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EXPLORING THE ENVIRONMENT: NATURAL SCIENCES IN THE COMPULSORY EDUCATION CURRICULUM

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Summary *– The article presents the structure of science curricula of different European countries as one of the factors contributing to development of coherent scientific knowledge and skills in compulsory education. It is the result of a wider research project conducted at the Institute for Social Research's Centre for Educational Research and Development. The project included a comparative analysis of the said European curricular documents and development of recommendations for potential closer alignment of the Croatian national curricula with the perceived tendencies in the selected European countries. The recommendations focus on potential conceptualisation of the Croatian curriculum (in the field of natural sciences) as a 'deduction' of the subjects' content from a coordinated set of competences, which are defined as a general outcome of compulsory science education.*

Key words: *natural sciences, curriculum, biology, chemistry, physics, environment*

For over a decade the European institutions speak of the need to encourage young people to study natural science and chose careers in the science and technology sector (cf. e.g. Council of the European Union, 2001). Although the specific science skills useful in employment are mostly not gained at the primary school, appropriation of theses skills is based exclusively on the development of basic competences in natural sciences and mathematics, and the latter are most effectively developed through primary education. On the other hand, there are reports that the interest in the natural sciences and technology begins to fade at the level of primary education (European Commission, 2007). The same report stresses the need for higher level of general competence in science and technology to increase citizens' participation in the public life and greater involvement in decision making and legislature.

It is, of course, not easy to quantitatively determine the extent to which different factors contribute to young people's attitudes to science Europe-wide (thus, stressing the differences in culture and educational systems among countries), but it is evident that conceptualisation and organisation of the primary school science curriculum (including here the choice of topics and mode of their presentation) also play a role. A recent comprehensive overview indicates that in many European countries sections of the curriculum devoted to science are changing from a long shopping list of facts into a more relevant and flexible curriculum that aims to assist the development of conceptual foundations of science and of the scientific mode of investigation of the environment.

Croatia also faces a challenge from the relative lack of interest in science courses among the young people, as well as the lack of professionals in the science and technology sector. On the pragmatic side, it is also necessary to satisfy the needs of the labour market for the highly skilled workforce in science, technology and medicine. The latter has recently been picked up by the media as problem concerning the society as whole (cf. e.g. Ponoš, 2007; Klepo, 2007). Moreover, this is not a case of a fad, but a long developing trend (Lenardić et al., 2005). Supposing that science teaching in the compulsory education is a contributing factor to this trend, it is worth to briefly report on the findings of a wider research, conducted in 2003, into attitudes of students and teachers to the prescribed teaching programmes and their implementation in school. The complete research results are presented in Baranović, 2006 and Marušić 2006 (for teachers and students respectively). Only those concerning mathematics and sciences are outlined here, with mathematics included due to close conceptual link to science ate this educational level and slight overlap of contents (such as mechanics) in other national framework curricula. The comparative analysis of the national curricula though, focuses only on the science segment due to overall organization of the project teams (cf. Baranović, 2007).

Students dislike science, subjects

Generally speaking, science and mathematics are among the least frequently selected most liked subjects (out of a total of 13), and among the most frequently selected least liked subjects by the 8th (final) grade primary school students (cf. Marušić, 2006). This is most applicable to Chemistry, and least applicable to Biology, as Table 1 indicates.

Table 1: "What subject do you most/least like?", % of student population from the sample that choose the given subject as the one they most/least like

Subject	Like most (%)	Like least (%)
Biology	8,6	4,5
Chemistry	4,0	17,6
Mathematics	5,9	17,3
Physics	4,0	12,0

N = 2601

Among the justifications given for individual choices sciences and mathematics are mostly liked for the interesting subjects matter and the ease of its appropriation, whilst physics in particular owes much of its appeal to the teachers. Among the justifications for the 'dislike', incomprehensibility of the subject matter dominates in the cases of Mathematics, Chemistry and Physics, whilst Biology is mostly 'disliked' for its teachers. It is interesting that in the case of physics greatest percentage of students (over 50% of them) notices the conceptual connections to other subjects in the curriculum.

The science and mathematics teachers (Baranović, 2006) perceive the horizontal coherence of their own subjects as the weakest characteristic of the curricular documents, with vertical coherence not faring much better. The teachers also agree in perceiving their subjects as overloaded with content, but also interesting and important in the future life of the students. When describing the classroom activities these teachers least frequently name individual practical work, practical experiments and field work.

Science in the curricular documents of some European countries

The following presents the results of a comparative study of the framework curricula and (in some cases) subject syllabi of a selection of European countries (for introductory remarks cf. Baranovic, this volume). There are many factors that contribute to students' perceptions of the subjects and the teachers' perceptions of the framework curricula and syllabi, but curricular organization and content, as the centrally prescribed framework, indisputably play a role. Given that the detailed presentations of the content and implementation of science subjects in primary and lower secondary (i.e. compulsory) education exceeds the scope of this text, and is presented in freely available publications (Eurydice, 2006), the subsequent paragraphs will focus on the trends and specific curiosities of the national framework curricula (or curricular documents in general), and especially their sections devoted to science. A principal comparison with the Croatian situation will also be presented. The analysis assumes that in the Croatian curricular documents science content is taught through the following subjects: Nature and Society, Nature, Biology, Chemistry, Physics.

Although there are great differences in organization of the national curricula among the countries in the sample there are also similarities, most notable of which is the tendency to keep compulsory science content within a single and broad subject dedicated to exploration of the environment using the method of science. Among other things such integration opens up more space for education for sustainability, but also for the understanding of the effects of science on the society (from everyday life to the great technological revolutions). As a more or less expressed trend in most of the compared countries there is a tendency toward perpetual (i.e. through almost every subject area and topic) linking of the subject matter with the context of everyday experience.

In order to economise on the word-count, the following often presents the cross-curricular, practical and socially engaging topics quantitatively disproportionately (though by no means qualitatively disproportionally, as most curricula hasten to mention) compared to those related to theoretical content of the respective school subjects. It is considered that for the analysis of this type it is of no crucial importance when and through what lessons parts of human anatomy, for example, are taught. It is taken that it is more informative to compare the less standard and more peculiar aspects of the science curricula, which in their respective countries make up an equally important part of the curriculum, as well as the teaching and evaluation processes.

Nordic countries: subject syllabi entailed by the general aims of education

In the said countries compulsory education lasts for a minimum of 9 years and science is taught throughout the whole period. Curricular science content is organized as presented in the tables 2 through 11. It is important to stress that the tables in this and other country-groups represent the structure of the organization of the content in the curricular documents, which needn't perfectly match the classroom presentation, as will be further explained in the presentation of individual country-groups.

Table 2: Structure of the presentation of the science subject matter in Sweden

Sweden									
Grade[1]	1	2	3	4	5	6	7	8	9
Subject	Science Studies (common syllabus)								
	Biology								
	Chemistry								
	Physics								

Curriculum for the Compulsory School, the Pre-School Class and the Leisure-Time Centre (*Lpo 94*), Ministry of Education and Science in Sweden and National Agency for Education, 2001; *Compulsory school Syllabuses*, National Agency for Education, 2001

1 In what follows tables for some countries are expressed in grades others in age. This follows the presentation in the original documents, and is not unified across the article so as to stay as true as possible to the sources and the specificities of individual educational systems. In all tables the grade/age range for compulsory education is presented, and the crucial information is the level of diversification of content throughout the table as a whole, not the specific age at which that occurs (as some countries permit different ages to follow the same grade subject content).

Table 3: Structure of the presentation of the science subject matter in Finland

Finland									
Grade	1	2	3	4	5	6	7	8	9
Subject	Environmental and natural studies				Biology and Geography		Biology		
							Geography		
					Physics and Chemistry		Physics		
							Chemistry		

National Core Curriculum for Basic Education 2004, Finnish National Board Of Education, Helsinki, 2004

Table 4: Structure of the presentation of the science subject matter in Norway

Norway			
Grade	1.-4. (primary level)	5.-7. (intermediate level)	8.-10. (lower secondary education)
Subject	Science and the Environment		

Attainment Targets for Compulsory Education, http://www.minocw.nl/english/education/doc/Kerndoelen_basisonderwijs_Engels.doc , February, 2005

There are similarities between the Nordic countries in the sample, both in terms structure of the curricular documents and in terms of the prescribed organization of educational practice. The curricular documents can clearly be divided into two parts: a detailed description of the values and organization of compulsory education on a national level, and a presentation of individual school subjects that form the content of compulsory education. The introductory description on the whole contains general pointers for educational practice, expected general outcomes of different levels of education, and standards of implementation at different educational levels and in different subject fields. General guidelines for assessment can also be found in this part of the document. A common aspect of all parts of the documents is that they do not prescribe in detail the methods of teaching of subject matter. The latter is entirely entrusted to schools, whilst at the national level only guidelines concerning overall teaching-hours allocation etc. are suggested. Even in the second part, more closely concerned with syllabus matters, only general topics that students need to be introduced to sometime during their education are listed. Unlike in Croatia, specific instances resulting from those topics as well as examples of their implementation are not nationally prescribed. It is important to note that science subject matter also includes appropriation of the scientific method and introduction to selected topics in the history of science.

Despite the prevailing similarities in the structure of national curricular documents, there are also obvious differences within this group of countries. The primary difference lies in the level of detailed analysis of educational aims of individual subjects. Thus, in Norway only concise justification for the teaching of science is listed, whilst in Sweden and Finland major academic disciplines within the field of natural sciences are specifically outlined alongside the skills and values that ought to be adopted in relation to the living and non-living environment. This is not a case, though, of a detailed proscription of the individual teaching units that need to be covered nor a list of facts that need to be transferred. Even among specific goals of individual subjects within the field of science, alongside obvious content (such as "to become acquainted with the structure and major vital functions of humans") a significant role is played by topics related to importance of science for contemporary life (from sustainable development to the social phenomena rooted in biological or physical foundations, e.g. sexuality).

Finally, an important difference between the three countries in this group is the level of integration of (at least according to the presentation of contents in the curricular documents) content in the field of natural science as a whole. Thus, Norway offers a fully integrated curriculum for science throughout compulsory education. Sweden provides a choice between the integrated version and division into biology, chemistry and physics for the overall time-span of compulsory education. It is important to note in this case, though, that it is explicitly stated that though separated in curricular proscription, this content needn't be implemented separately in the classroom, and this choice is left to schools and their science departments. Finland alters the level of integration through different stages of compulsory education (from fully integrated to separate subjects aligned with the traditional academic disciplines).

We can briefly note the other peculiarities (from the Croatian perspective) of the curricular documents from these three countries. Thus, for example, the Swedish documents state that alongside general and subject-specific goals listed in the curriculum, the state prescribes the minimal educational outcomes mandatory for each student half way through and upon completion of compulsory education. Subject syllabi are the documents that regulate what students have to learn from a stable body of knowledge, but do not specify how the schooling should be organised in order to transfer this body of knowledge nor by what method. They only specify the subject content that has to be transmitted and thus logically influence the teachers' choice of methods and teaching materials.

Norway, for example, expresses the initiative to provide equality in schooling not only on sexual, functional, geographical, religious, class and ethnic grounds, but also independent of the grade (i.e. year-group) the student is in. The teachers are expected to be aware of the limits of knowledge, thus staying permanently ahead of their working environment and are encouraged to gain new insights through professional development and research. On the other hand, it is also stated that the basic responsibility for education of the young people lies with their parents or guardians, and can not be transferred exclusively onto the school. The school is charged with supplementation of the youths' education in a supportive environment created jointly with the parents.

The Finnish curriculum explicitly states that the students can advance according to individual learning plans, not the general plans organized by year-groups and school grades. Timetables, educational aims and subject content are centrally set for individual educational units, and the units are defined in accordance with the subjects and subject areas defined centrally. The local school curriculum must prescribe which of the educational units are compulsory and which can be freely selected by the students. A combination of these units makes up the individual student's syllabus. If difficulties arise in the appropriation of specific subject matter individual additional teaching is provided so that the student may catch up with the originally set goals. Those students who 'move' through the curriculum in accordance with the externally set grades can move up to the higher grade even when their marks do not arithmetically permit it, provided that the teachers find them capable of grasping the content set for the following grade. On the other hand, the students can also re-enter the same grade given that they have 'failed' one or more subjects. But such students can also prove, according to criteria set in advance, that they have appropriated knowledge and skills at the required level and thus be instantly promoted to the grade above. Those that follow a non-standard individual teaching programme are considered promoted to the higher grade when they have successfully completed all the units of their plan assigned to a given grade.

Britain and Ireland: science subjects integrated into a single unit

In the group comprised of England, Scotland and the Republic of Ireland duration and organisation of education is somewhat more heterogeneous as is evident from the tables below. The national curriculum (i.e. the curricular document) mostly covers the period from nine (Scotland, Ireland) to eleven years (England), but in Scotland it is organised through grades, in England through educational cycles and grades, and in Ireland lower secondary education (content-wise falling into the domain of secondary education, undergoing thorough reorganisation at the time of analysis) is also a part of compulsory education.

Table 5: Structure of the presentation of the science subject matter in Scotland

Scotland										
Age	5	6	7	8	9	10	11	12	13	14
Subject	Environmental studies: society, science and technology									

The Structure and Balance of the Curriculum, 5–14 National Guidelines, Learning and Teaching Scotland, 2000; INCA - International Review of Curriculum and Assessment Frameworks Internet Archive, http://www.inca.org.uk, March 2005

Table 6: Structure of the presentation of the science subject matter in Ireland

Ireland											
Age	5	6	7	8	9	10	11	12	13	14	15
Subject	Science								JC: Science		

Primary School Curriculum, The Stationery Office, Dublin, 1999; *Junior cycle syllabus*, Department of Education and Science Republic of Ireland, Dublin, http://www.education.ie/, February 2005; INCA - International Review of Curriculum and Assessment Frameworks Internet Archive, http://www.inca.org.uk, March 2005; JC= «junior cycle», lower secondary education

Table 7: Structure of the presentation of the science subject matter in England

England											
Grade	1	2	3	4	5	6	7	8	9	10	11
Educational cycle	1		2				3			4	
Subject	Science									Science (B.P.)	
										Science (A.P.)	

About the National Curriculum for England, Department for Education and Employment, London and Qualification and Curriculum Authority, London, 1999, http://www.nc.uk.net ; *Science, The National Curriculum for England, Key stages 1-4*, DfEE, 1999, www.nc.uk.net**;** INCA - International Review of Curriculum and Assessment Frameworks Internet Archive, http://www.inca.org.uk, May 2005; B.P.= basic programme of study; A.P.= advanced programme of study

All the states in the group caution that their curricular documents are being updated (at the time of the analysis). Scotland proposes an entirely new curriculum for science, and the Irish curriculum for science in the junior cycle was under thorough reconstruction. Nonetheless, compared to the previous group, all the curricula documents are much more detailed about the general aims of science teaching. It is also clear that the level of integration of the content is much higher. Such integration enables a much clearer exposition of cross-curricular topics and their interweaving with the science subject content. A detailed exposition of the content and listing of the standards at different levels of comprehension is left over for separate syllabi documents, which are much more detailed in proscription than is the case in the Nordic countries (though still less than the Croatian case).

The framework curriculum in the countries of this group is more than a sum of theoretical content; it is highly reflective of the values and priorities of schooling. The curriculum contains other theoretical elements of teaching at the level of compulsory education, such as the balance of the overall curricular content, the role of education in society, relationship with parents/guardians, further educational options etc.

The English curricular document in particular contains but a few highly general, though commendable, goals that every educational system of contemporary free societies must satisfy. But it tends to show these few goals implemented as far as possible though the specific educational units and good practice examples. A great stress is placed on a wide spectrum of skills that are required to live in the contemporary society, and that do not belong exclusively to any established school subjects (such as biology, physics or German language). The cross-curricular topics are explicitly presented as a part of every subject, and the conceptual links between topics in different subjects are formidably explicated. Even in the more subject-oriented syllabi documents, more than a shopping list of facts is stipulated. The desired way of acquaintance with the facts from the list is indicated (whether students only have to differentiate between them or to be able to apply some of them in everyday life). Ever educational cycle carries an instruction about the depth and breadth of the survey of the prescribed content.

Finally in determining the educational outcome, instead of the list of facts that the students have to reproduce in order to satisfy the examiners at different stages of the educational process, every area of science carries a description of the instances of the successful demonstration of the appropriation of knowledge and development of understanding of the topics in the given area.

Croatia's neighbours: stress on listings of facts

In these countries, as a rule, the curricular document for compulsory education (at the time of analysis) covered a shorter time span (eight years) and the contents of science are structured in accordance with age, appropriate school grade or both.

Table 8: Structure of the presentation of the science subject matter in Austria

Austria								
Age	6	7	8	9	10	11	12	13
Subject	Social and natural environment				Biology and environmental protection			
								Chemistry
						Physics		

Lehrplan der Volkschule - Bundesministerium fuer Bildung, Wissenschaft und Kultur, Wien, 2001, http://www.bmbwk.gv.at/; *Lehrplan AHS* - Bundesministerium fuer Bildung, Wissenschaft und Kultur, Wien, 2000, http://www.bmbwk.gv.at/; *Hauptschulen HS Lehrplan* - Bundesministerium fuer Bildung, Wissenschaft und Kultur, 2000, 2003, http://www.bmbwk.gv.at/

Table 9: Structure of the presentation of the science subject matter in Hungary

Hungary								
Grade (age)	1(6)	2 (7)	3 (8)	4 (9)	5 (10)	6 (11)	7 (12)	8 (13)
Subject	Environment				Nature		Physics	
							Chemistry	
							Biology	

Framework Curricula for Primary Education, on behalf of Ministry of Education Dinasztia Publishing Company, Budapest, 2000

Table 10: Structure of the presentation of the science subject matter in Slovenia

<table>
<tr><th colspan="10">Slovenia</th></tr>
<tr><td>Grade</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td rowspan="3">Subject</td><td rowspan="3" colspan="3">Exploring the environment</td><td rowspan="3" colspan="2">Natural science and technology</td><td rowspan="3">Natural science</td><td rowspan="3">Natural science</td><td colspan="2">Biology</td></tr>
<tr><td colspan="2">Physics</td></tr>
<tr><td colspan="2">Chemistry</td></tr>
</table>

Velajvni učni načrti, http://www.mszs.si/slo/solstvo/os/ucni_nacrti/os/9letna/ucni_nacrti/skupni_predmeti.asp, February 2005

The curricular documents in this group of countries contain little of the general specifications of the subject aims and justification, over and above the appropriation of knowledge (mostly propositional) from the main academic disciplines of natural sciences. Thus, the stated aims are mostly an interpretation of the longer narratives that talk about the definition of the appropriate academic discipline and summation of the knowledge subsumed under it. The curricular documents are mostly concerned with the subject content and develop it to ever-increasing level of detail through several levels of generality. The document also lists different (minimal) educational outcomes to be achieved at different levels of compulsory education (expressed again as bullet points of theoretical content). Thus, the curricular documents are here, from the perspective of those in the previous groups, mostly subject syllabi with some general narratives added as an introduction. The greatest weakness of such an approach is a lack of logical connection between the list of specific topics that serve as outcomes of different educational stages and the general narrative goals of the science education stipulated in the introduction (other than that some outcomes happen to be verbatim included into those narratives, but others don't). It is, thus, not clear how exactly the list of requested minimal outcomes follows from the goals of science teaching and general aims of compulsory education. This remark applies most notably to Hungary (based on the listed document from 2000, available in English at the time of analysis, for potential clarifications from the updated and more general curriculum framework document cf. Baranović, 2007), and least of all to Austria.

The documents are also highly prescriptive when it comes to implementation of lessons in the classroom, with few options left to schools. The methodological and evaluative rules are set centrally, with few cross-curricular topics and suggestions for their implementation across different subjects. One might say that in these states, compulsory education is viewed through the lens of individual subjects, not the compulsory education as a whole.

There are, however, differences within the group, as well. Thus, in the Austrian case, general aims of education are listed and further differentiated into curricular areas that engulf all the school subjects through which the curriculum is implemented. The curricular areas mark significant segments of the educational process, and provide a foundation for cross-curricular cooperation between individual subjects. There are five such areas in total: Nature and Technology, Language and Communication, Man and Society, Creativity and Craftsmanship, Health and Activity.

Alongside the list of contents of individual subjects, Slovenian documents explicitly mention the links between some of the items in the list and items in other subjects' lists and same subject's lists from grades above and below. Sometimes, it is explicitly demonstrated how specific aims of individual science subjects follow from the general aims of education. There is also a narrative section aiming to justify the teaching of individual science subjects within compulsory education, as well as their importance for everyday life and participation in social processes. Nonetheless, the structure of the document clearly indicates that it is a case of syllabus with additional elements, and not a wholesome curricular document for an area of compulsory education.

Finally in the Hungarian case the lack of wholesome overview of the compulsory education, and logical conjunction of its various segments, is most clearly discernible (again in the 2000 document). It is often the case that same expressions are simply repeated through goals, outcomes and required skills adorned with different level of descriptive detail. Peculiar to Hungary is the listing of minimal knowledge and skills each student has to demonstrate at the end of the school year in order to be permitted to move to the next grade.

Netherlands: extreme freedom of implementation

This is a rare breed of educational system that possesses neither curriculum nor syllabi as centrally prescribed documents. The state only sets the expected educational outcomes at the end of compulsory schooling, and verifies their successful acquisition through national examination. There are two areas of outcomes content that cover the subject matter of science: Environment and Nature Study. However, these need not comply with the science subjects taught in schools (i.e. the schools can teach more content and organise it through whatever structure they think is best).

Additional instructions name science as one of the areas that have to be taught during compulsory education, and suggest the integrated form to achieve that. Such subjects also have to be appropriately connected with everyday life. Other than the outcome-sets close to the scientific disciplines, there are also compulsory cross-curricular outcome-sets, such as Work Ethics, Execution of Plans, Learning Strategies, Self-confidence, Social Behaviour and New Media. These standards are not listed as propositions to be adopted or elaborated on, but as descriptions of types of behaviour that students have to exemplify.

Germany – Nordrhein-Westfalen (NRW): turning around

Table 11: Structure of the presentation of the science subject matter in the German federal republic of Nordrhein-Westfalen

Germany – NRW										
Grade	1	2	3	4	5	6	7	8	9	10
Subject	'Nature and society'				Biology					
					Physics					
					Chemistry					

Richtlinien und Lehrplaene zur Erprobung fuer die Grundschule in Nordrhein-Westfalen –Sachunterricht (valid from 2003.); *Stundentafel für die Grundschule nach der neuen Ausbildungsordnung für die Grundschule (AO GS)* (valid from 01.08.2005.); *Bildungsstandards im Fach Biologie fuer den Mittleren Schulabschluss* (valid from 16.12.2004.); *Stundentafeln fuer die Sekundarstufe I – Hauptschule, Ministerium fuer Schule, Jugend und Kinder des Landes Nordrhein-Westfalen* (valid from 27.05.2005.); *Stundentafeln fuer die Sekundarstufe I –Gimnasium, Ministerium fuer Schule, Jugend und Kinder des Landes Nordrhein-Westfalen* (valid from 27.05.2005.); *Bildungsstandards im Fach Physik fuer den Mittleren Schulabschluss, Kultusministerkonferenz* (valid from 16.12. 2004.); *Bildungsstandards im Fach Chemie fuer den Mittleren Schulabschluss, Kultusministerkonferenz* (valid from 16.12.2004.)

In the sample of countries Germany is specific for implementation of exceptionally transitional curricular documents at the time of analysis. Though such documents primarily list the cognitive educational outcomes, they also contain elements that integrate all compulsory education subjects into a whole. Educational standards are defined at the federal level, and each federal unit then develops them into a state framework curriculum. These documents are also supposed to show how the cross-curricular content is to be implemented across several subjects. In an analogy to the national documents presented above, the NRW curriculum can be seen as a transition between the Dutch and the English styles of curricular organization.

Thus, in primary education (junior part of secondary education) curricular areas are divided according to central tasks or focus points (Aufgabenschwerpunkte), which are then further developed through curricular content or subject matter (Unterrichtsgegenstaende). Curricular areas, 'focus points' and the accompanying content are prescribed as mandatory by the state educational authority. The teachers are expected to present connections and explicate relationships between the curricular areas, 'focus points' and the compulsory content in the classroom practice. They are also expected (according to the analysed documents) to use the timetable allocation arising from such cross-curricular cooperation for *in-situ* learning (i.e. as incentive to cover the topics that arise spontaneously from such interaction).

Lessons for the Croatian educational system

Table 12: Structure of the presentation of the science subject matter in Croatia

Croatia								
Grade	1	2	3	4	5	6	7	8
Subject	'Nature and Society'				Nature study (mostly ecosystems and human health)		Biology	
							Physics	
							Chemistry	

Nastavni plan i program za osnovnu školu, Ministarstvo znanosti, obrazovanja i športa, Zagreb, 2006

Although the educational systems and their curricular documents presented above do not form a uniform block in terms of organization and mode of presentation of curricular content, it is possible to extract some coarse-grained recommendations for the improvement of the Croatian national curriculum (in the field of science) for compulsory education. The stress is placed on singling out the relative inadequacies of the Croatian documents and pointing to their potential for improvement. This is not so because of some negative overall evaluation of the quality of Croatian curricular documents, but because it is assumed that the space available is better used for constructive improvement than praises for exiting achievements.

Roughly, the Croatian equivalent of curricular documents (the subject syllabi and introductory narratives published by the Ministry of Science, Education and Sport in 2006) for compulsory education, which is at the time of analysis equivalent to primary education, consists of several distinct parts. It opens with the general aims and goals of compulsory education, and some special clauses adapting them to special needs education and accompanying definitions (e.g. what additional lessons should provide). This is followed by syllabi for subjects, laid out in progression of school grades. Each subject also contains a short statement of its general worth and aims, followed by the list of topics covered by the subject, the expected outcomes (expressed as tasks for the students) and didactic instructions. The topics are further divided into smaller logical clusters, each with an appropriate set of outcomes (e.g. 'students should be able to name the members of their family').

In the general introduction of the overall document, the importance and role of education for environmental protection and sustainable development are outlined. Following the narrative justification of introduction of such topics to compulsory schooling, and a more detailed description of its content, a recommendation for its cross-curricular implementation is put forth (apparently, in accordance with similar practice elsewhere in the world). Each teacher is asked to find topics within their own subject appropriate for education for sustainable development and to single them out as such in implementation of the syllabus. The text further states that, given the timetable constraints of the Croatian system, there will probably not be enough time to implement these topics in regular teaching practice and recommends that special attention be given to them during field work. It is nowhere in these instructions suggested how teachers of various subjects should try to adapt some of their teaching units to the education for sustainable development, nor are any examples of good practice suggested (including what is on offer through exiting national and international networks for sustainable development education).

In the detailed syllabus presentation of the science subjects some topics are explicitly associated with environmental protection and sustainable development, but there are but a few of them, they are far from interdisciplinary or cross-curricular style (or linked to everyday life) and are of highly cognitive character. As rule they are mainly concerned with isolated topics covering chemical and biological environmental pollution, and warning of the dangers of reduction in bio-diversity. Although it is praiseworthy that students should be warned of the negative effects of pollution, such examples are far from the cross-curricular approach (at least within the group of science subjects) advocated in the introductory narrative. Through insufficient interweaving with the ‘mainstream’ science content this important part of science education is marginalised, if viewed from the perspective of curricula of European countries presented above. It is desirable that an increasing number of science topics are immediately linked to explanations of their environmental effects, and that those are further linked to practical activities (i.e. are not purely cognitive) in the everyday life of the students.

The most prominent inadequacy of the Croatian curriculum relative to those analysed[2] above is the lack of explicit connections between the content of the science subjects, their lack of connection to everyday life and across grades. It is worth noting that the 2006 document (following the HNOS project in Croatia) shows an improvement in this respect relative to the 1999 document it replaces, but that it still maintains the structure of the organization of content within the subjects. The presentation of content exhibits a greater degree of organizational likeness within a single curricular area, but the differences between the areas in organizational structure are still visible at first sight. Examples of correlation of topics between the subjects are suggested, informative illustrations of inter-disciplinary topics are provided, but sporadically and relatively insufficiently. The materials accompanying the legally prescribed syllabus sometimes offer a greater range of such examples, but they are not systematically developed and symmetric between the subjects

2 The aim of this article is to provide an overview of the most striking trends among and specific peculiarities of educational systems and documents analysed. A more detailed and systematic analysis remains unpublished as it would require much more space than articles of this type can provide.

(i.e. one offers a potential link, but the other does not exhibit explicit space for its inclusion). The content presented in this way provides little ground for adaptation to individual needs of the students (which is suggested as desirable in the introductory narrative of the state prescribed document) as its main didactic units are not the logical segments of the content but a whole school grade.

There is a similar lack of logical connections between aims and implemented topics within the subject syllabi. Although definition of the subject and its general aims contain notable values those are not developed further in the topics and required outcomes. The latter are largely academic in style of presentation, oriented on cognitive development of the students and the appropriation of theoretical knowledge. In line with this, the expected outcomes are largely cognitive, the students have to comprehend and appropriate (in a way prescribed by the topic), but not do, seek, be able to perform or understand for themselves. Moreover, in terms of content, the outcomes are largely related to the theoretical aspects of the appropriate scientific disciplines, even when calling for exhibition of skills and application of theoretical knowledge. It is left as an unresolved matter how to evaluate any non-theoretic outcomes.

In the case of skills listed as educational outcomes it is often the case that the requirements for the cognitive appropriation are simply reshaped in action-oriented language (thus, the students are .e.g. expected to make a plasticine model of a molecule etc.). although the general introduction and definition of the subjects state their reliance on the general scientific method, their role in the development of civilization (as well as the historical development of the dominant theoretical world-view of the given subject) and contemporary society, the lesson topics and outcomes bear little or no mention of those. Basically, what is expected of students is to 'understand the importance of the discipline X for the development of civilization', with no instructions as to how to foster such understanding or what to base it on (except maybe materials in the textbooks, separate from the curricular document itself). There are thus too few topics, in relation to the curricular documents presented above, that deal with the history of science and the determination of the importance of the scientific method of the investigation of the living and material environment.

In terms of didactic instructions, there is little or no expectation that students should move from the facts they are presented with to the individually deduced conclusions, and are not encouraged to explore their own attitudes and world-views. Almost no practical activities are expected from the students, and they are not encouraged to show the adoption of values the subjects advocate in their statements of general aims (except in the case of end-of-school-year and elective topics exploring the possible effects of technology on the environment). Finally, excluding the case of junior grades Nature and Society and some topics in Biology specifically suggested for the rural schools, there are a few links between the prescribed subject content and the everyday life of the students.

Table 13: Prescribed timetable allocation of science and optional subjects

Number of lessons per week (minimum lessons per academic year)	Grade	1	2	3	4	5	6	**7**	**8**
Subject	Nature and Society	2 (70)	2 (70)	2 (70)	3 (105)				
	Nature					1,5 (52,5)	2 (70)		
	Biology							2 (70)	2 (70)
	Physics							2 (70)	2 (70)
	Chemistry							2 (70)	2 (70)
	Optional subject					2 (70)	2 (70)	2 (70)	2 (70)
	Extra allocated lessons	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)
	Extra-curricular activities	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)	1 (35)

Nastavni plan i program za osnovnu školu, Zagreb, 2006

The timetable allocation for science is somewhat lower than is the case in most European countries, with optional increase through elective subjects and extra-curricular activities. In a situation where a student chooses to maximise his/her science timetable (and given that this were possible to implement in a given school) he/she could increase science allocation by almost 150% relative to single science subject listed above, or by 50% for the science subjects overall. In such case the student's overall timetable commitments would rise by 12%, raising his/her science timetable to 31% of the overall timetable allocation, and thus bring it in line with a greater number of countries from the sample.

The results of the comparative analysis sketched above were presented in detail at the conference of various national educational stakeholders, on 1st December 2006 in Zagreb. A special section dedicated to science agreed on a set of recommendations for improvement of science teaching in Croatian compulsory education (cf. Štibrić, 2006 for the overall report). Although most participants rejected the idea of greater integration of science content in compulsory education, as is the case in grades 1-4 of the Croatian system and most European systems, they agree that, starting from a list of science competences, all subjects should work on the construction of a "coordinated" (instead of integrated) framework curriculum and secure strong conceptual links between content-units of different subjects.

Changing the organization and selection of science curricular content to maintain youths' interest in exploration of the material environment

In the light of increasing societal need for good science education, and a decreasing interest among students for appropriation of science content and further education in science, the role of organisation and presentation of science content cannot be neglected. The European Commission even suggests a common competence framework (European Commission, 2005) and provides recommendations for improvement of scientific education in Europe (European Commission, 2007). The later uses the language of impeding crisis to warn of the necessity top put pressure on the governments and local authorities because "Europe's future is at stake" (EC, 2007, p. 3). Novel methodologies for teaching science are also sought, especially through exploratory learning and networking of teachers for further education. Of exceptional importance is the lack of systematic methodological guidelines for future teachers as to how to cope with the students' pre-scientific conceptualisations (which are hardly dissected along the lines of traditional academic disciplines, which most teacher education in science adheres to). These conceptualisations ought to be respected and gradually replaced, so as to foster rather than discourage the initial motivation to explore the environment (Eurydice, 2006).

It is precisely in connecting the subject content to everyday life and in raising awareness of the methodical approach to exploration of the environment through natural science that the original pre-scientific conceptualisations can be modified without detrimental effects on the motivation. Finally, and this can be of special interest in Croatia, the aforementioned documents warn about careful construction of standardised evaluation in education, so as to respect the initial conceptual and methodological breadth of science and environment education, and avoid the reduction of teaching to preparation to predominantly cognitive tests. Curricualr documents can in this respect 'instruct' teachers about the values of trans-disciplinary organization of topics towards shaping of exploratory interests among students (over and above the strict application of the content units of individual science subjects). The latter can, among other ways, be achieved through conceptual presentation of the content as the product of unique exploration of the environment in line with the objective methodological procedures. In such context it is also easier to teach cross-curricular topics such as education for sustainable development and the civilizatory role of natural science and technology.

CURRICULAR DOCUMENTS, SYLLABI AND RELATED SOURCES

Several countries:

INCA - International Review of Curriculum and Assessment Frameworks Internet Archive, http://www.inca.org.uk

Sweden:

Curriculum for the Compulsory School, the Pre-School Class and the Leisure-Time Centre (Lpo 94), Ministry of Education and Science in Sweden and National Agency for Education, 2001

Compulsory school Syllabuses, National Agency for Education, 2001

Finland:

National Core Curriculum for Basic Education 2004, Finnish National Board Of Education, Helsinki, 2004

Norway:

Attainment Targets for Compulsory Education, http://www.minocw.nl/english/education/doc/Kerndoelen_basisonderwijs_Engels.doc February, 2005.

Scotland:

The Structure and Balance of the Curriculum, 5–14 National Guidelines, Learning and Teaching Scotland, 2000

Ireland:

*Primary School Curriculum***,** The Stationery Office, Dublin, 1999

*Junior cycle syllabus***,** Department of Education and Science Republic of Ireland, Dublin, http://www.education.ie/, February 2005.

England:

About the National Curriculum for England, 1999, Department for Education and Employment, London and Qualification and Curriculum Authority, London, http://www.nc.uk.net

Science, The National Curriculum for England, Key stages 1-4, DfEE, 1999, www.nc.uk.net

Austria:

Lehrplan der Volkschule **-** Bundesministerium fuer Bildung, Wissenschaft und Kultur, Wien, 2001, http://www.bmbwk.gv.at/

Lehrplan AHS **-** Bundesministerium fuer Bildung, Wissenschaft und Kultur, Wien, 2000, http://www.bmbwk.gv.at/

Hauptschulen HS Lehrplan **-** Bundesministerium fuer Bildung, Wissenschaft und Kultur, 2000, 2003, http://www.bmbwk.gv.at/

Hungary:

Framework Curricula for Primary Education, on behalf of Ministry of Education Dinasztia Publishing Company, Budapest, 2000

Slovenia:

Velajvni učni načrti, http://www.mszs.si/slo/solstvo/os/ucni_nacrti/os/9letna/ucni_nacrti/skupni_predmeti.asp, February, 2005.

Netherlands:

Attainment Targets for Compulsory Education; February, 2005. http://www.minocw.nl/english/education/doc/Kerndoelen_basisonderwijs_Engels.doc

Germany – NRW:

Richtlinien und Lehrplaene zur Erprobung fuer die Grundschule in Nordrhein-Westfalen –Sachunterricht (mandatory from 2003.)

Stundentafel für die Grundschule nach der neuen Ausbildungsordnung für die Grundschule (AO GS) (mandatory from 01.08.2005.)

Bildungsstandards im Fach Biologie fuer den Mittleren Schulabschluss (mandatory from 16.12.2004.)

Stundentafeln fuer die Sekundarstufe I – Hauptschule, Ministerium fuer Schule, Jugend und Kinder des Landes Nordrhein-Westfalen (mandatory from 27.05.2005.)

Stundentafeln fuer die Sekundarstufe I –Gimnasium, Ministerium fuer Schule, Jugend und Kinder des Landes Nordrhein-Westfalen (mandatory from 27.05.2005.)

Bildungsstandards im Fach Physik fuer den Mittleren Schulabschluss, Kultusministerkonferenz (mandatory from 16.12. 2004.)

Bildungsstandards im Fach Chemie fuer den Mittleren Schulabschluss, Kultusministerkonferenz (mandatory from 16.12.2004.)

REFERENCES:

Baranović, B. (2006): "Nastavni programi iz perspektive nastavnika i učitelja". Baranović B. (ed.). *Nacionalni kurikulum za obvezno obrazovanje u Hrvatskoj: različite perspketive.* Zagreb: Institut za društvena istraživanja, str. 107-180.

Baranović, B. (2007): "Europska iskustva i nacionalni kurikulum za obvezno obrazovanje u Hrvatskoj (Uvodni tekst u diskusiju o rezultatima istraživanja)", *Metodika*, this issue

Council of the European Union (2001): *Report from Education Council to the European Council on the Concrete Future Objectives of Education and Training Systems*. Brussels

European Commission (2005): *Proposal for a Recommendation of the European Parliament and of the Council on Key Competences for Lifelong Learning*. Brussels

European Commission (2007): EUR22845 - *Science Education NOW: A renewed Pedagogy for the Future of Europe*. Luxembourg: Office for Official Publications of the European Communities

Eurydice (2006) *Science Teaching in Schools in Europe: Policies and Research.* Brussels: Eurydice

Klepo, M. (2007) «Hrvatska prva u Europi po odljevu mozgova», Jutarnji list, 24. listopada

Lenardić, M., Radošević, S., Jurlin, K. (2005): Godišnje izvješće o konkurentnosti Hrvatske 2004., Zagreb: Nacionalno vijeće za konkurentnost

Marušić, I. (2006): "Nastavni programi iz perspective učenika". U Baranović B. (ur.). *Nacionalni kurikulum za obvezno obrazovanje u Hrvatskoj: različite perspketive.* Zagreb: Institut za društvena istraživanja, str. 181-218.

Ponoš, T. (2007): «Hrvatska će uvoziti arhitekte i liječnike», Novi list, 20. rujna

Štibrić, M. (2006): "Znanstveni skup "Europska iskustva i nacionalni kurikulum za obvezno obrazovanje u Hrvatskoj"", *Metodika* 7(2), str. 367-379.