCKA M., 1997, Intymne życie roślin, Wyd. UMCS, Lublin

JAROCKA M., 1999, Bogactwo lasu, Wyd. UMCS, Lublin

PEDRYC-WRONA M., 1998, Zwierzęta w środowisku, Wyd. UMCS, Lublin

SAMONEK-MICIUK E., 1998, Podwodny świat, Wyd. UMCS, Lublin

SAMONEK-MICIUK E., 1999, O środowisku dla środowiska. Poradnik metodyczny, LFOŚN, Lublin

SAMONEK-MICIUK E., Gajuś-Lankamer E. (red.), 1998, Zrozumieć i pomóc środowisku. Poradnik metodyczny, LFOŚN, Lublin

SAMONEK-MICIUK E., 2000, Wiosna w ogrodzie, Wyd. UMCS, Lublin

NIEMIERKO B., 1999, Między oceną szkolną a dydaktyką, WSiP Spółka Akcyjna, Warszawa

WÓJCIK A.M., 1998, Drzewa wokół nas, Wyd. UMCS, Lublin

# IV
# General and particular problems of interdisciplinary education

## Biodiversity Education for Sustainable Development: A Holistic Approach

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Biodiversity education for sustainable development is crucial for the challenges of the 21st century and provides us with an excellent context for interdisciplinary study or teaching. There are many different definitions and expectations of environmental education, sustainable development and biodiversity. Arjen Wals (1999) suggests that there is no one single perspective or definition which describes them all, in all situations or contexts. Indeed even within the European Union there is a divergence of opinion although there are many common features and goals in member states' educational systems (European Commission 1997). Outside the European Union there is a huge range of approaches and philosophy. Sharing of good practice globally, whilst not innovative, is common sense. In some countries environmental education often equates with ecology and nature study and teaching methodology can be traditional and formal with an emphasis on using textbooks and learning facts. Experiential learning and constructivist approaches to learning are thus innovative in these contexts. The pedagogy is just as critical as the biodiversity and sustainable development ideas. Constructivist teaching approaches facilitates interdisciplinary studies. At the core of constructivism is a " *view of human knowledge as a process of personal cognitive construction, or invention, undertaken by the individual who is trying, for whatever purpose, to make sense of her social or natural environment*" (Taylor 1993). The learning process is based in the personal experiences of the students and the acquisition of knowledge is the product of activities that takes place in particular cultural contexts. Knowledge is constructed by the learners in the sense that he or she relates new elements of knowledge to already existing cognitive structures (Bruer 1993). Thus this approach to teaching can help overcome some of the challenges of interdisciplinary education, notably students with a wide variety of experiences, prior knowledge and goals. If we compare the traditional science curriculum with that of constructivist approaches the benefits are further outlined.

Table 1: Comparison of traditional and constructivist curriculum ( after Duschl and Gitomer (1991)

| **Constructivist Science Curriculum** | **Traditional Science Curriculum** |
|---|---|
| knowledge about science | Scientific knowledge |
| how and why we know | what we know |
| emphasise knowledge, growth and explanation development | emphasise fully developed final form explanations |
| depth of knowledge | breadth of knowledge |
| conceptualised science knowledge | basic scientific knowledge |
| curriculum connected | curriculum units discrete |

The justification and need for education on Biodiversity in schools, universities and the general public comes from the Rio Earth Summit and the United Nations Environment Programme (UNEP) specifically The Convention on Biological Diversity. Specifically it states:

Na.92–7807 (5 JUNE 1992) Article 13. Public Education and Awareness

The Contracting Parties (who include the UK and Poland) shall:

I. *Promote and encourage understanding of the importance of, and the measures required for, the conservation of biological diversity, as well as its propagation through media, and the inclusion of these topics in educational programmes; and*

II. *Cooperate, as appropriate, with other States and international organizations in developing educational and public awareness programmes, with respect to conservation and sustainable use of biological diversity. Biodiversity Education*

Whilst biodiversity education and sustainable development can be taught through specific courses and educational materials they also can educate by demonstrating good practice. Teaching materials for sustainable development need to be **produced** sustainably too. Guidelines set down by the UK government panel on sustainable development (DETR 1999) include the following ten principles are:

- Principles of sustainable development
- Balance
- Knowledge and Skills
- Need
- Production
- Integrity
- Values and attitudes
- User-centred approach
- Development
- Promotion and Distribution

Two examples of working to meet these aims are:

Case Study One: Biodiversity Education projects with Teacher Education Students.

**1**. **Adventures in Ecological Education: from Classroom to Karst**. (Barker and Elliott 2000)

This project was a UK government funded project for Bulgaria. The aim was to work principally with teacher education institutions but we also worked with NGOs, zoos etc, anyone who was involved with delivering biodiversity education. We developed a series of activities which were interdisciplinary using constructivist methodology within the context of priorities for conservation of Bulgarian biodiversity.

An example one of the units **Seasonal Bird Migration**.

B**iodiversity concepts**: Bulgaria's importance as a destination and strategic stop off point for migrating birds e.g. storks and red-breasted geese. Species do not necessarily stay within national boundaries thus conservation often has to have international co-operation.

S**ustainable Development ideas**: The importance of wetlands as a sustainable resource and potential value for eco-tourism

**Teaching Methodologies**: Creative writing, role play, model making, poster design

**Description**: Introduces the routes taken by migrating birds and the problems they encounter, reinforced through Tanya's story – the diary of a migrating stork. Students are then provided with the information to create their own diary for a red-breasted goose and produce a poster promoting its conservation. Students explore the issues and conflicts in conserving wetland habitats and their importance to migrating birds through a role-play exercise. A model making project requires the production of life-size models of storks and geese using waste cardboard boxes to help students to empathise with the species and reinforce simple practical activities related to flight dynamics.

**Evaluation:** The stork has great cultural significance as a sign of spring and symbol of hope. Attitudes towards the birds are already quite positive but there was generally little knowledge of their migration or understanding of the hazards they face. Using species with such great cultural significance is a good strategy to help raise awareness of generic biodiversity issues.

Useful recommendations for biodiversity education for sustainable development within the context of our other units:

**Birds of Prey**. The role of top predators and consequently the vulnerability of populations is poorly understood. A food-chain focus is a good idea.

**Snakes A** good theme to explore the link between species and habitat conservation.

**Wine and Grapes**. Shows the value of biodiversity within domesticated species and its potential for economic development.

**Bats A** poorly understood but very vulnerable group of species that people as individuals can do a lot to conserve in urban/suburban habitats as well as rural. Raises awareness of the importance of the Karst habitat.

**Wolves** Changing perceptions of some species can be very difficult when they are based on centuries of prejudice and fear. One cannot hope to change some attitudes overnight but a start can be made.

**Herbs** Centuries of sustainable exploitation of herbs for medicinal and culinary purposes can lead to complacency. The protection offered by legislation can be poorly understood e.g. if the species are mentioned in legislation then there is a perception that they can still be harvested because they are deemed protected!

**Edelweiss A** good species to demonstrate the importance of genetic diversity by raising awareness of sub-species in different mountain ranges. It highlights conflict between recreational use mountain areas and conservation of vulnerable species. It also explores the use of sustainable cultivation of non-native cultivars to meet the demands of a trade in tourist souvenirs and the risk they pose to the purity of native populations.

**Local Diversity** To put some biodiversity concepts into a local context we recommend first-hand exploration of the immediate environments. Most people are surpassed to find such diversity on their doorstep.

**2**. **Hunting Foxes in UK**. A comparable project in the UK was a project about Fox-Hunting. The project was funded by the Countryside Foundation for Education and aimed at helping teachers, with specialism in science teach about hunting foxes. The critical issue here was dealing with conflicting scientific evidence about the contribution of hunting of foxes to conservation. Student teachers were given a series of workshops which promoted cross-curricular or interdisciplinary approaches to the teaching of this topic. They then transferred these skills into the primary school classroom.

Evaluation of both projects was excellent. All those involved with the delivery of teaching found the methodology motivating and indicated that they would repeat the project. Those on the receiving end were enthused by the content and wished they had more classes like it. Both are an endorsement for such interdisciplinary projects, however implementation in primary schools was much easier than in secondary schools due to timetabling issues.

**Case Study 2: Undergraduate science option in Ecology and Conservation**

In a department based university, true disciplinarity is hard to achieve. At the University of Warwick we have one degree programme in science which is truly interdisciplinary that is BA/BSc Environmental Studies. We also have courses such as BSc in Computational Biology and then a selection of joint honours degrees. There are problems with interdisciplinary degrees such as quality assurance, funding issues and student diversity etc. One approach to broadening the experience of science undergraduates is the provision of option courses. One such course is a second year option Ecology and Conservation. This option course for all students in the science faculty: **Mathematics**, **Computer Science**, **Biology**, **Chemistry**, **Physics**, **Statistics**. Also engineering students.

The challenges of teaching this option course are:

I. diversity of prior experience and knowledge
II. timetable issues,
III. physical location within the university ie distance from home department

How can an interdisciplinary option course, attended by students from a wide range of disciplines and with widely varying levels of scientific knowledge and IT experience and expertise, enhance all participants' understanding of the biodiversity and sustainable development. In traditional lecture courses the communication is presentational, the outcomes predetermined and the learner passive.

Through replacing some lectures with a text based computer conference the learner becomes 'active' (where learners have considerable autonomy and the mode of communication is a multi-faceted dialogue). The other benefits of text-based computer conferencing using software with a web interface are of the 'added value nature'. For example:

1. It has 'real world' currency as a tool in use in commerce, industry and the professions.
2. An increasing number of documented case studies of its use in professional development is becoming available (Birchall and Smith, 1996; Salmon, 2000).

The idea of a staged approach has more recently been formalised by Salmon following research and evaluation based on the Open University Business School's distance education programmes (Salmon 1998, 2000). Salmon has set out a five stage developmental model:

Stage one: access and motivation
Stage two: online socialisation
Stage three: information exchange
Stage four: knowledge construction
Stage five: development

**This very much parallels the process of constructivism as outlined earlier**. **I used it to**

I. reflect on lecture sessions by posing questions immediately after a lecture
II. substitute lectures with on-line lectures and web-based tasks
III. support for students leading up to the exams with responses to individual queries for all to see etc.

It is well known that computer conferencing does not engage the totality of any particular group. Some students participate fully but as both spectators and contributors; a third engaging to a degree, but mainly as spectators; and the final third with negligible involvement some never even logging on is not untypical

To encourage participation, online activity needs to be purposeful, authentic (in the sense of working with the characteristics of the medium) and embedded in the programme. Achieving this mix is not straightforward, as many commentators make clear (Birchall and Smith, 2000; Salmon, 2000; McConnell 2000; Stratfold 2000).

The most important area in which the conferencing needs to be embedded is assessment. Those ready and willing to participate deserve, and may need, recognition; those who are less forthcoming may be influenced by a direct connection with assessment arrangements. The assess-

ment in this case is purely by examination thus the immediate rewards to the student are not clear. The performance in exams is enhanced by a wider range of examples being used in answers but the mean mark and range of performance is not significantly changed.

**Problems**: some problems logging on if not a connection available experienced by students and myself.

**General observation**: students enjoyed the flexibility and opportunity to contribute and learned a lot more than they would have done without First Class

In conclusion supported self-study through a text-based computer conference can significantly improve the quality of teaching on interdisciplinary science courses. With the introduction of bench-marking into undergraduate degree courses in the near future the advantages will be even more pronounced.

## References

BARKER, S and Elliott P ( 2000) Adventures in Ecological Education, From Classroom to Karst in Bulgarian

BARKER, S and Elliott, P (2000) Teacher Training– Adventures in Ecological Education 227–237 in Educating for Sustainability Umweltbildung und Agenda **21**. Peter Lang Frankfurt.

Barker, S and Elliott, P (2000) Planning a skills-based resource for Biodiversity Education. Journal of Biological Education 34 p 123–126

BIRCHALL, David and Matty Smith (1996) 'Applying Groupware in Management Education Including Distance Learning' Active Learning 5.

BRUER, J.T (1993) Schools of Thought: A Science of Learning in the Classroom; Cambridge MA: MITT Press

Department of Environment Transport and Regions (1999) A Voluntary Code of Practice:Supporting sustainable development through educational resources. DETR London.

DUSCHL, R. A. & Gitoma, D. H (1991) Epistemological perspectives on conceptual change: Implications for Educational Practice. Journal of Research in Science Teaching Vol 28, pp 839–858

Eisenstadt, M& Vincent, T (Eds) (2000) The Knowledge Web:Learning and Collaborating on the Net. London KoganPAge

European Commission (1997) Environmental Education in the European Union, ECSC-EC-EAEC, Brussels &Luxembourg.

MCCONNELL, David (2000) Implementing Computer Supported Cooperative Learning. 2nd edition, London: Kogan Page.

Salmon, G. (2000) E-moderating: The Key to Teaching and Learning Online. London: Kogan Page.

SALMON, G. (1998) 'Developing Learning Through Effective Online Moderation' Active Learning 9.

STRATFOLD, M. (2000) 'Promoting Learner Dialogues on the Web' in Eisenstadt and Vincent, 119 – 134.

TAYLOR, P (1993) Collaborating to reconstruct teaching: the influence of researching beliefs in 'The Practice of Constructivism in science education' Ed Tobin K Washington DC: AAAS press.

Wals, A.E.J. (ed) (1999) Environmental Education and Biodiversity IKC NATUURBEHEER Report Number 36, Wageningen, Netherlands.

# Evaluation of the transition between Secondary and Higher Education. Case: The evaluation of the entrance systemin the Public Universities in Catalonia. 2000

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One of the key elements for improving the universities lies directly on the quality of the new students that come from Secondary Education and their adaptation to Higher Education working methods. It is very important they have not only the capacity to learn but also some ability and attitude to put their knowledge into practice.

In that sense, there is no doubt that the transition between Secondary Education and Higher Education is a strategic phase to ensure the quality of education in University, considering the institution but also the student as well.

On the other hand it is important to notice that the transition phase analysis can not be focused only on the study programs structure. There is certainly a lot to consider during the first year in the university (motivation in the subjects, academic background of new students, academic counseling, communication between institution and student, etc).

According to these facts universities decide to evaluate the transition with a specific methodology.

**The framework of this evaluation** takes into consideration four important issues of our university system:

The first one is the introduction of a new secondary system that consists of two additional years of mandatory education and new requirements, specialization and new contents in Secondary.

The second issue is related to the legal situation for which the universities have delegated the management of the entrance exam to one centralized office. Thus there is a one exam for all students (related to their secondary requirements, science, humanities, technology etc). Each requirement therefore determines the possibility to choose one or another program. In other words the secondary background is a determinant factor when entering in one specific program at the university.

The third point has to do with the diversity of organizational structures that controls the processes of application and admission in every university and college.

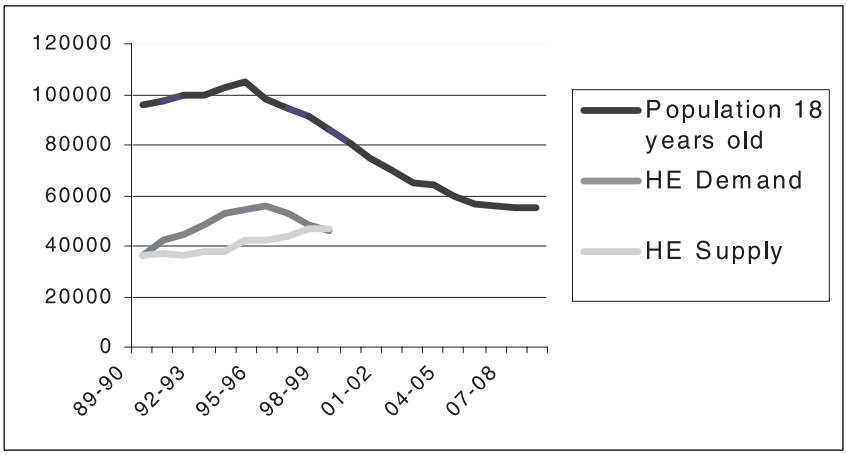
And finally the fourth point is related to the

Błąd! Nie zdefiniowano zakładki.**contextual situation of decrease in admissions**.

The birth rates are decreasing and it's stands to reason that it will affect the future of the demand for higher education. As you can see in the figure 1, in Catalonia it is expected an excess of higher education offers (bachelors and masters). This situation will increase the competition between the universities but also it will force the re-organization of the supply and demand. In that sense there are some study programs that will continue with a high demand such as medicine or IT technologies and others with deficits, specially in the field of humanities (the effect will not be homogeneous of course).

UWAGA: w tym artykule sygnalizowane są BRAKI!!!

Figure 1: Forecast in Catalonia




**Considering that situation the Quality Assurance Agency designed a specific methodology** of evaluation followed the temporal path of transition between secondary and higher education. The process considers the situation from recruitment actions to academic results at the end of the first year in the university.

The contents of the evaluation analyze 5 main dimensions:

1. – Błąd! Nie zdefiniowano zakładki.**Recruitment and admission**
   - Analysis of the potential of each institution.
   - Recruitment policies and methods (information, advertising, and other actionsĽ)
   - Admission Results (period 1996–1999) and Objectives for the next years.
     - Quantity and quality of students intake.
     - Characteristics of the students admission. (Full time, part time, geographical origin).
   - Strategies to improve the results.
   - Attention to various groups within the population (for example foreign students, students with physical handicaps, etc).
   - Błąd! Nie zdefiniowano zakładki.Administrative procedures to notify the admission to new students.
   - Admission formalization –registration–.
   - Data bases structure for that procedure.

Błąd! Nie zdefiniowano zakładki.**2.– Institutional Welcome**

How the university informs their new students about:

- The organization and the key persons in the university.
- Students associations.
- Rights and duties.
- Services.
- Facilities.
- Grants.

Błąd! Nie zdefiniowano zakładki.**3– Academic welcome**

- Information about the Study program structure.
- Information about examinations, schedules etc.
- Tuition and counseling.

- Teaching for a good Transition:
- Coordination with the curriculum of secondary:
  - o Propaedeutic and special courses to avoid deficits of some knowledge (for example in mathematics).
  - o Specific training in the use of libraries or computer literacy.
  - o Strategies to improve the academic results.

**4– Communication institution-student**

- Extracurricular activities such as seminars, workshops, etc.
- International Exchange programs.
- Channels to receive the Students' voice and opinions.

**5. – Academic Results**

- Academic results during the first year.
- Data bases functioning.

Considering this methodology we followed a process of self-assessment and site visits that covered meetings with the rectorat teams, deans and head of departments, professors and lecturers teaching in the first academic year, students, and personnel from administrative and service areas.

**The results of this evaluation**

First of all, to evaluate if the **organization**, **structure and objectives** are well designed to carry out the functions about recruitment, admission, etc. There were meetings with the rector team and central management responsible. As a result it appeared that there was a good implication of the Rectors and their teams in the mentioned objectives.

The Centralized structure helps to accomplish the objectives concerning admission. It makes the professional development of all involved staff easier. The use of a scaled economy in communications, advertising, marketing and the idea to advertise the characteristics of the university with a centralized strategy was considered very effective. For example the universities try to communicate their characteristics to new students with a simple message. Let's say, the campus, or tradition, or academic climate, or job orientation, or elite. Obviously there are some other characteristics.

However, in general, the objectives concerning admission are not well defined or sometimes they are unknown by the rest of the academic community.

Is the university expecting to recruit the best students or does it only take into consideration the number of students registering? There is a debate on this subject. Certainly the colleges and universities are instructed to attract the best students but are the centralized decisions working in the same direction? Budget has a huge impact on that matter. Sometimes volume can be more important to receive funding.

On the other hand there is not enough information about the forecast of admission turnout for the next years. The population of 18 is declining but for sure there will be new students typology (graduates, for example).

Although it is not possible to give absolute numbers for a "satisfactory" admission turnout in the universities, the figures in each academic field can be considered in the light of the labor market and the need for new academic staff.

It's necessary to point out that the academic staff have little information about secondary education and the changes in its curriculum.

Błąd! Nie zdefiniowano zakładki.**Student's recruitment**

More and more the universities are setting up measures to inform about HE, and specifically in order to attract students. Thus we can see several different actions such as:

- Presentations in Secondary schools to explain what the universities offer and their characteristics.
- Or presentations in main town halls for students.
- They plan visits for students to show the faculties, classrooms, laboratories, etc.
- There is also a national fair with information stands from all participating universities and higher education possibilities for secondary students.
- Colleges specializing in science have a specific program oriented to attract women.
- Sponsoring of some secondary schools by the universities (that means that one professor establish a more direct relationship with some Secondary Schools.

The results of the evaluation show that the most useful activities to promote admission are:

Open-door visits to present the campuses to the students of secondary. (Students like to contact with the academic atmosphere of the faculties).

Sponsoring of some secondary schools is also very interesting to improve the links between the universities and high schools.

Another important positive fact is the increasing information about universities available in Internet.

On the contrary, among the weaknesses we found were, a low interest shown by the academic staff concerning Admission's goals. They tend to think that students go to campuses on their own without having received information prior to admission.

Additionally, there is not enough information about quality indicators of every study program. Specially students have no idea about the quality of one program compared with the same program in another university. Usually they choose more according to geographical location of the of study program, than by the quality of the program.

There is no definition of the recommended background or adequate profile to get into a specific study program. For example which is the recommended level of mathematics to study psychology?

And finally there is no data about the effect of recruitment actions carried out by the universities and faculties.

About admissions it was detected:

- A constant improvement of registration procedures (auto application, assisted application, etc).
- There is also a better information (booklets, and guides) to students.

On the academic aspects:

- There are innovations in the faculties about counseling and propaedetical activities.
- Preparatory courses on mathematics, physics (called course zero) in some faculties.
- The number of students per group is decreasing in the first year.
- The creation of commissions for a curricula coordination between Secondary Education and Higher Education.

However among the weaknesses the study programs have not been adapted to the new secondary curricula. The academic results are not well analyzed and they are still poor during the first year.

Błąd! Nie zdefiniowano zakładki.**Recommendations**

- Define the objectives of recruitment better and make them clear to all the academic community.

Improve the source of information on all procedures: admission's indicators, the efficiency in recruitment action, the characteristics of secondary schools that submit students to our university and their academic results.

- Detect which is the best moment to inform Secondary students about Higher Education.

- For example, It's recommended to take some recruitment action when Secondary students choose their field because their choice affects when later, they apply for a program and choose a specific degree.
  Universities (professors and deans), need to have a better understanding of secondary education
- Define the recommended secondary background needed to study a program.
- It is convenient to analyze if it is required to set up measures to avoid knowledge deficits in the first year, such as introductory courses.
- Increase the links with secondary schools that belong to the same area of a university.
- Recommend information about the career market opportunities per program. Theoretically but also with real data such as the labor posts obtained by graduates.
- For first year students it's more convenient to give all the information about the university step by step. To avoid giving all the information at the same time.
- Set up better policies of counseling during the first year.
- Pay attention to the contents and organization of the first year in order to avoid bad academic results and drop out rates. (An elective first could be accepted but always with a motivating set of subjects, with the best professor). Introduction of some applied matters in order to introduce the reality of the academic field.
- It is very important a synergy between a study program coordination and secondary education framework.

# Aiming for Scientific Literacy Through Self-Regulated Learning

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## 1. Introduction

Scientific literacy is a complex and multifaceted concept, one not easily represented in a single definition. Those who have written about scientific literacy suggest that it embodies the scientific and technological knowledge, understandings, and abilities needed for the 21st century (Bybee, 1997; Shamos, 1995). Scientific literacy is truly an international challenge. The economic and social foundation of many nations is tied to educating a scientifically literate citizenry. The need for international cooperation on issues of scientific literacy is critical, particularly as advancing technologies make what once were national interests and concerns international ones. Unfortunately, what is meant by scientific literacy is often not clear. It is taken to mean everything and nothing. Lack of agreement on what is meant by scientific literacy has tended to stifle the development and explication of learning experiences intended to promote it. The First International IPN Symposium on Scientific Literacy was convened in Hamburg, Germany, in September 1996, with sponsorship from the German government through the German Institute for Science Education (IPN) at the University of Kiel. The purpose of this symposium was to identify conceptions of scientific literacy held by European and North American science education researchers and to explicate dimensions of scientific literacy that are truly international in scope. The dimensions agreed upon were:

- Scientific literacy is not something that you do or do not have. It is best represented as levels ranging from illiteracy to the highest levels of scientific understandings and abilities. It is reflected in individual and group decision making.
- Scientific literacy is multidimensional. It is best to speak about domain specific literacy, such as in chemistry, biology, physics, and scientific inquiry. Because the understandings associated with science are so vast and increasing daily, it is impossible for any person to achieve the highest level of scientific literacy in all domains.
- Scientific literacy is a value. Pursuing scientific literacy is dependent on one's motivation to do so and the encouragement received from others. If scientific literacy is valued by a person and his community, then he will be motivated to pursue it (see Gräber & Bolte, 1997).

There is worldwide consensus that our societies, regardless of any cultural differences there might be, need scientifically literate citizens. The National Research Council (1996) of the US in its National Science Education Standards states: "All of us have a stake, as individuals and as a society, in scientific literacy. An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force."

And the BLK (1997), a governmental commission for the coordination of research activities and educational matters in Germany, in its expertise for the preparation of a recently installed program for the enhancement of science education claims: "Biology, chemistry and physics provide basic scientific concepts for the interpretation of nature, humanity and a world that is formed by science and technology. The various epistemic methods of the sciences serve as basic tools for understanding oneself as part of the world."

**2. Outcomes of Science Teaching**

Again, it seems, we can reach some kind of consensus on what school science should be about. The next step then is to have a look at the outcomes of science teaching. What does school science really achieve?

We found that even the daily press has called attention to this: For example, the British newspaper "The Observer" (Noble 1993) pointed out that pupils turn their backs on chemistry because of its negative image. "It is that, compared with 30 years ago, the downside to science and technology is more fully recognized. Technological disasters such as Chernobyl and ethical problems arising from advances in genetics have weighed heavily with those who imagine that life was once relatively problem-free." The study by Heilbronner and Wyss (a chemist and a Fine Arts teacher from Switzerland) (1983) demonstrates it in an impressive way: 11 to 15–year old students at various "Gymnasiums" and "Realschulen" were asked to portray their imagination of chemistry in a drawing. Two thirds of the drawings predominatly displayed the negative aspects such as the pollution and destruction of the environment or animal experiments.

IPN's own studies on students' interest and attitudes in physics and chemistry (Gräber 1998; Häußler 1987, Hoffmann & Häußler 1995) confirm worldwide research findings that the "hard" sciences physics and chemistry rank very low, particularly with girls.

Sjöberg (1997) concludes: "We have to admit that science and technology, at least in Western democracies, are met with distrust and suspicion, and that there seems to be a falling interest in science in schools. Norwegian data show declining enrollment in schools, especially in physics, and we are facing a recruitment crisis in the whole sector of science and technology. Similar trends are visible in many OECD countries."

Not only are the outcomes in terms of interest and attitude questionable, science education does not seem to succeed in imparting knowledge and understanding in the sciences either. Miller (1997) has been involved in measuring the scientific literacy of the American public for many years, and has extracted two factors from the data that were produced by the National Science Foundation: the vocabulary dimension, and the understanding of the nature of scientific inquiry. Only 7% of the people investigated in 1995 scored high on both factors, and can thus be considered fully scientifically literate.

Sjöberg (1997, p.13) states that among the adult US population,

- 65% do not know that earth moves around the sun in one year
- 50% believe dinosaurs and humans lived together on earth before (Flintstone effect)
- 50% do not believe in evolution
- 50% believe in incarnation.

In the European Union (1993) 13000 Europeans were asked about their knowledge of and their attitudes towards scientific and technological issues. The knowledge of the German population of science content and methods of inquiry are low. The source of that little knowledge is unclear. Science education in school seems to play a minor role in comparison with common life-experience and popular presentations in the media.

For Germany the findings of TIMSS/III are particularly disheartening, but there are several other countries which cannot be happy either. Baumert et al. (1998) state in their German report

that "only a small portion of the students reach a level of assured and independent application of their knowledge. Whenever the tasks leave the familiar school-context, the majority of participants in the basic courses face great difficulties.There is a substantial discrepancy between the competencies which, according to the curriculum should be expected, and the really achieved goal at the end of upper secondary level. Particular deficits are in the areas of conceptual understanding and of understanding scientific inquiry and reasoning."

These disappointing observations raise the question of whether we even treat the right topics in school and follow adequate goals. Which criteria are important for selecting goals and content? P. Häußler listed the following five points in his presentation at our IPN seminar on scientific literacy: the academic disciplines, life situations, recommendations of experts, interests of students and concepts of general literacy. Each of these criteria has its own significance, while the last one, a concept of general literacy, which of course also includes parts of the others, is the most important and leads us to scientific literacy.

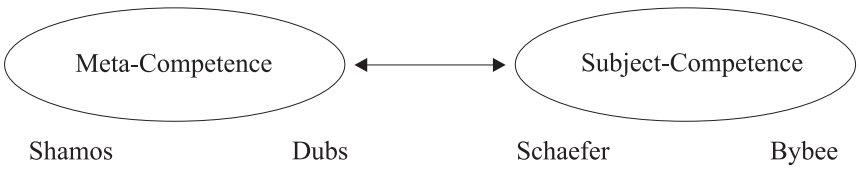
**3. Scientific Literacy as goal of science teaching and learning**

We organized two international symposia on scientific literacy at the IPN, which helped to structure the topic and formed the base of further research and development. While the first one (1996) focused on the theoretical background, with the second one (1998) our intention was to bridge the gap between theory and practice.

The 2 International IPN Symposium on Scientific Literacy (Kiel, October 7–11, 1998) (http://www.ipn.uni – kiel.de/projekte/a4_5/sympos2/allgem2.htm) was part of a long-range multi-national initiative to promote the development of scientifically literate citizens. It built upon and extended the outcomes of the first symposium and involved some past participants as organizers. Specifically, the purpose was to apply our conceptual understanding of scientific literacy to the concrete world of science teaching and learning. The symposium also strived to bridge the gap between theory and practice by having academics, university professors and researchers, develop and teach lessons to pupils. Four keynote speakers (RODGER W. BYBEE, ROLF DUBS, GERHARD SCHAEFER, MORRIS SHAMOS) described the theoretical background and tried to bridge the gap to practice, while 12 video contributors presented real science lessons. These video contributors from different countries all over the world showed tape recorded science lessons of how they try to promote the development of aspects of scientific literacy. Each video presentation was complemented by a discussant who was expected to enrich the discussion with his own view on the subject.

Our keynote speakers' definitions of scientific literacy could be placed (roughly taken) along a continuum with the poles of focussing more on subject competencies or on higher meta-competencies.

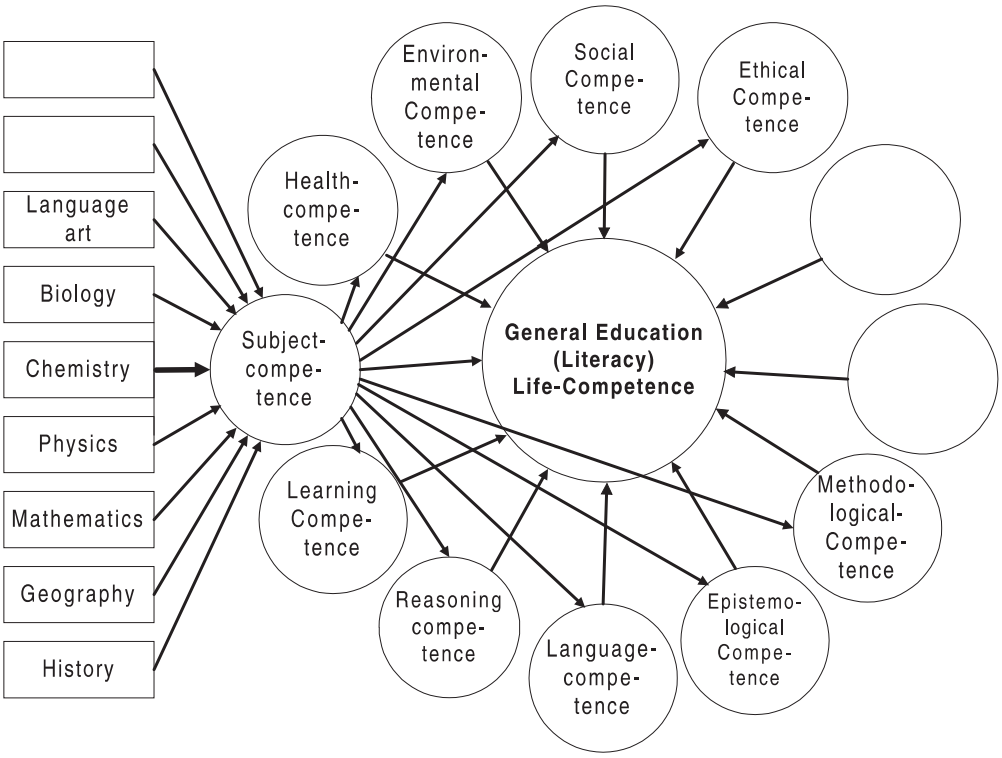
**Concepts of Scientific Literacy**




**Rodger Bybee** (1997) has proposed a sequence of steps for all students to achieve higher levels of scientific literacy. He distinguishes nominal, functional, conceptual and procedural, and multidimensional scientific and technological literacy. His comprehensive hierarchical model,

which forms the base of the National Science Education Standards of the USA, is still very much driven by subject competencies (by of course considering life contexts and cross-curricular competencies).

**Gerhard Schaefer** tries to mediate between the two extreme positions. His literacy model is not based on a mosaic-like summary of academic defined subjects as propagated by many scien-




tists, but there are general competences which constitute the construct general literacy or life competence. He mentions several competences which are necessary to survive and live well in our contemporary society. A central position is taken by subject competence through which the different subjects contribute to develop the other competences.

According to **Rolf Dubs** the general aim of teaching science should not be to reproduce the university disciplines at the general school level but to be oriented towards societal requirements, to learn how to deal with social issues and to make rationally founded decisions:

*Students must learn*

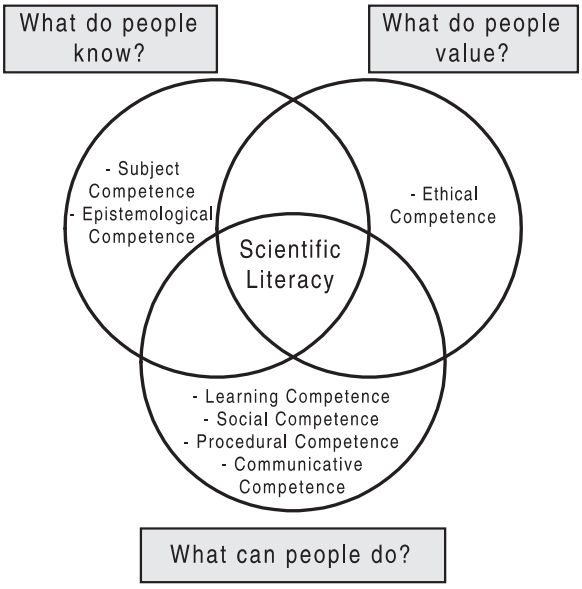
- to recognize scientific problems in real life situations
- to recognize contradictions in argumentations and conflicts in aims and underlying interests
- to evaluate potential solutions including their possible consequences
- to make their own decisions in value related issues.

**Morris Shamos** (1995) refers to the negative outcome of science teaching and has suggested that the science education community has deceived itself into thinking that a definition of scientific literacy which includes both wide and deep content knowledge and process competence is possible. He proposes a more realistic definition which challenges science educators to help students become competent consumers of science and to trust the real issues to science experts:

*Developing an awareness of science through the process of science*

Shamos pleads to cut on the quantity of content in science teaching and to rather deal with the methodology and processes of science:

- Logical Thinking
- Quantitative analysis
- Meaningful questioning
- Reliance upon sound evidence.




Summarizing the various proposed definitions and models and taking into account the skepticism of Shamos and others, we would like to suggest a competency based model of scientific literacy, going back to Schaefer's request for "life-competence" as a goal for education in school. In this approach the question is not the causal "why" do we teach science to children but rather the final "what for", and consequently the answers are not "because our societies need a scientifically literate workforce" (or other justifications). The answer is "for the individual to cope with our complex world." Competencies are needed for that task, and some specific competencies can be acquired in the science domain better than in others.

**Subject competence** includes declarative and conceptual knowledge: a continuum of science knowledge and understanding throughout the various domains of science. When combined, depth and breadth provide an individual profile of science knowledge and understanding.

**Epistemological competence** includes insight into (the general idea of) the systematic approach of science as one way of seeing the world, as compared with technology, the fine arts, religion, etc.

**Leaarning competence** includes the ability to use different learning strategies and ways of constructing scientific knowledge.

**Social competence** includes the ability to co-operate in teams in order to collect, produce, process or interpret – in short, to make use of scientific information.

**Procedural competence** includes abilities to observe, to experiment, to evaluate; ability to make and interpret graphic representations, to use statistical and mathematical skills, to investigate literature. It also includes the ability to use thought models, to analyze critically, to generate and test hypotheses.

**Communicative competence** includes competence in using and understanding scientific language, reporting, reading and arguing scientific information.

**Ethical competence** includes knowledge of norms, an understanding of the relativity of norms in time and location, and the ability to reflect norms and develop value hierarchies.

## 4. How to teach for scientific literacy

Science teaching traditionally concentrates on the knowledge aspect, adding perhaps a few of the procedural skills, but usually neglecting the other competencies. The view proposed here may help to reconsider the balance between the various competencies and to reflect, what specific contribution science education can make.

An analysis of science-classroom videos at the II International IPN-Symposium on Scientific Literacy shows that science teaching can be described in three dimensions. Each dimension can be characterized by two extremes on a scale:

**teacher centered – student centered**

It is either the teacher governing the classroom activities, steering the students' learning processes, and dominating the communication process or the students taking responsibility for their own progress, initiating their learning processes in a more or less autonomous way.

**teaching facts – teaching processes**

The teaching/learning activities aim either at science facts, laws, and formula or at the acquisition of problem solving strategies and skills of processing information and interpreting data.

**discipline oriented – daily-life oriented**

The aim of the lessons can be to either delineate the structure of a scientific discipline and to reproduce research findings on a reduced level or to provide means to understand daily-life phenomena, including their social, technological and economic implications.

Traditionally, science teaching is lopsided towards the left side of each of these scales. Teachers tend to dominate the teaching/learning process with fact oriented lesson contents and the aim to reproduce (at least part of) the structure of their scientific discipline in the heads of their students. The results of these efforts have been disillusioning world wide.

A look at the list of competencies which, each with their own weight, constitute "scientific literacy", makes it evident that such science teaching must fall short of reaching the goal. We are not suggesting now that all engines should be turned on reverse and that the opposite approach – student autonomy, acquisition of process skills, daily-life orientation – is the recipe for successful science teaching. Obviously often enough students do not take responsibility for their own learning processes, facts are necessary for applying skills, and daily-life phenomena are often too complex to understand with regular students' limited knowledge.

## 5. Self-regulated learning

However, to reach some extent of scientific literacy for all students, more of these ingredients must be introduced to science classrooms, and in order to do that, teachers must be able to act expertly on both sides of the scale in all three dimensions.

If we take scientific literacy serious as a goal of science education, and if we want science classes to contribute to the general education of emancipated citizens, we must re-balance the orientation of our teaching. Careful guidance of children towards self-regulated learning must have priority. This can be justified with terms such as self-determination, self-responsibility and self-activity.

Self-determination as a basis of all emancipative efforts makes the learner independent of a teaching person. Self-responsibility for one's own learning process is the prerequisite for life-long learning, which depends on self-activity, if it is meant to be fruitful and lasting.

The new electronic media are ideal vehicles to support relf-regulated learning. We are going to use this chance by starting a new project ParCIS (Partnership between Chemical Industry and Schools) in cooperation with schools and industry aiming for developing competences for self-regulated learning and media-competence:

**ParCIS**

Partnership between Chemical Industry and Schools

- Goals: Learning competence and media competence
- Method: "Case studies" with self-regulated learning
- Internet based retrieval of information
- Regional industry-partners provide information on their websites
- Close cooperation between schools and industry

The most important goal of ParCIS is to promote self-regulated learning and media-competence. In addition to ordinary classes, the students will work autonomously in small groups on open questions. They will gather information from various sources (e.g. textbooks, encyclopedias, newspapers), but in particular from the internet, where information is supplied by several educational services, textbook publishers, schools, universities as well as industry. All these possibilities are to be used, but the focus of this project will be on those webpages created by chemical enterprises in the neighbourhood of the schools.

Most of the information nowadays found in the internet is – although it might be relevant in terms of the curriculum – either incomprehensible or not meaningful to the students, and cannot be used in the classroom. The chemical enterprises participating in this project will help close this gap. They will present general chemical content as well as specific information from their field in a way that is meaningful to students. These webpages will be designed and developed by a research group consisting of industry representatives, researchers and teachers.

## 6. References

BAUMERT, **J**. **et al**. (1998). *TIMSS/III. Schülerleistungen in Mathematik und den Naturwissenschaften am Ende der Sekundarstufe II im internationalen Vergleich*. Berlin: MPI für Bildungsforschung. Studien und Berichte 64.

BUND-LÄNDER KOMMISSION FÜR BILDUNGSPLANUNG UND FORSCHUNGSFÖRDERUNG (BLK) (1997). Gutachten zur Vorbereitung des Programms "Steigerung der Effizienz des mathematisch-naturwissenschaftlichen Unterrichs". *Materialien zur Bildungsplanung und zur Forschungsförderung, Heft 60.* Bonn: BLK

BYBEE, R. 1997. *Achieving Scientific Literacy: From Purposes to Practices*. Portsmouth, NH: Heinemann Publishing.

GRÄBER, W. (1998): Schooling for Life-Long Attention to Chemistry Issues: The Role of Interest and Achievement. In: *Hoffmann, L.; Krapp, A.; Renninger, K.A. & Baumert, J. (Eds.). Interest and Learning: Proceedings of the Seeon-conference on interest and gender.* Kiel: IPN-Schriftenreihe.

GRÄBER, W. & C. Bolte (Eds.) (1997). *Scientific Literacy – An International Symposium*. Kiel: IPN.

HÄUßLER, P. (1987). Measuring students' interest in physics — design and results of a cross-sectional study in the Federal Republic of Germany. *Int. J. Science Education,* 1987, 79–92.

HEILBRONNER, E. & E. Wyss (1983): Bild einer Wissenschaft: Chemie. In: Chemie in unserer Zeit 17, 3 S. 69–76.

HOFFMANN, L. & P. Häußler (1995). Assessment of students' interest in physics as a means to improve instruction. Paper presented at the Annual NARST Meeting in San Francisco.

MILLER, J. D. (1997) Civic Scientific Literacy in the United States: A Development Analysis from Middle-School through Adulthood. In: W. Gräber & C. Bolte: *Scientific Literacy – An International Symposium*. Kiel: IPN.

National Research Council (1996). *National Science Education Standards.* Washington, National Academy Press

OECD-PISA, (1998). "*Framework for Assessing Scientific Literacy*." Unpublished paper from the Science Functional Expert Group.

SCHAEFER, G. (1998). *Scientific Literacy for general Competences – Teaching "subject-transcending Subjects" at School*. Keynote address at the Second International IPN-Symposium, Strande, Germany.

SHAMOS, M. (1995). *The Myth of Scientific Literacy*. New Brunswick, NJ: Rutgers University Press.

SJÖBERG, S. (1997): Scientific Literacy and School Science. In: *Sjöberg, S. & Kallerud E. (Eds.) Science, Technology and Citizenship.* NIFU – Norsk institutt for studier av forskning og utdanning: Oslo, 9–28.

# Implementation of Environmental Education: interdisciplinary co-operation

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Environmental Science is a rather new discipline dealing with rather complex problems. As with other new disciplines it has difficulties with finding its own identity and in my view environmental science is an interdisciplinary research area and not a multi-disciplinary one. The environmental problems have so far been owned by the natural scientists, which showed their dignity and opened the eyes on both the politicians and general public.

Most people today, at least in the western world, have heard about climate change, stratospheric ozone destruction, acid rain and so on. The scale has changed from local to more global effects, which have forced the global society to take action.

Several international agreements have been signed in order to achieve a sustainable society; most known is probably the Rio-summit in 1992. One of the documents from this conference, Agenda 21, is an action plane for the future and present solutions to the present environmental problems. One of the chapters is about education and it is stressed that education is crucial for the possibility to solve environmental and developmental problems.

Integration of environmental issues in higher education has been going on in several countries and I can particularly mention an English project "Higher education 21 project. The aim of this project was to integrate environmental questions in teacher training courses and in engineering and economy.

All their students get a basic education in environmental science to understand ecological relations and to understand the importance of bio diversity and limits to economic growth.

Another attempt is the Copernicus charter, which is a declaration that has been signed by many European universities. Copernicus stands for Co-operation Programme in Europe for research on Nature and Industry through Co-ordinated University studies. Copernicus declaration stresses the necessity of environmental aspects in all higher education so students get the ability to understand and handle environmental questions.

Natural scientists continue their work trying to understand how the world works and how human systems interact with it. The task is to find how much we can affect the ecosystems without detrimental effects. According to Nebel & Wright "Sustainable ecosystems are entire natural systems which can persist by recycling nutrients and maintaining a diversity of species in balance and by using the Sun as a sustainable energy source. The problem is that the natural scientist cant them self change the society in a sustainable direction, it has to be an interplay with individuals, society and other research areas. We have to solve the problems with new technology, new knowledge, environmental laws and a different way of living.

The universities have an important role in this work, which also were stressed in Agenda 21. The world society should integrate environmental issues and development in all education on every level. Agenda 21 is not a binding document and therefor the implementation differs between countries. In Sweden the government has set up as a goal to build an ecological sustainable society in just one generation. All universities have started their work with environmental management systems. We, Karlstad University state in our environmental policy that all courses and programmes should include and integrate environmental and developmental issues. Further should

all students have the possibility to continue on to more advanced levels, and combine it with their main subject.

From writhing of the policy we now have to go from words to action and start integrating environmental issues in the curriculum.

There are several difficult obstacles to overcome before this is done; one is to convince the some time's stubborn teachers. To convince those teachers that have doubt of the importance or can't see the relevance for their subject we have decided to encourage and look for good examples. There are already in Sweden examples from different areas, for instance economy, law, sociology and English. No subject can be separated from the society and the importance of environmental issues is increasing.

The companies could see competitive benefits from implementing environmental management system and its obvious that these questions should be part of all education.

Sustainable development is a concept causing quite a lot of confusion mostly because its not properly defined; for instance it means different things for an ecologist and an economist.

We educators have to tackle this problem and find a way to integrate it into the curricula. The environmental didactic research is still in its beginning on all levels and cant show us any real answers. Those that traditionally discuss environmental issues in the classroom are also those that already are convinced, and there is a risk that they teach the students to see the world with their eyes. Perhaps there are no right and wrong in environmental matters so its important that we just give the students the tools to follow the public discussion and from this make up their own mind.

There is an urgent need for didactic research in this field and I think a prerequisite is a co-operation between different research areas and subjects, perhaps also on an international level. To start with its important that the already existing environmental science institutions are forerunners in braking new ground.

In Karlstad we have tried to do this on a one-year course in environmental science.

The first semester contains three parts:

1. Natural resources and environmental problems
2. Environmental Instruments of control
3. Environmental history and ethics

The second semester

1. Science and sustainable development
2. Natural resources in a global perspective
3. Applied course – project work either on EMS or development issues in Africa

Another course I would like to mention is a summer course, which was held in Poland with students from different subjects and countries around the Baltic Sea. The education was basically problem oriented and the students had to solve problems in smaller, mixed, groups. It was really fascinating observing the discussions and listen to how the groups solved the problems with experiences from different countries.

# Bioremediation – Interdisciplinary Approach to Scientific and Technological Literacy

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Bioremediation is relatively new technology based on several scientific disciplines (biology, chemistry, geology, etc.) which can be used for cleaning of soil contaminated with, for example, petroleum hydrocarbons (1). The pilot teaching unit developed for secondary school students is based on the cleaning of the soil from waste lagoon in about 100 years old petroleum refinery in Czechowice (Poland), near the town Katowice. The whole project is done during the last three years as Polish-US cooperation. Teaching unit can be used for science lessons or chemistry lessons (after teaching about petroleum) or biology lessons (after teaching about microorganisms or cleaning of environment). This new interdisciplinary teaching unit is suitable for use in secondary schools and it is relevant for development of the scientific and technological literacy of students.

Bioremediation technology is based on intensive scientific research and it could be used for remediation of contaminated soils. The basic concept of this technology is easy for understanding even by the pupils of age 10 – "Microorganisms eat bad substances in the soil". For older pupils, "microorganisms eat organic pollutants in the soil". More detailed explanation suitable for teaching in upper secondary school is: "Biotechnology is a pollution treatment technology that uses biological systems to catalyse the destruction or transformations of various chemicals to less harmful forms. Bioremediation uses microorganisms, such as bacteria to break down organic contaminants (for example, hydrocarbons) into harmless substances such as carbon dioxide and water."

$$C_xH_y \quad ® \quad CO_2 \quad + \quad H_2O$$

Hydrocarbon  Carbon dioxide  Water

Students could be asked to apply their knowledge and to explain what is needed to convert hydrocarbons to carbon dioxide and water (Answer: Oxygen). Furthermore, they can be asked to complete the reaction:

$$C_6H_{14} + O_2 \; ®$$

Such reaction could also be used for calculation of the amount of oxygen (grams or liters) necessary to convert for example 1 kg of the hydrocarbon $C_6H_{14}$ to carbon dioxide and water.

There are several ways how bioremediation could be used (1):

a) Intrinsic bioremediation (when we only use analyses to monitor natural biodegradation process),
b) Biostimulation (aeration and/or adding of nutrients are applied in order to stimulate microorganisms), and
c) Bioaugmentation (another microorganism is added in order to augment biodegradative capabilities of intrinsic microbial population).

Genetic engineering could also be used for creation of microorganisms with higher capacities for degradation of different hydrocarbons, for example. Successful experiments were made in laboratories. However, there are many controversies about the use of genetically engineered microorganisms in the environment. Furthermore, present regulatory framework is rather conservative and therefore it is not likely to expect the use of genetically engineered microorganisms for full scale bioremediation in the near future.

There are many reasons why the bioremediation technology is of interest for teaching and/or learning. Our civilisation is very dependent on the use of oil (petroleum). Occasionally, it is necessary to clean the soil from various amounts of oil (petroleum) or some similar products. The amount which should be removed can be as small as several grams to many tons (when some tanker is damaged). Cleaning up of Alaskan oil spill and shoreline was an important example where bioremediation was effectively used after the accident of the oil tanker Exxon Valdez (2). Bioremediation became very important for solving environmental problems as it is quiet and relatively inexpensive, without disturbation of the environment. Furthermore, mutual interdependence of science and technology is quite transparent in the case of bioremediation (that makes it important for scientific and technological literacy). Bioremediation require the cooperation of scientists and engineers. In the case of Czechowice refinery it is also an international cooperation. That case is particularly favorable as it is done "here" (in one of Central and Eastern European country) and "now" – the actual bioremediation process is still running, although it started three years ago [3,4]. Students can be active during the teaching/learning about bioremediation – they are in the role of scientist and engineers who design experiments, interpret results and apply technology. Results obtained during bioremediation are often good and simple – that was the case with Czechowice refinery, so the students could interpret them easily and correctly. Having all these advantages in mind, the bioremediation unit is important for development of scientific and technological literacy of the students.

Practically several institutions participated in Czechovice refinery project [3,4]:

Czechowice Oil Refinery (Poland), Institute for Ecology of Industrial Areas (IETU, Poland), US Department of Energy (DOE) – Office of Environmental Management (EM) Florida State University (USA), Westinghouse Savannah River Company (USA) and Ames laboratory (USA).

In the mentioned refinery there was a process lagoon which was for several decades used for deposition of various waste material. The tarry deposit was finally removed. However, the soil was heavily contaminated with petroleum waste material and bioremediation technology was used for cleaning. In fact, biopile technique was used [3,4]. Occasionally it was necessary to analyse the soil for the content of hydrocarbons. As the dimensions of the lagoon were approximately 70 x 45 meters, the question for students (and also scientists and engineers) was how many samples should be taken ? Or in other words, what are the advantages and disadvantages if we take just a few or to many samples ? Most of students were usually giving as the answers just the numbers between 1 and 100. However, the best answer obtained from one student was: "I shall take 10 samples of the soil and if the analyses show that they differ considerably, I shall take another 10 samples". Scientists and engineers who really participated in the Czechowice refinery project, decided to take 24 samples. The content of total petroleum hydrocarbon in the samples varied considerably (Table 1).

Table 1: Total inventory of petroleum hydrocarbons

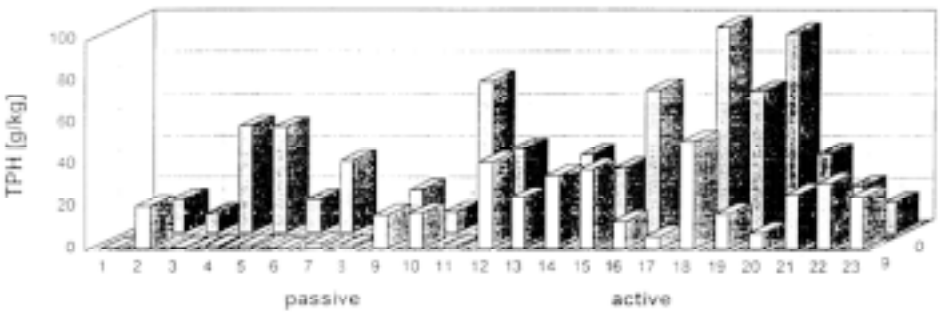
| | |
|---|---|
| Average | 27g/kg |
| Minimum | <1 g/kg |
| Maximum | 95 g/kg |

Total amount of petroleum hydrocarbons was 148 metric tons while the mass of biopile soil was 5000 metric tons.

Within the Czechowice refinery project, a lot of laboratory experiments were always made before undertaking any decision with the biopile. One half of the biopile was aerated as laboratory experiments confirmed that increased concentration of oxygen stimulate microorganisms. That section of the lagoon was called “active” and another (without aeration) “passive”.

The total amount or petroleum hydrocarbons (TPH) in each sample at the beginning (0 months) and after 9 months were presented at Fig.1. TPH is expressed as g of hydrocarbons per kg of soil.

Fig. 1: Total petroleum hydrocarbons (TPH) at the beginning and after 9 months of bioremediation.




Students should try to understand completely the complex, three-dimensional Fig. 1. There are also several possibilities for discussions. For which samples unexpected results were obtained? (Answer: Samples 2, 10, 12, 15, 22 and 23). Why are they unexpected? How these results could be explained?

In this case of Czechowice oil refinery excellent results were obtained by bioremediation. During the nine months over 80 tones of hydrocarbons were removed. After 24 months the total of 120 tones was removed or more than 80% of the initial amount.

## CONCLUSIONS

Bioremediation is relatively new technology based on several scientific disciplines (biology, chemistry, geology, etc.) which can be used for cleaning of soil contaminated with, for example, petroleum hydrocarbons. It was shown how it could be used effectively, especially for development of the scientific and technological literacy of the students.

One of the possible follow-up activity could be the forming of the team (working group) who will continue with the activities and communications in order to produce better teaching material for bioremediation. Teaching material could be tested by IOSTE participants and their colleagues from different Central and East European Countries. Results of these activities could be reported in the STL – international newsletter [5].

## References

[1] R.M. ATLAS: “Bioremediation”, Introductory lecture on the Training course Remediation technologies: new trends and tools for soil decontamination (organized by UNIDO – International Center for Science and Technology, Trieste, Italy and Institute for Ecology of Industrial Areas, Katowice, Poland), Katowice, November, 30 – December, 4, 1998.

[2] J.R. BRAGG, R.C. Prince, J.B. Wilkinson and R.M. Atlas: “Bioremediation for Shoreline Cleanup Following the 1989 Alaskan Oil Spill”, Exxon Company, Houston, TX., USA, 1992.

[3] A. WORSZYTYNOWICZ, A. Tien, K. Ulfig, K. Zachraz, M. Adamski, D. Rzychon and T. Hazen: "Soil cleaning at the Czechowice refinery", Symposium Proceedings: WARSAW ' 98 – Fourth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Manuscript No. 62, Warsaw, Poland, 1998.

[4] D.J. ALTMAN, T.C. Hazen, A.J. Tien, A. Worszytynowicz and K. Ulfig: "Test plan: The Czechowice oil refinery bioremediation demonstration of a process waste lagoon", pp. 1–65 Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, USA 1997.

[5] V.D. KRSMANOVIC: "Towards scientific and technological literacy for all: STL international newsletter", in: R. Sulcova (Ed.) Science and Technology in the New Millennium, pp. 49–52, Third IOSTE Symposium of Central and East European Countries, Prague, Czech Republic, June 15–18, 2000, Peres Publishers, Prague 2000.

# ODL at Karlstad University

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Swedish universities are independent of the government in terms of budgetary control, but there are State-defined objectives that must be fulfilled. The Ministry of Education determines how many students can be admitted and into which areas (science,humanities a o), and the university receives payment per student, although more is paid for students studying scientific subjects. The government has put a great deal of money into expanding and widening participation in higher education. A particular strategy is the opening of new locations where students can study closer to home. The proportion of students participating in higher education is increasing each year, but there are still national shortages in certain subjects, such as the sciences, which are under subscribed in Swedish universities. This is partly a result of a lack of ability of HEIs to respond to changing student demands for higher education, and subsequently a structural mismatch in the education system. There are currently more places available on scientific courses at university than students who study science programmes in upper secondary school. Conversely, there are many more students who want to study ICT-related courses than there are places available, but the HE system is not sufficient flexible to adapt to these changes in students' requirements. This imbalance is an on-going problem in the Swedish higher education system.

**Karlstad University**

The university is a state-controlled (rather than a private) institution, but it has a large degree of autonomy. The university is headed by an elected rector (appointed by the Swedish government) who has overall responsibility, but major decisions on policy and budgetary matters are taken by a governing body that constitutes a majority of external members and also student and staff representatives. Karlstad University, in common with other universities in Sweden is struggling to recruit sufficient students to study maths, science and engineering courses.The number of students is around 10000.

Karlstad University has good links with partners from different sectors in the region. Ericsson, a large Swedish mobile phone company, requires civil engineers, of which there is a shortage, thus the company works closely with the university to help meet this need. For example, Ericsson funds two professors at the university, and there are a number of collaborative projects. Karlstad University also works with Telia, the State Telecom company, this year partly privatized. The chemistry and forestry department has links with the Swedish-Finnish multinational company, Stora Enso. The university, in partnership with the municipalities, run regional centres for professional development of teachers. The office is situated in the university with a full time project leader. A lot of various activities for new competencies from one day conferences to longer courses. Another very important regional network is based on contacts with small and middle sized companies in the near region.

The university runs five local offices linked to the municipalities with a half time employee paid by the university. These local persons have good knowledge about the university. Hereby they can inform the companies about the possibilities to use the knowledge and research within

the university. These various partnership arrangements also enable students to spend time in companies, schools and other placements for work experience and to prepare their final dissertation.

In 1999–2000 there was a large influx of students, as the institution's status was changed from that of a university-college to a university. But this year there was a significant decline (about 30%). All universities have a decline in the number of applicants in 2000–1, this is primarily due to the fall in the number of young people as a result of the declining birth rate, accompanied by a strong economy with low unemployment rates. Traditionally, most of the university's courses have been full-time, with only about 10% of students studying part-time. In general however, once young people have started working and earning, they are reluctant to give up the lifestyle to become a full-time student. Some staff at the university are therefore aware that it is increasingly necessary to offer part-time options to students: 'we must think of new ways to meet with students'. The vice-chancellor recognises that the university must be more flexible, but 'this is a new attitude, a new perspective for academics – you can't sit in your ivory tower any longer'. One outcome of the recognition by the senior staff that the university must change in order to meet the emerging new needs of potential entrants is the initiation of a distance learning programme in the Värmland province and around the lake Vaner.with the local municipalities. This forms the basis of this case study.

**Case study: Regional Distance Learning Scheme**

The regional distance learning scheme aims to deliver distance learning courses via ICT to students who are unable to travel to the university, but who are instead located in regional learning centres: 'The use of information technology in distance education has made it possible o bring higher education to every part of the region' (Karlstad University, 2000, p5).

When the university was reorganised three years ago (year January 1997) with a follow up in 1999 its core activities were divided into five boards ( one board for bachelor and masters programmes, one for engineering, ICT and technology, one for health and care, one for teacher education ond one for lifelong learning).A sixth board has been added for Masters Programme on Engeneering.The main task for the board for lifelong learning is to facilitate the development of distance learning. The goal set for the distance learning board was to have the equivalent to 500 full-time students by the year 2000. As the majority of students on distance learning programmes are not full time,but most commonly study half time, 1,000 half-time students are required to achieve the target of 500 full-time equivalent students. The scheme came into operation in spring 1998, and during this year the distance learning programme has recruited almost 400 full-time equivalent students – which constitutes about 1,500 part-time students, as some are studying 0.25 of a year. The university board has revised the goal which means that we shall stay at 400 full time students.

In partnership with the municipalities in the province of Värmland and the wider region around the lake Vaner, the University's distance learning programme delivers higher education modules using ICT and video conferencing to students in learning centres outside of the immediate university district. The closest study centre is about 50km from the University, and the furthest is 300km away. This is the regular case but we have some courses on national level given all over the country.The distance learning scheme targets students who cannot leave their geographical area and travel to the university for a range of reasons, such as employment commitments, unemployment and other economic restrictions, cultural reasons (i.e. 'they are not prepared to go to university') and domestic responsibilities. Students participating in courses include a significant number of older people (aged 25–40) and more women than men.

The teaching and learning includes computer conferencing, mostly using 'FirstClass' software, e-mail contact with tutors and lectures and seminars through videoconference links. In

addition, the university library distributes requested books and literature to students via the learning centres. New platforms are being developed,one called Q-Learn in the UNISKA-network with Norwegian university colleges. The majority of courses delivered are one-semester (20 weeks) first or basic level (known as the 'A level' in the Swedish system) courses in a range of subjects, which are requested by the learning centres in the municipalities.

For example, a fully-accredited teacher-training programme in maths and science is due to be delivered shortly with a start in Jan 2000. This program would take a full-time student 3,5–4,5 years to complete, but the whole course will be delivered via ICT and video conferences distance learning enabling students to learn partly according to their own time-scale. The students will be based in seven learning centres in the municipalities around the region, and there will be at least five students in each group, thus a minimum of 40 students will be enrolled on the course. Teaching and learning will be composed of videoconference lectures once a week, school teaching practice one day per week plus practice periods of longer duration with a base for each student in a partner school, group-studying and computer conferencing. The teacher training course is of particular significance, as there is a shortage of trained teachers in Sweden, especially in the less urbanised areas such as the municipalities where the course is being delivered.

The university is not actively involved in the local promotion of the distance learning programmes, as this is the responsibility of the municipal learning centres. The courses are advertised both from the university catalogue and web page as well as in the local newspapers, information is sent via videoconferencing to the learning centres, and university staff visit the centres to meet with prospective students.

**Funding the programme**

The university funds the distance learning scheme, and funding for students is drawn down from the national funding body. More funding is needed for this programme in order to develop and promote it. Furthermore, there is currently a difficulty regarding the receipt of payment from the funding council. 50% of funding per student is paid for delivering the course, and the second payment is made if the student successfully undertakes the assessment. There is, however, a pattern emerging in the distance learning programme: a significant number of students study the course, but opt not to be assessed, which therefore has negative financial implications for the university. The reasons for non-participation in the assessment seem to relate to the academic confidence of the students and/or their instrumental requirements. Non-traditional students are unused to academic assessment, and often lack confidence in their own ability to perform well, and thus study for interest and other reasons, rather than certification. As a corollary, or in addition, some students do not need to participate in the course assessment; for example students in some employment situations do not require certification, but the course does provide them with knowledge and skills to assist them in their work. Overall, the senior administrator commented:

'They are not used to academic ways of assessing. Sometimes they are not interested in the points because they have a job and they do it for being better in their job. They are not interested in the certificate'. These issues that contribute to low participation in the assessment element of the courses are however are not recognised by the funding council. These financial issues call into question the viability of the scheme as the non-participation of students in the assessed element of the courses results in the university forfeiting 50% of fees from the funding council. The Karlstad University distance learning board would like the government to change its funding formulae to help address this problem, and to enable universities to provide courses for non-traditional students who do not require certification, or who are put off by it. This change however is not likely in the short-term (there are no signs so far from the ministry of education). The university board has therefore decided not to recruit more than 400 full-time-equivalent students per year, and to

focus on developing forms of assessment that are more acceptable to the students concerned, especially on the most popular courses. The senior administrator said:

'I think we are doing a good job in developing distance courses, but the more students the worse business for us! So that's why the board of the university has decided that we will stop at 400 full-time students per year for the moment, and we need to develop the assessment of the students and we need to develop the most popular courses.'

Why was this approach to widening participation chosen?

This approach to widening participation was chosen primarily in response to a government directive that places responsibilities on universities to become more regional. Swedish universities traditionally have had to undertake two core functions, teaching and research. A third task has been added to these responsibilities, which is 'networking with the region'. It is for this reason that the University decided to prioritise the development of distance learning programmes, in partnership with learning centres in the province of Värmland and rhe region around the lake Vaner. In addition, the municipalities are very keen for universities to provide higher education courses in their learning centres for local people. The learning centres are well-established in providing basic level adult education, but currently only a minority are developing as university-centres.

The courses are open to anyone who lives in the areas where the learning centres are, but in order to participate in the distance learning programme the same admission rules apply. Thus, applicants must have the subjects required for a particular course and the distance learning route does not have an easier admissions policy.

The university staff identified the primary barriers to participation in higher education for these groups as being partly the distance people live from the university, and secondly people's attitudes towards university, travel or commuting and borrowing money. Over the last three years the government has provided courses to enable people who do not have the upper secondary school certificate to prepare to the entrance level for higher education. These people are mainly women (70%). Now they have achieved the entry qualification these students want higher education to be delivered in their geographical areas. (The University did not carry out its own research out to establish the existence of this demand, but national research is being conducted). (Is there anymore information about this?) As a result of demographic issues there will be a significant demand in the labour market for public sector staff – teachers, doctors, nurses, municipality employees, engineers in the coming 5–10 years, when the big group of people born in the 1940s reaches retirement. Simultaneously, there has been a decline in the birth rate, so there are fewer young people to meet the demands of society and to fill these public sector jobs. Remote areas, such as Värmland, lack teachers and nurses more than the urban areas, as qualified teachers do not want to go and live in these regions. In the light of this issue, the next distance learning programme to be offered by Karlstad University is likely to be nursing, thus it is addressing the same difficulty.

Secondly, in addition to the distance of the hinterlands from the university in the provincial capital, people in these rural areas often lack the tradition of entering higher education. For example, in the past farmers and the urban working classes needed only basic skills such as literacy and numeracy, and did not require higher education to meet their employment needs. In Sweden traditional attitudes towards higher education prevail outside of the large urban centres. The attitude is highly respectful, and people often believe that higher education is too difficult for them. Furthermore, not only is higher education not the norm, borrowing money is culturally alien.

'The problem is their attitudes, their culture. In a working class family, for example, there are very strong hesitations taking loans, and also in the old farming society – "you should not borrow money, it's dangerous". You still hear this argument – "I don't want to borrow money". But

everyone can borrow money. So that's one problem – to get rid of this idea. That was part of the social welfare programme – everyone can borrow money to go to higher education. But you get a big debt, and now the balance is not that good. So for the moment if you don't get a well paid job afterwards, you can't get rid of your debt until you get your pension, then the government cuts it all, and it doesn't matter at all, but you have a lifelong debt to pay monthly a small percentage – so if you don't get a well paid job it's a bit of a problem'.

The distance learning programme overcomes the barrier of geographical distance from the university. To some extent it alleviates the financial barriers: students are able to continue working, and young people do not necessarily have to move away from home (and incur additional costs), and travel costs are removed or substantially reduced. The distance learning programme however does not directly try to change attitudes towards learning in general and higher education in particular. However, efforts are made in the municipalities to effect people's aspirations and perceptions – research in Sweden is showing that men are more entrenched in traditional attitudes, while women are more flexible (hence the high proportion of women compared to men participating in the distance learning programme). The distance learning programme does not have the money to target specific groups, such as men in traditional roles, but it is hoped that the learning centres do reach these people, but it is acknowledged that more could be done. Men may be reached for example through the unemployment service, who may suggest that people study higher education by distance learning at the learning centre, and unemployment benefit can be converted to a grant for studying. The unemployment service however will not compel people to participate in education and training. It is anticipated that students who study by distance learning at the outreach centres will achieve a degree qualification equivalent to their peers who study at the main university site. There is no expectation that these students will achieve a lower qualification (e.g. such as a diploma rather than a degree, which is sometimes the case in the UK, or that the qualification will have less kudos, as the qualification is awarded by the niversity). The university provides support services at the main site, but there do not appear to be special support services for students studying at the distance learning centres. In the local learning centres learning-support courses are provided to assist people returning to education and undertaking higher education for the first time, and to help them gain the entry qualifications required for HE courses.

**Success of the Programme**

The scheme has not been rigorously evaluated, but it is deemed to be successful in terms of the number of students enrolling on the courses offered: 1,500 students enrolled per academic year. The issue of success is, perhaps, hampered by the financial problem relating to the lower level of non-participation in assessment than on other courses. Furthermore, there are more students who drop-out from distance learning courses, but it is not seen as a significant problem. For example, they have run two teacher-training courses, and out of 40 students, 35 completed their course after 2,5 years. This suggests that retention is an issue for the programme organisers to address in the future. (Are there any statistics comparing distance learning and traditional teacher-training courses?No).

Karlstad University is ahead of other universities in the region in this field of distance learning. Although there are some issues to be resolved, which are discussed below, the university would recommend this approach to other institutions wanting to reach students who are unable to attend the main university site. Overall, ICT distance learning is seen as part of the future, but it is important for a university involved in the developmental stages of this field to keep up with new technology, which is costly.

Limitations of the programme and problems encountered A number of difficulties have been encountered, which the university is seeking to overcome. These are primarily delivery and man-

agement issues, and do not relate directly to the student experience (as this has not been investigated).

**(i) Timing, planning and flexibility**

One difficulty of the programme is the timescale. Courses are currently being planned over one year in advance of when the courses will be offered. The planning finishes in December for courses to commence the following September. It is therefore difficult to respond flexibly to the requirements of students with regard to course type, for example level and particularly subject. The distance and open learning 'board' feels that they need the ability to make decisions in a shorter timeframe, to 'change directions, open up and be more flexible' in response to students needs. This however is not currently possible with the university's organisational structure.

**(ii) Staff and teaching issues**

Distance learning involves change of the part of teaching staff. For example, lecturers must be prepared to delivery lectures by video-link and reply to e-mails on a daily basis, as the computer is the primary teaching method. Some university staff 'think of this as a new and very interesting form of teaching, and some don'tŠ We don't want them'. The distance learning board, however, are not able to select the teaching staff who participate in the distance learning programmes. The staff from the distance learning board discuss with the head of each department and the course coordinator the new teaching skills that are required for distance learning – video conferencing, computer conferencing – and new aims that teaching staff must be aware of. Sometimes it is difficult to find appropriate teachers, and in such cases the course is not successful.These examples are rare,fortunately. The skills and attitudes of individual teaching staff is therefore a key element in the success or otherwise of individual courses and the scheme as a whole. Lectures delivered by videoconference need to be thoroughly planned and well-structured, and are less open to distraction. There is an example of lecturer in a distance course who was required to teach via videoconferencing, which she did not want to do it. When she arrived she said 'I hate it', but she was well prepared, and after the first lecture by videoconferencing she received e-mails from students who were very pleased and complimentary about the lecture, which encouraged the lecturer, and she has continued to be successful with this form of teaching. If teachers are not well-prepared to deliver their lecture, this is often when problems arise. It is therefore important for the university to prepare lecturers fully, both in terms of pedagogy and technical skills, but this is still a problem occasionally.

The distance learning board has developed pedagogic courses for lecturers involved in distance learning, and to develop technical knowledge. There are about 100 of university staff involved in delivering distance learning courses. Not all courses involve videoconferencing, in fact the majority are taught via computer conferencing on FirstClass. Videoconferencing however is an important part of the distance learning programme, and thus training staff to be effective videoconferencing lecturers is crucial. Ideally, it is argued that more money needs to be invested in staff development, but staff training is seen to be essential and at the current level is 'sufficiently successful'.

**(iii) Laboratory practice for scientific courses**

For subjects such as physics, biology and chemistry new teaching methods are required for distance learning to overcome the limitation of not having access to laboratoriesand other technical resources. Sometimes students on science courses in learning centres do have to travel to the University to use special equipment. Students are responsible for attending the university, and no practical or financial assistance is provided.

**(iv) Assessment and funding**

As was noted above, one of the difficulties of the distance learning programme is the comparatively low level of participation in assessment by the course participants. This reduces the income that the University is entitled to from the funding agency, and thus calls into question the economic viability of the programme. This is particularly important as the cost of updating the technology means that ICT distance learning programmes are not a cheap option.

**(v) Technical difficulties**

The distance learning programme is reliant on technology, and on some occasions there have been difficulties. For example, sometimes the connection fails and the lecture cannot be delivered. This however is a minor problem now compared to a few years ago. At the University of Karlstad the technology is updated regularly, to help reduce technical problems.

**Networking**.

Karlstad university is involved in several networks in ODL. The The West Swedish Consortium on Flexible Learning which consists of a dozen universities and university colleges in the western part of Sweden started as a project in the mid nineties with some state grants for developing distance courses together. Karlstad was very active in this project and the courses developed constituated the base on which the university built its present system These five courses are now some fifty. The consortium now takes the lead in the region by giving conferences within different areas such as language and health as well as technology and pedagogics for distance courses.

UNISKA. A Swedish-Norwegian Network with Karlstad university and three Norwegian university colleges mainly in the county of Hedmark. With Interreg grants from EU a dozen short courses, each of them four weeks long, have been developed by teams each consisting of teachers from the different institutions. Municipalities from both sides of the border are also involved. A new platform is being developed for this and one of the goals is that the platform should work with problem based learning. An introductory two week course, “ICT and learning”will be offered to the students. This course will also be used as introduction in the teacher program in Jan 01.

A few examples:

Strategic development for industry.
Management development.
Project development.
Stress and stress management.
Hosting and destination development in the tourism industry,culture and communication.
Creating and maintaining personal networks.
Distance working and flexible methods using new technology.
Ethical issues in caring for the elderly.
Development and change in the care sector.

There will be a pilot version of these courses this autumn and next year the courses will be added to the regular course catalogue for the participating institutions.

This project has received a grant for next year of 1,7 million SEK from the Swedish National Board on ODL (DISTUM) for next year.

The municipal learning centers in the wider region of Western Sweden are linked to our university and the other universities in the region in an informal network.

Twice a year Karlstad university arranges a conference where staff from the learning centers meet with course tutors and secretaries from the university to discuss issues as follow ups, evaluation, assessments and technology.

More than thirty municipalities receive courses through video and computer conferencing, mainly basic courses on A-level, one semester part time which is spread over one year.

**Lifelong learning for engineers**.

A network for the universities providing engineering programs on a national base.The goal is to upgrade the engineers with new competencies by giving them opportunities to fill empty places in regular courses as well as tailor made inset courses.

**Network for further education for teachers**.

Consisting of a group of universities nationwide where courses are offered to teachers with an old teacher exam to get a new exam.especially teachers with one subject only such as art,sport a o can take a second subject and get the new exam for secondary or upper secondary school. These courses are run by at least two and up to six partners with one university as coordinator.

Karlstad is coordinating English and gives courses up to D-level which means two years full time study. This network is mainly run through computer conferencing (First Class). We are also involved in maths, Swedish and computer science.

**Bergslagens Utbildnings Konsortium**.

Bergslagen is a region in Mid Sweden formerly based upon mining and iron and copper ore processing. High unemployment rate. A consortium of 25 municipalities and 5 universities and university colleges in the region develop tailor made courses for the needs of development such as Management, Law, Business and others.

**The Tourism Academy**.

A major project om tourism is being developed in the municipality of Malung in cooperation with Karlstad university. In Malung the biggest winter resort area in northern Europé is situated. The aim is to develop tourism and tourism research on a wide scale. Links to other municipalities as well as university colleges in the nearest region which includes Norway.

**Internal management**.

The new technologies need new strategies and networks within the university.

Our university is in many respects a matrix organisation. When new ideas are being developed information is needed because so many initiatives are taken around the university and we need a joint arena for information and discussion.

The management with the rector´s group at the top decides. The board for lifelong learning has to decide on ODL development and therefore is an important arenaThe director for internal services including rooms and the technology has important decisions in her hand. The University Pedagogical Group handles inset courses. The library develops new types of literature services for ODL students. The information office is constantly developing new ideas. The University Board has decided on the ICT-Policy of Karlstad University and it says that a joint arena for ODL management and development of support of technology and pedagogics should be created in the near future.

# Active Learning / Activating Teaching – new Approach for Interdisciplinary Education at Schools

**Iwona Maciejowska**

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The reform of educational system has been recently introduced in Poland. Nowadays the **Polish education system** generally consists of:

- primary school (6 classes, age 7–13),
- lower secondary school "gimnazjum" (3 years, age 13–16),
- upper secondary school "liceum" (3 years, age 16–19),
- university.

During the first three years of the primary school, one teacher is responsible for teaching everything within one subject (integrated teaching). There is block teaching in older classes, which means that nature subjects are grouped into the one called "science". In gymnasium and upper secondary school pupils become acquainted with particular scientific disciplines separately (e.g. during chemistry, biology and mathematics classes); also they participate in the so-called **interdisciplinary paths** – integrated activities (e.g. ecological path).

On the other hand the reform underline the necessity of developing so-called 'key skills': cooperation in group; solving a problem creatively, use of various sources of information; material selection skill, communicating, listening to the arguments of the other side and answering them; constructive discussion. planning, organising and evaluating one's own work.

In order to develop these skills in our students it is not enough just to expose them to a lecture or to a set of laboratory exercises in which they closely follow instructions provided by the teacher. I believe it is necessary to implement activating methods to achieve the aim. By this name we shall call such methods of teaching which force the learners to be active and independent participants in the process of learning (and involving, preferably, all four spheres of psyche: sensory perception, cognition, feelings and own will.

In activating methods:

1. the stress is moved from the teaching syllabus to the learner and the development of the learner's competencies;
2. the learner is the active agent, who gains knowledge in the process of searching for the answers (applying trial-and-error method) and verifying own ideas;
3. the teacher facilitates the process of learning by providing the learner with proper conditions to experiment, engaging the learner emotionally and encouraging him/her to think independently;
4. the group dynamics processes are involved in group work.

Activating methods can be undoubtedly classified as searching methods. Among them we may distinguish: didactic discussion, case study, simulation, role-play method, didactic game, project method and many others. I find them very useful especially in conducting the lessons and activities in the frame of ecological pathway or environmental education in general. Below are given some examples.

## 1. DIDACTIC DISCUSSION

**a) Brainstorming** – Delayed Evaluation Session. Exchange of Ideas. The Old Curiosity Shop of Ideas

The aim of these activities is to find out the largest number of unconventional solutions to presented problems. Even some of the once bizarre ideas were eventually put into practice: e.g. Jules Verne's Twenty Thousand Leagues under the Sea – the submarine; Star Wars – the antimissile defence system. The specialists and laymen work together. An evaluation of ideas follows, which is done by another group of specialists. In the end the participants choose the best idea (through voting).

Last summer, using the above procedure, I discussed the problem of water pollution reduction with the youth attending the scientific camp. Of course, they also suggested some more standard solutions, such as the construction of small sewage treatment plants, or obtaining water from the river below the sewage release point but… they also proposed: To force the "flag of convenience" owners and petroleum producers to swim in the sea polluted with oil (what in reality means to widen the audience of environmental education).

**b) Judgement of a Concept (the Trial, Staging)**

Stages:

– description of the working methods and sources of information;
– assignment of roles (judges, defenders, prosecutors, witnesses etc.);
– preparation of speeches and interrogations;
– the Sitting of the Court;
– conclusions

The final stage is of particular importance since the students usually have a great time during the classes, and yet the recapitulation of the most vital points of discussion and a summary are. The technique is used to discuss various controversial issues, such as acids, drugs, or radioactivity)

### VISUALISATION of discussion

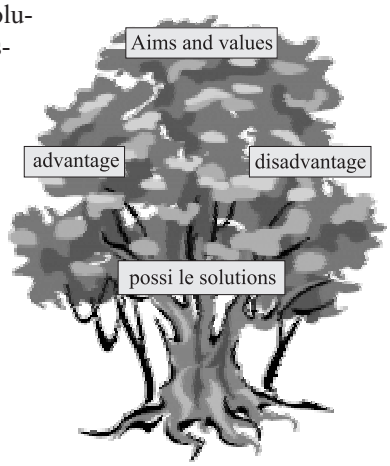
**a) Notice Board**

Working in groups students write their ideas on sticking cards and place them on a notice board (one board for each group). Next, each group familiarise themselves with the ideas stuck to the other boards, adding some of their own (if the topics are different, e.g. different aspects of the same problem). Each individual has to add at least one idea of his/her own. This technique can be used e.g. to collect the ideas concerning sources of energy (conventional and unconventional, renevable)

**b) Decision Tree**

Working in groups student write their ideas on posters. Those notes are organised in the special structure: description of situation (the roots), possible solutions (main 2–3 boughs), effects and results (negative and positive – branches). On the top of the poster they place aims and values (leafs and fruits).

This technique can be used, e.g. to choose a method of synthesis – what is more important: time, expenses, possible pollution, complex measuring apparatus, expensive reagents or complicated procedure?



description of situation

**c) Metaplan**

This technique is frequently applied to solve problems concerning environment protection (green house effect, acid rains etc.), but also employed to optimise actions that need to be undertaken, or to deal with ethical issues. Posters are organised as follows: The way it is. The way it should be. Why it is not the way it should be?

## 2. CASE STUDY

Case study is more complex than a mere discussion based on a press-cutting describing explosion in a mine during a lesson on the properties of methane.

Stages:

- Preliminary analysis of the problem (presentation of the basic information, defining the problem, first suggestions)
- Introduction of further details (enumerating limitations of certain solutions, preparing a catalogue of questions, searching for information)
- Suggesting alternative solutions (exchange of information, solution proposals)
- Reaching a decision (evaluation of advantages and disadvantages of suggested solutions)
- Verification (implementation of the solution, analysis of the results)

Case study was used in a lesson on reactions of neutralisation. As an example a road accident resulting in a leak from a truck carrying $H_2SO_4$ was given. The students were expected to suggest possible scenarios for a rescue operation. Possible solutions: cover the leak with sand – absorption; neutralisation of the leak with ammonia or NaOH, $CaCO_3$. Also, the students need to take under consideration the economic aspects of their actions: e.g. the sources for obtaining the neutralising matter – $H_2SO_4$, the costs of its obtaining, and the ways to utilise the resulting product. Their ideas are verified by finding out which method was actually adopted by the chemical rescue team.

## 3. ROLE PLAY METHOD

Firstly, the teacher introduces the students to the situation, e.g.:

"You are the members of a Commune Council for the Tatra Mountains Region. The Region embraces both the urban complex of the Town of Zakopane, with its 30,000 inhabitants, and the picturesque Tatra Mountain Range with its unique flora and fauna (mountain pine, crocus, chamois, marmot) and unmatched topography. The whole area of mountains is granted the status of a National Park. Numerous mountain streams flow through the town. Also, the region is rich in geothermal and mineral water springs. Tourism (accommodation and catering), trade and services are the basic source of income for the local community. The access road is much too narrow and its capacity does not meet the needs. The majority of houses are heated with natural gas and oil heaters, the others with coal-fired furnaces and even solar-energy collectors. Nearby hills are covered by pine forests, which may suffer damage if exposed to acid rains. At the today's sitting of the council you need to decide whether you should give your consent to a proposition to build a hotel centre with such facilities as ski-lifts and swimming pools on the border of the city and the National Park."

Teacher prepares role-play cards for the students, who play their parts accordingly. Suggested roles: the mayor, an inspector at the Environment Protection Department of the Council Office, a chemistry teacher, a mother, a guide, a shopkeeper, a farmer, a doctor, a TPN (Polish Tatra National Park) employee, an unemployed person, etc.

For their arguments the students may quote research data, but also the results of the experiments they have conducted themselves. The activity allows for a discussion of such issues as: the renewable and non-renewable energy sources, combustion processes, oxides production, air pollution, processes resulting in acid rains and the effect of the latter on various types of plants, mineral springs and the mineral salts they contain, the effect of Pb and $NO_x$ present in car fumes on human health, the mechanisms of smog, and many others.

## 5. PROJECT METHOD

The technique is excellent in integrating skills and in multidisciplinary teaching. In Poland it had been first introduced before the First World War, and was broadly used in the 30s. At the university teachers are familiar with that method. Much more exciting is to involve project as a method of teaching at the secondary level of education, especially by interdisciplinary education.

## References

ARENDS, R.I. (1994) "*Learning to Teach – Uczymy się nauczać.*" WSiP, Warszawa.

BAER, U. (1999) "Remscheider Diskussionspiele – Gry dyskusyjne", Klanza, Lublin

CHAŁAS, K. (2000) "Metoda projektów i jej egzemplifikacja w praktyce", Nowa Era, Kraków

KĘDRACKA-FELDMAN, E. (1999), "Wybrane metody i techniki aktywizacji uczniów" CODN, Warszawa

KURKOWSKA, A. (1999) "Rozwiązywanie problemów" CODN, Warszawa

NOWACKI, T.W. (1999), "Aktywizujące metody w kształceniu", CODN,Warszawa

SZLOSEK, F. (1999), "Dyskusja wielokrotna i burza mózgów", CODN,Warszawa

SZYMAŃSKI, M.S. (2000), "O metodzie projektów", Wydawnictwo Akademickie Żak, Warszawa

WERNECK, T., HEIDACK, C. (1977) "*Gedachtnisstraining*" Munchen

WÓJCIK, W. (2000), "Metody aktywizujące w pedagogice grup" Rubikon, Kraków

# Application of Diffrent Types of Exercises in Interactive Genetics Teaching and Learning with Computer Use at the Junior High School

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Analysis of literature regarding genetic education points to numerous problems connected with the processes of teaching and learning genetics at the secondary school level.The authors of the new biology syllabus in Poland suggested the transformation of cytological and genetics knowledge from a higher stage of education ( grades 11–12) onto a lower one (8–9). The authors of this paper suggested the examples of didactic aids – the own computer programs – that may help teachers in the realization of some genetics problems.

The computer programs as a didactic aid are more and more often discribed in didactic literature all over the world. The computer programs which are available are informative or encyclopaedic in nature.Our own programs are prototypes which are used in the research. Literature analysis connected with research on conception of active biology teaching points that multimedial methods of teaching have a positive influence on knowledge structure and effects of teaching.

There are some teaching principles – it means the main foundations of the ways of realization of teaching aims in diffrent didactic situations, also with available computer programs.

The computer programs which are presented aim at:

– Simulation
– Decision game
– Evaluation
– correction

and regard three teaching problems, namely:

1. Mendel's laws
2. Heredity of human features illustrated by the example of the colour of eyes,hair and rolling up of the tongue
3. Application of genetics illustrated by transgenic animals.

The examples of interactive exercises:

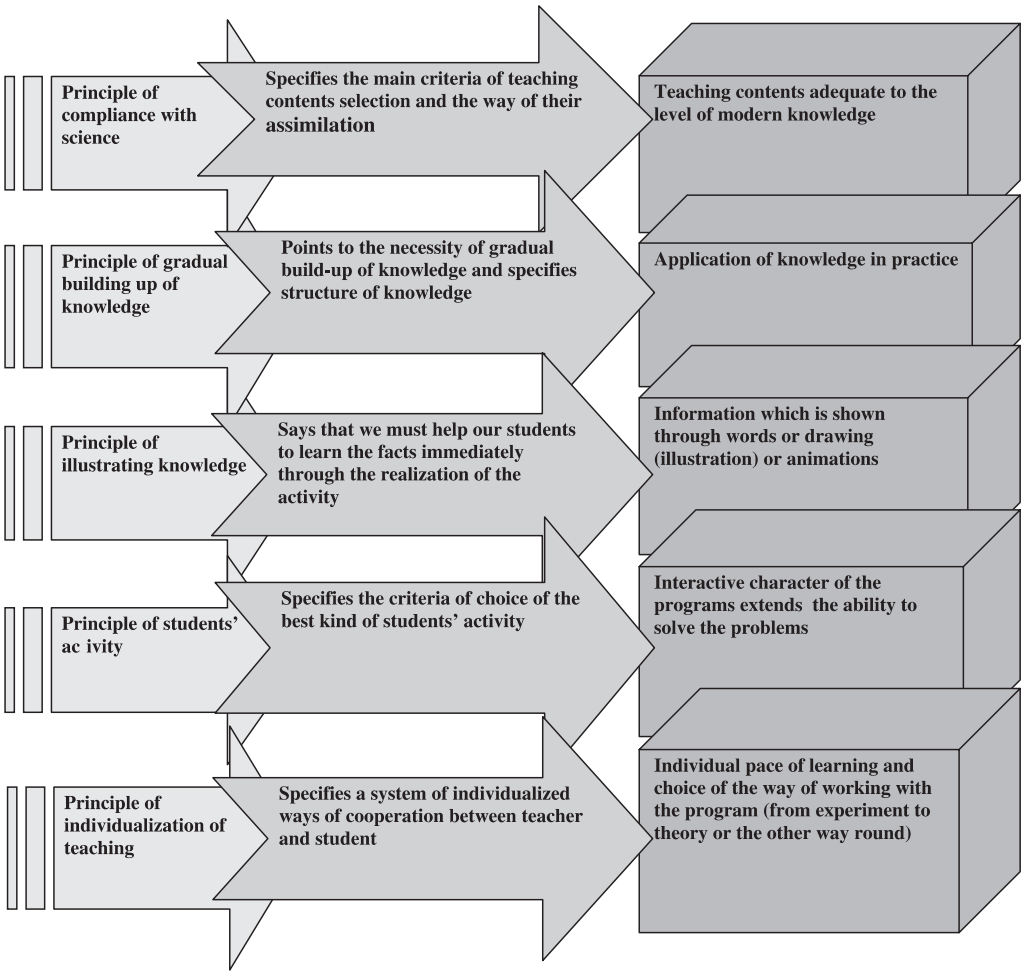
Re 1:

"decision tree" multiple choice task whose successful completion is awarded with congratulations and failure makes you try again.

Re 2:

The whole program is interactive in nature. The student must choose parents' phenotype, specify children's phenotype and finaly their genotypes.

Chart 1. Main principles of teaching (A), what they involve (B) and their computer-aided realization (C)




Re 3:

This program was prepared on the basis of the French program "Clonage et transgenese de l'animal a l'homme?". It was translated from French, and then adapted and modified for Polish junior high school purposes.

The interactive parts of the program are

a) "research laboratory" – the student has to choose from several charts, e.g.
   - Animal charts
   - Equipment charts
   - Activity charts
   - Charts containing explanations

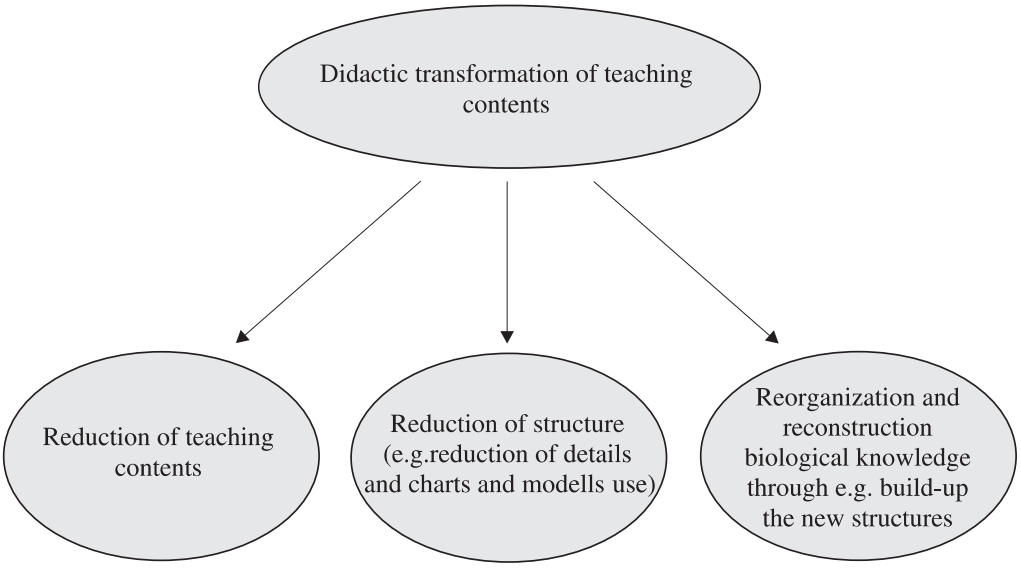
   accompanied by instruction. This task often ends in failure to show that not everything can be accepted ethically.
b) multiple choice test – result will be confirmed by the word" congratulations" or "sorry, your choice is incorrect".

In the process of learning active participation of the learner, his or her motivation and interests are vital. It means building constructive new knowledge on the basis of the already possessed knowledge. It is often connected with selecting and solving problems and answering the questions. Computer programs may support this kind of learning ( U. Unterbrunner 1999). Moreover, social need for the ability to store, reorganize, using and transferring information in various forms keeps increasing.

The tendency to introduce genetic problems at lower and lower stages of education involves the necessity to perform didactic transformation of teaching contents in genetics. (*Chart 2 )*

The project connected with the introduction of new methodological solution was subjected to a practical test connected with the observation of its course and measurment of the effects of the teaching and learning processes organized closely according to the assumptions taken by the author. The first part of research was carried out in 3 high schools in Kraków from September 1999 to February 2000, 365 students of the first grade ( ninth year of education), including 9 experimental classes and 2 control classes were involved in the research. Altogether the course of 175 genetics lessons was observed. 87 times computer was used in the program. At the end with the help of a school achievement test the results of teaching gained in experimental classes were compared with the results in control classes. In control classes a teacher carried out the lessons according to his or her own concept, based on traditional teaching and educational solutions. The research is continued.

Chart.2. The ways of didactic transformation proccess realization




The research results of the author, among others, point to the fact that properly selected computer programs or parts of them used correctly at lessons in genetics ( apart from other teaching aids) influence the degree of interest of the students in the discussed issues and affect the increase of the degree of mastering knowledge and skills by them.

**The research carried out to date allows to draw**, **the following conclusion:**

School achievements of students in genetics at the junior high school level are differentiated mainly by the following factors:

– teaching material which should have an ordered structure, in which some elements are basic due to their number and importance of relations with other elements. It is connected with a proper choice and range of curriculum contents – simplyfying structures of building and processes, eliminating names, formulas, detailed notions disturbing genetic knowledge structure in students,
– taking into consideration the relations between teaching contents and teaching aims formulated as aimed students' achievements,
– way of realization of curriculum problems ( methods and forms of work, teaching aids ).

Hence the conclusion that although the students of teacher training colleges are well prepared to take up teaching novelties in human genetics at the level of junior high school, as they have the opportunity to master the necessary knowledge and skills in the course of their studies, yet in future plans of teaching students – future biology teachers, more emphasis should be put on the forming of the following abilities:

- The ability to make a choice and select a range of teaching contents according to the number of lessons
- The ability to perform a didactic transformation of teaching contents
- The ability to perform control and evaluation of students in a modern way
- The ability to work with modern teaching aids
- The ability to put the notions in a correct order and structure the knowledge properly.

Attention must be paid to the confrontation of plans and studies programs at biology teacher training colleges and the real needs in their professional work.

## References

U. Unterbrunner (1999) "Einsatz verschiedener Aufgabentypen beim interactiven Lernen an computer (Klasse 5 bis 7) [in:] "Lernen im Biologieunterricht" VdBiol Tagung, Salzburg

# V
# Guidelines and recommendations for future policies at national and university level

## SUMMARY OF THE POLISH SESSION

**16 December 2000**

Science module for the students of humanities, humanistic modul for the students in science.

Moderators: E.Mańczak – Wohlfeld, E. Kantowicz, A. Borowski

Following main aspects were under discussion:

1. To whom modules should be adressed, intellectual elite or the average students?
2. Objective of the module,
3. Way of implementing the modules into existing programmes.

Though the difference of the expectations and needs between the best and the average students is unquestionable the offer should be adressed to all students. The objective of the science module should concentrate on showing the way of thinking in science and the explanation of common day phenomena and medial facts as well. The offer of the humanistic modul may be the free choice of selected lectures given in standard curricula existing at the faculties. In case of science module the offer should be elaborated by clear and attractive means to be understood by the students of humanities. Environmental Protection Programme is recommended as the helpful offer of lectures in science elaborated with special practical profile. The settlement of particular share (7 – 10%) for respective module was proposed.

It should be mentioned here the discussion begins to go a bit outside of its scope.

The basic concept we are talking about can be stated as follows:

In the case of science 5–10% of education effort is devoted to humanities, and vice versa – in the case of humanities 5–10% of the effort is devoted to science. The discussed case should be very clearly distinquished from so called dual-career studies, where the aim is to get deeper knowledge in both fields, and the proportion of efforts is 50 50%, 40 60% or so. These are respective examples: chemistry and law, engineering and busines science, and environmental protection studies based mainly on biology and chemistry.

# Panel Discussion

**Andrzej Hennel**

*(Faculty of Physics, Warsaw Unversity)*

I think that there is a basic difference between humanists and naturalists which has to be taken under consideration. In case of the students of Mathematical and Natural Science Faculties it is possible to take part in the lectures apriopriated for the participants of Faculty of Art.

Many years ago Warsaw University introduced the principle of obligatory completion of 7% lectures beyond the main specialization.

For example students of Faculty of Physics can participate in lectures of Philosophy, Psychology, History etc, without any barriers connected with understanding the problems and conceptions.

Contrary situation is in case of humanists who desire to expand their knowledge in the field of Mathematical and Natural Science which mostly use mathematical language. That is why at the Faculties of Physics and Chemistry during the first years of studies a lot of time is spent on learning mathematics. It can build a kind of barrier which can unable non-prepared person to understand the problem.

In this situation I opt for creating the special lectures for those whose mathematical knowledge is at the level of the Secondary School.

For few years I have lectured, at the Faculty of Physics at Warsaw University, "Physics for naturalists" which do not require mathematical preparation. Lectures' topics combine both important problems of everyday life, for example physics of the eye, as well as important events from the XXth Century, for example about atomic bomb. Detailed plan of the lecture can be found in Internet: http://www.fuw.edu.pl/~ajduk/inf00/ik5_00.html

With the great satisfaction I observe that except the students of the Natural Science Faculties, there are also some humanists at my lecture.

I am convinced that this way of presenting the Natural Science enable students of the Faculty of Art to enter the area of "the occult", that the exact sciences unfairly become.

# The Humanities for Natural Scientists (on the example of linguistics)

**Elżbieta Mańczak-Wohlfeld**

*The Institute of English Philology*
*Jagiellonian University*

It is difficult to suggest one solution concerning the humanities for natural scientists. There are basically two possibilities:

1. The students of natural sciences join different courses offered at all the humane faculties. Although the choice of subjects is totally up to the student s/he has to have something like 5% or 10% of all the credits (ECTS) s/he obtains at his/her department. This is a fairly cheap solution as it does not require any great financial effort. The only objection may arise from the academic teachers who may claim that they are overloaded with additional work like checking more tests or examination papers or examining far more students than usually. Perhaps it could be remedied by paying the teachers for this extra work.
2. There are modules or courses on the cultural matters (in a very broad sense of the expression) especially designed for the students of natural sciences. Again there should be a number of different courses offered for the students of natural sciences to enable them to choose let's say four 30h courses from such subjects as e.g. history of art, history of music, film studies, theatre studies, language as a means of communication, literatures of different nations. During these lectures the names of famous Poles in respective fields should be exposed apart from the presentation of a very brief history of the development of each discipline and the discussion of a particular trend with the emphasis put on one problem which could be of the utmost interest to the lecturer. As a linguist I would like to suggest the following as an example of such a lecture: a short history of linguistics which dates back to the antiquity when the basic grammar terms and concepts were put forward and thus the so-called traditional or classical grammar was established. This framework was continued till the 19$^{th}$ century when historical linguistics started to dominate. The 20$^{th}$ century witnessed the development of structuralism with its different varieties. Here the names of such great Polish scholars should be mentioned, that is Baudouin de Courtenay ( a predecessor of structuralism) and Bronisław Malinowski (among others, known as one the founders of London school of lingustics). A variety of structuralism, e.g. the American one could be described in detail and then if e.g. I were to conduct such a lecture I would concentrate on language contacts, stressing the influence of English on Polish. Certainly, this solution is far more expensive because it requires opening special courses for natural scientists.

It is impossible to state which suggestion is better as most probably there is no ideal solution.

# VI
# CONCLUSIONS