VIRTUAL INSTRUMENTATION ASSISTED SCIENCE TEACHING AND LEARNING ACCROSS EUROPE - COMPARATIVE CURRICULAR REFLECTIONS

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Abstract:
The present paper presents an exploratory study on the Science curriculum in a number of European countries involved through a number of nine educational institutions in the Socrates Comenius 2.1 Project *VccSSe - Virtual Community Collaborating Space for Science Education*. The author of the article offers critical comparative conclusions regarding the current state of curriculum in Science disciplines across Europe and the trends in science teaching and learning in terms of curriculum structures and modes of presentation, teaching methodologies, roles of teachers and students in Science lessons, attitudes towards new technologies.

Keywords: Science school subject matters; Science teaching and learning; trends in Science education

1. Introduction

The field of Science education comprises across Europe curriculum contents related to the following school subjects: Mathematics, Physics, Chemistry, Biology and Geology. In a limited number of cases, such as the case of Spain, Science area includes transversal, integrated school subjects like science, technology and society, a subject aimed to study the social aspects of science and their impact in the past, in the present, and in the future in our society. All these subjects are included in lower and upper secondary curriculum with different number of teaching hours at different levels.

The above mentioned project involved educational specialists form five European countries: Spain, Poland, Greece, Finland and Romania. Even though the specific data we offer in the following lines particularly reflect the Science teaching realities in these countries. However, given the balanced distribution of the involved countries across Europe and different European communities (former communist countries, Northern and Southern

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European countries Western European countries) we trust that the data presented here can be regarded that relevant for the European Science teaching and learning in general.

2. Materials and method

One of the main objectives of the European project Virtual Community Collaborating Space for Science Education was identifying the suitable and up to date tools that offer teachers of Sciences in different European countries the possibility to effectively meet national curriculum requirements while proposing dynamic and relevant learning situations based on scientific reality experimentation through electronic means and into an virtual learning space.

In order to collect the prior necessary data for reaching the above detailed aim, a thorough analysis of the Science curriculum requirements was made, in terms of Science **teaching aims and objectives, values and attitudes, contents and typical learning situation.** The analysis offered interesting comparative conclusions that make the object of the present paper.

Added to this, we gathered data regarding the trends in European countries in Science teaching and learning in terms of:

- new methodologies that are advised;
- new teaching behaviours;
- new roles for the students;
- new ways of evaluation;
- new technologies and materials;
- other new curricular recommendations and trends.

Data were collected with the help of two data protocols that required the educational representatives of the institutions involved in the above mentioned project to sort the curriculum data according to a number explanatory criteria: curriculum aims and objectives, content units, typical learning situations, values and attitudes targeted, for both lower and upper secondary Science curriculum (protocol 1) and to reflect upon the trends in Science teaching and learning (protocol 2) . Data were grouped on main Science subject matters included in Science curricular area of each country.

3. Results and Discussions

Science curriculum offer vary in different European educational systems in terms of:

- contents structure and degree of contents integration;
- types of competences targeted and trained;
- recommended teaching methodologies;
- types of learning experiences to be organized.

At a general analysis of the above detailed curriculum programmes some conclusions may be extracted regarding the types of competences targeted, types of contents and their organization, types of values and attitudes promoted:

Throughout Europe Science curriculum is focused on:

- Systemic acquisition of knowledge;
- Training of the research competences;
- Development of a critical attitude towards the effects of science on the technological and social development and of the interest for the environmental protection;
- Values such as respect for truth and diversity, respect for individual needs and nature, curiosity and initiative, openness for the opinions of others and disposition to modify own perspectives in the light of new facts;
- Exploration of transversal concepts such as: motion and force, energy and electricity, heat, substances around us, natural structures.

Contents integration either at a thematic level (see for example Finnish curriculum) or at the abilities level (see for example the Spanish curriculum).

3.1. Current state and trends in European countries Science teaching and learning

3.1.1. Finnish Science curriculum

The Finnish national core curriculum has been formulated on the basis of a conception of learning as an individual and communal process of building knowledge and skills. Learning takes place as purposeful study in a variety of situations: independently, under a teacher's guidance, and in interaction with the teacher and peer group. Learning depends on the learner's previously constructed knowledge, motivation, and learning and work habits. Learning is an active and goal-oriented process that includes independent or collective problem-solving. Learning is situational and opens new possibilities for participating in social activity.

Tools and approaches

The study tools and facilities must be designed and organized so as to allow the employment of diverse study methods and working approaches. The learning environment must also be equipped so as to support the pupil's development into a member of today's information society, and provide opportunities for the use of computers, other media technology, and, as possibilities allow, data networks.

In instruction versatile working approaches support and guide the pupil's learning. The function of the working approaches is to develop social, learning, thinking, working, and problem-solving skills, and to foster active participation. The approaches must further the development of skills with information and communication technology. They must also provide opportunities for the creative activity, experiences, and play characteristic of the

age group in question. The teacher selects the working approaches. It is their task to teach and guide the work and learning of both the individual pupil and the entire group.

Physics and Chemistry

The starting point for instruction in physics and chemistry are the pupils' *prior knowledge*, skills and experiences. The instruction relies on an *experimental approach* in which the starting point is the *observation* and *investigation* of substances and phenomena associated with the environment. The purpose of the experimental orientation is to help the pupils both to perceive *the nature of science* and to learn new scientific concepts, principles, and models; to develop skills in experimental work and *cooperation*.

The instruction guides the pupil in *thinking in a manner characteristic of science*, in acquiring and using knowledge, and in evaluating the reliability and importance of knowledge in different life situations. The instruction gives the pupil the ability to discuss and write about questions and phenomena within the realm of physics/chemistry and technology, using appropriate concepts. It also provides capabilities for making everyday choices, especially in matters related to environmental protection and the use of energy resources.

The curriculum is a process curriculum and the formative assessment should be used more than the summative assessment.

Mathematics

The core task of mathematics instruction in the sixth through ninth grades is furnish adequate basic capabilities encompassing the modelling of everyday mathematical problems, the learning of mathematical models of thinking, and practice with remembering, focusing and precise expression.

3.1.2. Greek Science curriculum

Greek Maths and Science curriculum is expected to contribute to develop an effective scientific culture that will, in turn, allow individuals to interpret natural events, phenomena and processes, thus situating and scoping the interaction between human beings and nature as part of a constantly changing Nature. The teacher is formally required within the curriculum documents to use modern concepts and understandings of psychology and educational research to form the appropriate learning activities. The main goal is to bring modern ideas and topics of Science in the front line of student's knowledge, adopted in the intellectual level and interesting of students, without loss of rigorous scientific value.

The teacher supports the student to: explain the chemical phenomena, build and use appropriate models, trying to describe, interpret and predict chemical phenomena and procedures. The use of new tools (such as educational software, www etc) today plays an essential role in the teaching procedure.

3.1.3. Spanish Science curriculum

Student development must be ultimately targeted towards the acquisition of basic knowledge, scientific preparation and ones ability to use different technologies pertaining to one's field(s) of activity.

In secondary Education, the proposed focus now emphasizes general training, as opposed to specific training; and is focused on the acquisition of basic competences.

These competences are understood in general as the development of one's ability to research, seek out information, analyze it and select it; the ability to learn, create, formulate, as opposed to a mere exercise in memorization.

The new society resulting from the technological revolution and its implications to information-related processes has features that can ensure an unprecedented level of autonomy to education. The development of the cognitive and cultural competencies required for full-fledged human development has now coincided with production-related expectations.

What competencies are we talking about? One's ability to sustain abstract reasoning; the development of systems-based thinking, as opposed to a partial and fragmented understanding of phenomena; creativity, curiosity, the ability to think of multiple alternatives to solve a given scientific problem; in other words, the development of diverging thinking,

Even more, the curricula is focused on the ability to work in teams, the willingness to seek and accept criticism, and the development of critical thinking,

The methodology aims towards providing for mathematics competition and competition on knowledge and interaction with the physical world, insuring activities that allow the approach and problem solving through simple searching, sorting and processing of information. Practical exercises are carried out as well as simple field work or lab experiences.

They prevailing work methodologies for insuring effective learning are:

- Project Based Learning;
- Cooperative Learning methods and strategies;
- Inclusive education methodologies;
- Effective field work, visits to museums of science, industrial facilities, research centers, treatment establishments , waste treatment plants etc;
- Experimental work, handling of laboratory instruments;
- ICT instruments must become a routine: virtual environments, interactive and multimedia which can be accessed through the network.

Student participation in their own learning process is recommended.

Since, some years ago a bilingual program has started in a good percentage of secondary schools, some of these subjects are taught in English in some cases. The general rule is to change the subject taught in English every two school years, in order to avoid that

students acquire specific concepts and names only in one language. This is, if they study biology in English one year, next one, they will study it in Spanish, to acquire the specific terminology in both languages.

Curricula also include science, technology and society, a subject aimed to study the social aspect of the science and their impact in the past, in the present, and in the future.

3.1.4. Romanian Science curriculum

New innovative ways of contents structuring are implemented. Sciences contents tend to be structured in an increasingly inclusive manner, this tendency being obvious in primary school and less present in secondary level. Yet, within classical science fields integrated topics may be observed, particularly in Chemistry curriculum.

Aims and goals in Sciences school subjects focus on competences of scientific information processing, research skills, and humanistic values.

Methodology highly recommended is focused on inquiry based learning, experiential learning, discovery based learning.

Teachers are regarded as designers of reach learning situations and guiders in knowledge construction.

3.1.5. Polish Science curriculum

There are three goals that the lower and higher secondary school education wants to achieve:

1) To allow students to acquire a defined knowledge scope of facts, principles, theories and practice;
2) To make it possible for students to acquire skills necessary to use the acquired knowledge while doing activities and solving problems;
3) To form attitudes ensuring efficient and responsible functioning in the contemporary world.

New methodologies that are suggested

The way to achieve those goals is complementing traditional teaching and learning methods with new methods with the stress on the following:

1) Problem solving approach (e.g. projects);
2) Applying the functional teaching, in accordance with the student's mental development stages;
3) Polisensory teaching with a wide use of multimedia and experiment.

New teaching behaviours

The teaching process should take into account students' individual learning styles as well as their special education needs. The designed tasks should take in consideration students experience as well make them search for and use the knowledge and skills taken

from both other school subjects and everyday life. Indispensable is developing the skills of defining one's education needs, learning styles and group work.

Teachers of all subjects should make use of school libraries and cooperate with school librarians with the aim of overall preparation of their students to carry out self-study as well as intentional searching for, selecting and using information.

New roles for the students

The student is an active subject of the educational process. According to the constructivism theory students construct the structure of their knowledge themselves. The basic skills connected directly or indirectly with science, which should be mastered by students are as follows:

- Reading – understood as a skill to comprehend, make use of and process reflectively texts among which are culture texts – leading to the achievements of one's own goal, personality development as well as active participation in society life;
- Mathematic reasoning – a skill of using mathematics tools in everyday life situations as well as of forming views based on mathematic reasoning;
- Scientific reasoning – a skill of using scientific knowledge to identify and solve problems as well to make conclusions based on empirical observations concerning nature and society;
- The skill to communicate in a native as well as foreign languages, both in a spoken and written form;
- The skill to use efficiently new information and communication technology;
- The skill to search for, select and critically analyse information;
- The sill to identify one's educational needs and learning styles;
- The skill of group work.

New ways of evaluation

The evaluation of students' achievements is two-dimensional:

In-school evaluation based on school curriculum requirements (an extended curriculum is possible) is to a great extent of a forming character, stresses the knowledge accumulation as well as students' skills, promotes students' self-evaluation. Examinations based on curriculum requirements is mainly of a summarizing character with its aim to form a system monitoring students' knowledge acquisition and skills after each education phase; for school results analysis it uses educational methodology of added value.

New technologies and materials

The education process should be widely assisted by new technologies which allow for the common usage of multimedia, such as the computer, projector, interactive board, DVD player, etc. It is essential to use the computer as a teaching and learning tool for subjects other than computer science.

Achieving educational goals should be assisted by school libraries with updated sources, in the form of both books and multimedia. Intentional and selective use of the Internet should be its adequate completion.

E-learning is recommended to play a more significant role in education, being a component of the traditional teaching and learning (blended learning).

4. Conclusions

In synthesis, here are some of the actual principles and trends that are common to European countries involved in the VI project:

- Learning is regarded as an individual and common process of building knowledge and skills.
- Learning is situational and opens new possibilities for participating in social activity.
- Learning is focused on competences: ability to sustain abstract reasoning; the development of systems-based thinking, as opposed to a partial and fragmented understanding of phenomena; creativity, curiosity, the ability to think of multiple alternatives to solve a given scientific problem; in other words, the development of diverging thinking. The curricula is focused on the ability to work in teams, the willingness to seek and accept criticism, and the development of critical thinking.
- Teaching focus on evaluating the reliability and importance of knowledge.
- Methodology supports active learning: problem based learning (mentioned by all countries), project based learning (3 countries), cooperative learning (2 countries), integration of special needs and individual learning habits (2 countries), extending the learning environment towards social factors such as museums, laboratories, medical centers (mentioned by Spain).
- Tools that foster active participation: computers, media technology, data networks, interactive board.

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