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STUDY REPORT

Core Curriculum for Science Subjects in Selected Countries

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Summary

The aim of the study was to compare the meaning of scientific reasoning skills and use of the scientific methods across curricula of selected European countries. This objective was achieved by comparing the Polish science core curriculum at the low secondary school and the first class of higher secondary school with corresponding documents of the five selected European countries – England, Czech Republic, Estonia, Finland and France. Countries were selected for comparison guided by the results of the PISA survey in parts of Science in 2006 and economic status measured by the height of GDP. Similarities and differences have been identified in the structure and content of these documents, with special attention paid to valuable solutions, presented in curricula of studied countries. Those solutions promote the acquisition of skills in using the scientific method, which could be applied in the Polish National Core Curriculum.

1. Introduction

1.1. Definitions of basic concepts used in the Report

1.1.1. Core curriculum and curriculum

Definitions and understanding of the concept of core curriculum are provided in various countries, not only European. One scope of that concept may be understood in various ways and may diverge from the definition of the concept of 'core curriculum' as defined in the Polish education system. Therefore, problems with definitions should be discussed in the first place. This will also help to specify the scope of this study.

In the Anglo-Saxon tradition of curricula studies, curriculum may be understood as both the goals and the content of teaching defined at the national level, common for all schools, as well as a curriculum applied in a specific school. Here, it is useful to differentiate between an enacted and an implemented curriculum. Also a hidden curriculum can be studied, which is implemented in schools in a more or less conscious way.

Similarly, the content scope of curricula or core curricula can be understood in diverse ways. Usually, they are responsible for three basic questions: why teach?, what to teach?, how to teach? For instance, Stanisław Dylak (2000) defines curriculum as "a record of measured educational events, covering assumed learning outcomes, students' actions referred to a specific study material and the conditions necessary for effective and efficient learning." Thus, curriculum definitions include not only educational goals and learning content, but also teaching principles and methods, as well as assessment methods (see Kruszewski, 1995:180–211, see also Komorowska, 2012). Core curricula may differ in terms of coverage of those elements. The Polish Core Curriculum is limited to educational aims and learning content and formulates only general recommendations concerning the conditions and ways of teaching. It is related to the distinction, existing in the Polish Educational Law since 1999, between the core curriculum (determining the aims and requirements) and the curriculum (determining, above all, the ways of implementing them). In some foreign school systems, the border between the core curriculum and the curriculum may be obliterated due to lack of clear distinction between those concepts in the valid educational law.

Core curricula and curricula may also differ in terms of level of detail. Bernstein (Bernstein, 1990) introduced a differentiation between two dimensions of that differentiation, the first of which concerns the degree to which a curriculum distinguishes specific areas of knowledge or strives at integration of skills (weakly classified), while the other concerns the degree to which a curriculum provides freedom in selecting content and teaching methods (weakly framed).

1.1.2. Educational Standards

Other issues to be noted are similarities and differences between the concepts of curriculum and core curriculum, and the concept of educational standards. Educational standards shall be understood as

a description of students' knowledge and skills, constituting the basis for assessment of skills, usually after the end of studying at a given year or a given stage of education. Educational standards constitute the basis for constructing diagnostic tools, or constitute criteria for assessing student progress.

1.2. Key skills in science subjects and learning outcomes

The Polish Core Curriculum, described in *Regulation of the Minister of National Education on core curriculum for pre-school and general education in specific types of schools of 23 December 2008, amended on 27 August 2012*[1] (Journal of Laws of 30 August 2012, item 977) hereinafter referred to as the core curriculum, described in a language of requirements, identifies in detail the key skills, which should be mastered by a student at a given stage of education. In science subjects, scientific reasoning, comprising, among others, recognition and formulation of research problems, posing and verifying hypotheses, analysis and reasoning, is the key skill. The way to shape and develop the scientific reasoning skills is the direct participation of students in learning about the mechanisms, phenomena and natural processes, by, among others, observation and experiment. The 2012 Core Curriculum places a lot of emphasis on formation of those competences, identifying precisely the issues related to research methodology and a list of observations and experiments recommended for implementation. In particular, this applies to science education in lower secondary school and the first grade of upper secondary school, which is its curriculum continuation. This is consistent with the postulates of the European Commission, which indicates that the most important goal at this stage is making the student interested in sciences, as well as formation and development of the scientific reasoning skills and using the scientific method (Poziomek, 2012).

Provisions concerning scientific reasoning and the use of the scientific method have been introduced into the core curriculum as a result – among other things – of analysis of data obtained by the Ministry of National Education from a survey carried out in Poland within the Programme for International Student Assessment, PISA. The survey more deeply diagnosed the reasoning skills in sciences (when solving scientific problems) of students completing lower secondary school. In the survey, it was determined that Polish students who finish lower secondary school cope better with reconstructing information on sciences than with scientific reasoning, specific for those sciences, as well as with problem-solving with the use of complex skills. This concerned, among others, interpretation of and acting on scientific results and evidence, covering the process of reaching scientific information, drawing conclusions on the basis of available data or recognition of issues, which can be scientifically examined (Instytut Filozofii i Socjologii Polskiej Akademii Nauk, 2007).

The 2006 PISA study diagnosed the level of competence of lower secondary school students who implemented the core curriculum of 2002[2], and its results – as noted above – became the guideline for curriculum changes in the Polish educational system, as well as in teaching sciences.

Obviously, learning outcomes – the diagnosed level of students' competency – do not depend on the structure and content of the core curriculum only. For they are a derivative of curriculum documents (including the core curriculum) and the broadly understood school practice, which comprises both strategies, forms and methods applied by teachers to implement the content and achieve the educational aims resulting from the provisions of that document (the intended and implemented curriculum). The

1 Currently in force.

2 Regulation of the Minister of National Education and Sport of 26 February 2002 on core curriculum for pre-school and general education in specific types of schools, Appendix no. 2, http://bip.men.gov.pl/men_bip/akty_pr_1997-2006/rozp_155.php (access on 18.11.2013).

significant role of curricula and textbook cannot be overlooked. Pursuant to Regulation of the MNE[3], a curriculum should be consistent with the goals and content of learning described in the subject core curriculum and meet many other criteria defined in the Regulation. However, it is not subject to verification at the ministerial level – it is permitted for use by the school principal. It is otherwise with textbooks, which are subject to verification by the MNE experts and are approved by the Ministry for school use. Studies revealed that the content contained in them, verified by the Ministry, enjoy teachers' trust and have a significant influence on implementation of the core curriculum by the way of conducting lessons by them (Grajkowski, 2013).

However, it should be noted that frequent uncritical use of textbooks by Polish teachers may widen the existing gap between the intended curriculum and the implemented curriculum. For textbooks often replace the core curriculum. Teachers too often fail to use the right to autonomously shape the curriculum, adopting ready-made solutions proposed by publishing companies. The time provided for in the core curriculum for meeting specific students' and class's needs remains, in practice, occupied by solutions proposed by the selected textbook's author. Such a situation may reinforce the enacted-implemented tension, underlying the inadequacy of the implemented curriculum to the needs of specific classes.

Learning outcomes also depend on the conditions, in which the teaching process takes place, i.e. the equipment of subject rooms, the number of classes, the level of safety in the school. Neither can it be overlooked that school principals not infrequently use the right of unequal distribution of hours for implementation of science subjects, which result from introduction into the science part of the core curriculum[4] and from Regulation of the MNE on framework curricula, and which would facilitate conducting scientific experiments in the school and in the field, developing the ability to use the scientific method.

Another important factor is the students' home environment – supporting and motivating the child to make an intellectual effort contributes to achieving learning outcomes, development of students' subject competences (Konarzewski, 2012).

In the presented study, it was assumed that there exists a connection between the core curriculum, its structure and content and the learning outcomes by virtue of the fact that core curriculum is a document binding in each school (public or non-public with the authorisation of a public school), and the teacher is obliged to implement all general and detailed requirements laid down therein.

In the context of science subjects, the emphasis placed in the core curriculum on the recommendation to create and develop students' ability to reason scientifically and use the scientific method merits special attention, and, therefore, that element became the focal point of the study concept.

It was also assumed that becoming familiar with the core curricula binding in those European countries which obtained high scores in the PISA survey in terms of *the ability to recognise scientific issues and interpret scientific results and evidence,* i.e. England, the Czech Republic, Estonia, Finland and France, as well as comparison of those documents with the core curriculum binding in Poland, may constitute one of the ways of finding efficient solutions enhancing the quality of science education in Poland, and improvement of teaching efficiency in that scope.

3 Regulation of the MNE on approval of pre-school curricula and curricula for use in the school and approval of school use of textbooks of 21 June 2012.

4 Prof. Z. Marciniak: *The most important change in the framework curriculum is lack of determination of the numbers of hours per week in the educational cycle dedicated to specific obligatory classes. (...) Possible unequal distribution of hours of nature, biology, geography, physics or chemistry may serve, for instance, to carry out scientific outdoor observations.*

2. Study objective

The aim of the analysis was to examine whether the issue of formation and development of the skills of scientific reasoning and using the scientific method plays a similar role and is assigned just as high importance in the Polish Core Curriculum at a specific educational stage binding in 2010 in Poland and in the European countries selected for the study.

The goal was implemented by comparison of the Polish Core Curriculum for Science Subjects (in the part binding for lower secondary school and the first grade of upper secondary school) with the corresponding documents at the same or a similar educational stage binding in the five European countries. The comparison yielded twenty partial reports available as source documents (background papers) in the archive of the Educational Research Institute.

They compare the structure and content, as well as the location of the provisions concerning the skills of scientific reasoning and using the scientific method in the area of specific science subjects – biology, chemistry, physics and geography.

Similarities and differences between the documents were described with special attention paid to provisions which might be an inspiration to supplement the Polish Core Curriculum with new solutions contributing to the formation and development of the skills of scientific reasoning anduse of the scientific method.

2.1. Study questions

Comparison of core curricula for science subjects was supposed to clarify whether and how core curricula from selected countries refer to the formation and development of the skills of scientific reasoning and the use of the scientific method.

At the same time, it was noted whether and in what form the analysed documents, especially in the part dedicated to scientific reasoning and the scientific method, concern and refer to the school practice.

Obtaining an answer to the above questions required a thorough analysis of the structure and content of the documents, identification of the similarities and differences, especially with reference to the provisions binding in Poland.[5]

5 A template for comparative analysis containing a detailed list of questions is included in the Schedule 21A.

3. Study of core curricula in the scope of science subjects

Analytic studies, undertaken in order to compare core curricula for science subjects binding in European countries (and not only) are scarce. There is, however, a relatively rich database of articles dedicated to implementation of the core curriculum in school practice and adjustment of the methods and strategies to implementation of provisions written in that core curriculum.

In the English education system, each significant curriculum change, concerning the core curriculum, is preceded with a discussion based on results of educational studies, including comparative studies of the structure and content of core curriculum from England and other countries, leading in student competency diagnoses. The British Department for Education publishes study reports, so that everyone participating in the discussion could become familiar with them. In 2008, a report was published, prepared by the National Foundation for Educational Research entitle *Comparison of the Core Primary Curriculum in England to those of Other High Performing Countries*. In 2011, the Education Department published a report entitled *Review of the National Curriculum of England. What can we learn from the English, mathematics and science of high-performing jurisdictions*?

The results of studies published in both reports contributed to the direction of changes in the core curriculum (the national curriculum) in 2013. In the first of the above mentioned reports the structure and content of the English National Curriculum for science, the native language and mathematics in compulsory education were compared with the analogous core curriculum from five geographic areas characterised by a dynamic economic and educational growth, including some that continue the tradition of the British education system remaining from the colonial days, that is Taiwan (now the People's Republic of China), Hong Kong (now the People's Republic of China), Singapore and Ontario, Canada, and Latvia. The comparison incorporated elements such as: teaching content (e.g. elements of scientific enquiry, including carrying out experiments and observations, life processes and living things, substances and their properties, physical phenomena), the scope of the content (the area of issues recommended for implementation), the substantive level and difficulty level, degree of adjustment of the curriculum to the students' capabilities (adjustment to students with special educational needs), the cross-curricular nature of teaching science subjects. The comparison also concerned the main goal of teaching science subjects and the way of formulating it, as well as the most important elements of the education system (school starting age, duration of compulsory education, etc.).

The comparison revealed that the scientific enquiry is present in all examined documents, in three of them – just like in the English National Curriculum – it constitutes a base element. A high level of convergence in the teaching content and the scope of content in the section *Live processes and living things* was noted. As regards the substantive level and the difficulty level the documents – with the exception of the core curriculum from Hong Kong, which stood out for narrowing the aims and content – had a similar difficulty level to the English one. As regards the English core curriculum, it was distinguished by a broader coverage of the issue of scientific enquiry and related procedures than the other documents (Ruddock and Sainsbury, 2008).

The 2011 report analysed core curricula in the area of mathematics, English, and science subjects in the countries, which obtained better scores at the international surveys PISA, PIRLS[6] ad TIMSS[7] than the United Kingdom. For each of the examined areas of education, five countries and regions with tradition (related to educational system) common with the United Kingdom were selected for comparison. For science subjects, they included: the Province of Victoria in Australia, the Province of Alberta in Canada, Hong Kong in the People's Republic of China, Singapore and the State of Massachusetts in the United States of America. The main research problem in the comparative analysis in the area of science subjects was to identify what role in teaching three subjects – biology, chemistry and physics is given to scientific enquiry, including experiment and observation and whether they are taught separately or in an integrated way. In addition, the level of requirements imposed by the core curriculum was compared. The most important finding was the lack of significant differences in terms of approach to learning science subjects, as well as in terms of the teaching content in key areas of biology, chemistry and physics.

It also turned out that in most of the studied countries the science subjects are implemented jointly, not as separate subjects, although the way of writing the content makes it easy to locate issues concerning biology, chemistry and physics. Earth geography (the equivalent of Polish physical geography) is present in all core curricula, but it is implemented as a separate subject only in Alberta.

All analysed documents underlined the importance of motivating students, raising curiosity in nature, arousing their interest in science subjects, especially at the primary school level. Another common element for all the examined documents is the socio-constructive approach. It is manifested, among others, in emphasising a central position and high weight of scientific procedures – observation, experiment, enquiry, testing, measurements, that is all that enables construction of the edifice of knowledge (scaffolding) used to solve problems not only in science, but also in private and social life. Singapore's core curriculum states directly that, in the rapidly evolving world of technology, it is not possible to learn about and understand all facts on a given topic, thus it is important to equip the teenager with research skills, develop and enhance in him or her the scientific attitude which will be useful for him or her in the situation, where he needs to obtain and process information.

To summarise the conclusions included in the English report, one may formulate three overarching goals, entered into the core curricula and adopted for implementation in science education in comparable countries and regions

- deepening scientific knowledge by interconnections between biology, chemistry and physics – cross-curricular teaching,
- learning about process and phenomena through practical actions – observation, experiments and measurements,
- deepening reasoning and improving ability to use the research method, including perceiving and understanding the relations between empirical evidence and scientific theories, not only in the area of science, but also in everyday life of a responsible citizen.

It should be mentioned that most of the documents described in the above mentioned English report emphasise that science subjects should be taught in the context of history of science and current social problems.

6 PIRLS – Progress in International Reading Literacy Study, implemented by the International Association for the Evaluation of Education (IEA).

7 TIMSS – Trends In International Mathematics and Science Study, implemented by the International Association for the Evaluation of Education (IEA).

In recent years, projects aimed at analysis of the structure and content of science core curriculum in selected countries of the European Union have also been implemented. The main reason for undertaking studies is looking for a way to increase interest in science subjects among young Europeans, and thus contribute to faster growth of the scientific and technical potential of European countries and maintain the competitive position of European countries against quickly developing Asian or American economic powers.

In the report *Science Education In Europe: Critical Reflections, A Report to the Nuffield Foundation* (Osborne and Dillon, 2008), to which a group of Polish scholars from the Nicolaus Copernicus University in Toruń contributed, contained a chapter on core curricula binding in European countries. The document discussed the Polish core curriculum of 2002.

The document presents general characteristics of core curricula in the part concerning science subjects, binding in selected European countries, paying attention to shortcomings which may and should be improved. The shortcomings – according to the authors of the report – include especially too low emphasis placed on getting students interested in studying science, as well as using mainly teaching methods based on presentation, with limited use of methods activating students (Osborne and Dillon, 2006).

The authors also point out high differentiation of the analysed core curricula in terms of structure, content, recommended ways of implementation and assessment. It was determined that most of the documents recommend a spiral form of delivery of the content – at the initial educational stage, the basic information is introduced and developed gradually later on at the next stages. It was also noted that most European core curricula put more emphasis on teaching content than formation and development of skills and that the teaching content is out of context, including reality of everyday life, which might affect the extent of students' interest in that field of knowledge. The educational aims are often formulated in a way little understandable for the reader, and the system of assessment places emphasis on memorising information and recalling it, not the ability to use scientific knowledge and apply it in everyday life (in understanding and proper assessment of reliability of commercials or press information, at the least) (Osborne and Dillon, 2006).

Another document, which contains – among other things – information concerning the structure and content of core curricula for science subjects binding in European countries is the report *Science Education in Europe. Policies, Practices and Research*, developed by the Eurydice Office within the activities of the European Commission, with the participation of national experts from 32 Member States, published by the Education, Audiovisual and Culture Executive Agency in 2012 (Eurydice, 2012). The study was implemented in 2011 and covered both Polish core curricula binding in 2011 – of 2002 and 2008 – in the scope of science subjects. The report concerned stages ISCED 1 (primary school) and ISCED 2 (lower secondary school), in some areas also ISCED 3 (Polish upper secondary school). A chapter dedicated to core curricula, *Curriculum Organisation and Content*, presented, among others:

- the way of teaching science subjects in terms of degree of interdisciplinary integration, at two education levels,
- the thematic context, in which science subjects are implemented, including: science (meaning natural sciences) and the environment, science and technology in everyday life, science and the human body, science and ethical problems, science and cultural context, the history of science, the philosophy of science.

- recommended student activities, related to the applied working methods, including carrying out scientific observations, recognising issues which might be examined with the scientific method, planning experiments or studies, evaluation of actions, presenting results of experiments, describing and interpreting natural phenomena, describing problems in the scientific terminology, and others.

- status of science subjects at level ISCED 3 recommended by the core curriculum or other documents of the education law (Eurydice, 2011).

The aim of the Eurydice report is to make reliable information on science education in European countries available to stakeholders. Therefore, the document presents, first of all, data concerning the structure and content of core curricula, with a limited comparative analysis. As planned, the document does not contain any assessment of usefulness of specific provisions in obtaining high quality science education and high efficiency. Nevertheless, the selection of elements for comparative analysis testifies to the fact that the authors of the report are aware of the importance of scientific enquiry in teaching science subjects.

Another European project – SECURE, that is *Science Education Curriculum Research*[8], concerning, among others, analysis of core curricula for maths, science and technology, binding in 10 European countries (Austria, Belgium, Cyprus, Germany, Italy, Poland, Slovenia, Sweden, the Netherlands, the United Kingdom) was implemented in the years 2011-2013 with the participation, on the Polish part, of the Physics, Astronomy and Applied Information Technology Department of the Jagiellonian University in Cracow. The aim of the study project SECURE was to collect and analyse relevant data concerning teaching maths, science and technology (MST) and transform them into recommendations, which will make a significant contribution to the discussion and making decisions in the future on core curricula for those subjects in Europe. Within that project, core curricula were analysed and compared, among others, in the part concerning science subjects, binding at level ISCED 1 (primary school) and ISCED 2 (lower secondary school), as well as questionnaire surveys and interviews with teachers and students at the same education stages were carried out. The project used a study tool called Curriculum Spider Web (Van den Akker, 2003) and specialist software to analyse the results. The comparison incorporated also such elements existing in core curricula as vision, mission, learning objectives, teaching content, teaching methods, teacher role, recommended teaching materials, way of delivering subjects (cross-curricular or separate), time of implementation and assessment method. A valuable element of the SECURE project is combination of analysis of documents with analysis of the opinions of teachers and students on ways of conducting classes.

The common objective of the studies presented above is, first of all, comparison or presentation of differences in the structure and whole content of core curriculum documents.

The study of the Science Section of the Education Research Institute (IBE), *Core Curricula for sciences in selected countries*, focusing on the aspect key for science education – scientific reasoning and using the scientific method, assumed deepened reflection. Its results may constitute valuable supplementation of the information obtained by international research teams.

The specificity of our study consisted in analysis of documents with a clearly defined objective, described in the study questions. The study was aimed at establishing what importance is attributed in the core curriculum of a given country to formation and development of the skills related to scientific reasoning and using the scientific method.

8 Secure-project.eu/poland.

The remaining elements subject to comparison were important mainly in the context of the study objective presented at the beginning of this report.

The study project of the Science Section of the Educational Research Institute, *Core Curricula for Science in Selected Countries* assumed thus interpretation and assessment of elements of the structure and content of educational law documents in the context of the main objective of the study.

To fully diagnose the importance of formation and development of the skills of scientific reasoning and using the scientific method in teaching and learning science subjects in selected countries, three study visits were additionally carried out – to England, Finland and France. The completed study visits provided rich material concerning the methods and forms of work used at classes, and above all the pedagogical approach to the student and the delivered curriculum.

4. Methods used in the study

4.1. Object of comparison

4.1.1. Selection of countries for comparison of core curricula

The analyses concerned documents binding in five European Union Member States: the Czech Republic, Estonia, Finland, France and England[9]. The choice of these countries was guided by:

students' skill level. The selection criterion was constituted by the students' results in Science at the international PISA survey in 2006. The selected countries with high average results and average results similar to the Polish ones.

economic status, described by the GDP index, calculated per capita[10]), the geopolitical location and the related history of the development of the education system. The selected countries were similar to and different from Poland in some aspects.

Table 1. Characteristics of the countries selected for comparison of core curricula for science subjects with the Polish core curriculum.

No.	Country	Result in the science part of PISA 2006 survey [points]	GDP/capita in 2010 [PPS[1]]	Geopolitical location
1.	Czech Republic	513	80	Liberated from the Soviet sphere of influence, obtained statehood in 1993, undergoing intense economic growth
2.	Estonia	531	63	A post-socialist country, former republic of the CCCR, regained independence in 1991, undergoing intense economic growth
3.	Finland	563	114	A state in the Soviet sphere of influence and the first to have been freed from it, oriented on development of the education system and growth of the education level of citizens
4.	France	495[2]	109	Western European country with a high level of wealth
5.	United Kingdom[3]	515	112	Western European country with a high level of wealth
6.	Poland	495	63	A post-socialist country, undergoing intense economic growth

9 It should be stressed that this does not concern the whole state (the United Kingdom of Great Britain and Northern Ireland), but only England.

10 URL: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tec00114 (access on 18.11.2013).

4.1.2. Selection of educational stage

The focus of the study was on level ISCED2, that is the Polish lower secondary school. It resulted, among others – from the age of students diagnosed in the PISA survey. The study sample in this study are fifteen-year-olds, that is students in the third grade of lower secondary school. Moreover, the important position of the lower secondary school in Poland, resulting from the fact that implementation of the new core curriculum started in September 2009, the year precisely at the level of the first grade of lower secondary school, was taken into account.

In the case of Poland, the comparison incorporated a part of the core curriculum for science subjects (biology, chemistry, physics, geography), valid at the stage of lower secondary school (3 years) and in the first grade of upper secondary school (4th educational stage, basic scope of teaching a science subject, 1 year). The age of the students implementing this part of the core curriculum for science subjects is 13-17 years. Pursuant to the assumptions of the curriculum reform of 2008 (repeated in 2012) the four years of studying jointly form a full learning cycle. At the same time, this is the last stage, at which teaching science is common and obligatory, thus this period is particularly important for development of scientific knowledge of young citizens.

The selection of analogous educational stages in the chosen countries was not always simple, as the education systems of the countries have different structures, and thus the division into primary, lower secondary and upper secondary schools does not overlap [Eurydice, 2011]. In the case of **England**, compulsory education is divided into four key stages – stages three and four were adopted for analysis, which correspond to students' aged 12-16. In the **Czech Republic**, studying at the secondary school (*gymnazium*) may last, depending on the adopted educational path, 4, 6 or 8 years, whereas a division into the 'higher' and 'lower' stage of the multiannual *gymnazium*. In terms of student age, each of the stages overlaps only partially with the Polish lower secondary school and the first grade of the upper secondary school, so the decision to compare the higher stage of the multiannual *gymnazium* (students aged 15-19), was made largely arbitrarily. For **Estonia** and **Finland**, the last three years of the nine-year common school, which corresponds to student age of 13-16 years. In **France**, the lower secondary school (*collège*) was taken into account, which is attended by students at the age of 11-15 years.

4.1.3. Selection of school subjects

There were compared the parts of core curricula which corresponded to the four science subjects taught in Poland: biology, chemistry, physics and geography. In some of the studied countries, other science subjects are taught that those in Poland, so it was unequivocally determined, which subject or subjects were to be incorporated into the comparison:

Table 2. Description of science subjects taught in the studied countries.

No.	country	subjects	comments
1	England[4]	Science, geography	Science may be delivered in an interdisciplinary way or in division into biology, chemistry and physics.
2	Czech Republic	Biology, chemistry, physics, geography, health education (*Výchova ke zdraví*)	Subject *Výchova ke zdraví* covers issues related to human health, some of which are delivered in Poland within biology.
3	Estonia	Biology, chemistry, physics, geography	the curricula of the so-called leading topics of cross-curricular nature were taken into account – biological, geographical, chemical and technological properties of objects and processes occurring in the environment and their connections and interactions are discussed at lessons of specific subjects.
4	Finland	Biology, chemistry, physics, geography	delivered separately, just like in Poland
5	France	Subject block "physics-chemistry" (*physique-chimie*) and the subject "life and Earth science" (*sciences de la vie et de la Terre*), which covers biology and physical geography	The analysis did not include issues from human geography, which in France forms a part of the subject block called "history-geography-civic education" (*histoire-geographie-education civique*) and is not treated as a science subject.

4.2. Obtaining source documents

Core curricula binding in the countries selected for the study were collected in the electronic form from the official websites of institutions responsible for drafting them or were received from employees of an embassy or consulate. The fragments of core curricula to be analysed were translated into Polish from the native languages, with the exception of the Finnish core curriculum which was translated from the English version, available on the websites of the Finnish Ministry of Education. At the same time, information was gathered on the status of the document of core curriculum in the examined countries by means of desk research (online resources, Eurydice, 2012/13) and interviews with employees of educational institutions during study visits (England, Finland, France).

4.3. Preparation of the tool for comparative analysis

A tool called *Template for developing comparisons of core curricula* (*Wzorzec opracowania porównania podstaw programowych*) (Appendix no. 21), was prepared for the analysis and was used to compare the respective parts of each of core curricula binding in the countries selected for the study with the Polish core curriculum and covered the following comparative elements:

- place of the core curriculum in the education system,
- structure of the document,
- way of including learning (educational) objectives,

- scope of content,
- description of skills and formation of attitudes,
- role of science subjects in development of social competence – civic attitudes,
- profile of the student completing the educational stages selected for the study.

The Template determined – besides the main paths of comparison – the framework organisation of the specific parts of the report, in particular contained the template of the table forming a formalised comparison of the Polish and a foreign core curriculum in terms of thirteen specific characteristics. The specificity of subjects, the significant formal and content-related differences between the analysed documents, made the partial reports, which were developed on the basis of the analysis of the obtained data, differ in terms of size style and degree of detail in treatment of some issues.

4.4. Experts performing the comparative analyses and partial reports

The analysis was performed by four external experts using the *Template for development*. The experts had been selected by way of an open competition. Their short biographical notes form Appendix no. 23 hereto. Each of the experts worked independently of the others on the analysis of respective fragments of the documents referring to one of the four science subjects which are analysed in the Polish school at the stage selected for the study – biology, chemistry, physics or geography. For each of the four compared science subjects, there were developed five partial reports, comparing the relevant fragments of the Polish core curriculum and the core curriculum from the specific European countries (5). In total, 20 partial reports were drafted. The partial reports prepared by the experts are original in nature. Each of the partial reports contains the table from the Template for Comparison filled in by the expert.

The degree of implementation of the study objective and obtaining an answer to the study questions varies depending on the complexity of the elements subject to analysis (for instance, experts underlined difficulties related to comparison of two different subjects assuming that they correspond to a certain degree in terms of objectives and content, necessary for the analysis) and the individual approach to the task by the authors of specific reports. However, the said variety did not prevent formulation of generalisations, which form a response to the study questions.

Source materials used by the experts have been attached to the partial reports: original copies and translations of the core curricula excerpts selected for analysis. Unless otherwise stated by an expert, the quotations placed in the reports and notes referring to sources refer to Polish translations of the analysed documents.

Each subject expert formulated, in the summary of the comparative analysis of the structure and content of selected parts of core curricula, conclusions and recommendations result from it.

The recommendations concern, among others, elements, identified in a given core curriculum and having no counterpart in the Polish document, which – perhaps – may affect the quality of teaching science subjects understood as formation and development of the skill of scientific reasoning and using the scientific method.

Analysis of the content of the partial reports, in particular their summaries, was served to formulate the major similarities and differences between the core curriculum documents, as well as listing the common features of core curricula of countries obtaining high scores at the PISA test, concerning the skills of scientific reasoning and using the scientific method, which are absent in the Polish document. Based on the analysis, general conclusions and recommendations resulting from the study are formulated herein.

5. Results

The results presented in the report seem to be significant and interesting. A detailed comparative analysis of the studied documents, covering many aspects of teaching science subjects, included in the twenty partial reports, description of the role of core curricula and characteristics of education systems functioning in the studied countries became the basis for formulation of preliminary conclusions and recommendations, which may form a valuable guidelines (as based on study results) for revising and perfecting the Polish core curriculum for science subjects in the future.

5.1. The role of core curriculum and structure of education systems in the studied countries

The information provided in this part of the report constitute an extract from partial reports, forming appendixes hereto, where more data on this issue can be found.

5.1.1. Poland

In **Poland**, the core curriculum for pre-school and general education in specific types of schools[11] forms the basic document that describes the compulsory, at a given stage of education, set of educational aims and content taught within specific subjects, which must be incorporated in the implemented curricula. The educational aims (general requirements) and teaching content (specific requirements), as described in the core curriculum, enable establishment of the criteria of internal school assessment and fulfil the role of exam standards in the system of external exams. The core curriculum covers pre-school education (ages 3-5), early years education (ages 6[12]-8), primary school (ages 9-11), lower secondary school (ages 12-15) and upper secondary school (depending on the type of school, ages 16-19). In Poland, compulsory education covers children from the age of 6 until completion of the lower secondary school, not longer than until the age of 18. The obligation to study refers to those students who completed the lower secondary school but are under 18. They continue studying in upper secondary schools of various types or other educational institutions. Science subjects (in the same form) are obligatory for students until completion of studying in the first grade of an upper secondary school.

It should be added that after completion of compulsory science education in the first grade, students of a general upper secondary school and a technical upper secondary school are obliged to select one of two options of further science education – either science subjects in the extended scope, preparing for the school leaving exam, or an interdisciplinary supplementary subject *nature.*

11 Regulation of the MNE of 23 December 2008 on core curriculum for pre-school and general education in specific types of schools, as amended.

12 Compulsory education from the age of 6 will come into force in 2014, at the moment it depends on the decision of the parents at what age the child starts studying in the first grade.

5.1.2. England[13]

In **England**, primary and secondary education is obligatory between the age of 5 and 16.

In 1988, the Education Reform Act[14] introduced in England the compulsory National Curriculum[15]. It is a state document, which forms the basis for teaching in state schools. The National Curriculum is a document used since 1988 by all state schools (primary and secondary) in order to ensure a balanced and coherent teaching system.

The National Curriculum comprises:

- a list of subjects taught at school,
- educational aims,
- definitions of four stages of compulsory education (Key Stages),
- programs of study,
- levels of attainment.

In 2002, the Education Act (part 6) introduced some changes, including modification of the list of school subjects.

Just like in Poland, the period of compulsory education has been divided into educational stages, identified in England as Key Stages. The first stage covers two years of studying, the second – four, the third – three, and the fourth – two. Stages I and II comprise the primary level, while stages III and IV – the secondary level.

Besides identification of the main directions of educational processes, including science education, the National Curriculum contains a detailed specification of skills, which students should obtain at specific educational stages (levels of attainment).

5.1.3. Czech Republic[16]

Compulsory education in the Czech Republic covers students aged 6 to 18.

In the Czech Republic, studying in primary school (Základni škola) lasts 9 years. Under the revision of the Act on schooling of 1995, the first stage of primary school has been extended from four to five years, while the second stage (lower secondary) – shortened from five to four years. More able students can complete the compulsory nine-year-long primary education earlier, moving on to an eight or six-year-long secondary school (after grade 5 or 7). Comparing the Czech Gymnázium with the corresponding Polish school, it can be said that Czech Gymnázium is a combination of the lower secondary school with the general upper secondary school. Gymnázium ends with an exam – an equivalent of the Polish matura secondary school leaving exam (maturita).

13 Appendixes no. 1, 6, 11, 16.
14 Education Reform Act 1988, London, Her Majesty's Stationary Office, Reprinted 1989.
15 URL: https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study.
16 Appendixes no. 2, 7, 12, 17.

General education core curriculum is binding in the Czech schools – *Framework Curriculum for General Secondary Education*[17].

The legal basis for teaching in the Czech education system is Framework Curricula. The legal basis for primary education (*základni škola*) and for the lower stage of the secondary school (*gymnázjum*) is the Framework Curriculum for Primary Education (*Rámcový Vzdělávací Program pro Základní Vzdělávání*). The legal basis for teaching in the secondary school *(gymnázjum*) is the *Framework Curriculum for Secondary School* (*Rámcový Vzdělávací Program pro Gymnázia*).

Based on the Framework Curricula, schools prepare their own School Curricula (*Školní Vzdělávací Program*).

The *Framework Curriculum for Secondary School* determines only basic parameters of the organisation of study, thus it opens up many possibilities of alternative solutions in School Curricula. It contains a limited volume of teaching content, which is extended only at a higher educational stage.

The Framework Curriculum determines the minimum numbers of hours for delivery of specific school subjects[18] (in Poland, the minimum numbers of hours are determined in a separate Regulation of the MNE on framework curricula).

It should be added that the Czech core curriculum has included – since the reform of 1997 – a part dedicated to the principles of school education, just like the English National Curriculum. There can be found statements on subjectivity of the student (the child is in the centre of formative education), the key role of the teacher in the educational and deductive process (the teacher as the animator and stimulator who helps developing possibilities and abilities of the child), the partnership between teachers and students (the teacher and the child are free as partners in the school), teaching through real experiments in real life (active learning is stimulated by practical activities and the child's own experiments), holistic perception of reality (the essence of education is holistic acquisition of knowledge).

5.1.4. Estonia[19]

In Estonia, education at the primary level is delivered by a nine-year-long primary schools, usually combined with secondary schools into school complexes.

Education is compulsory until completion of primary education *Põhiharidus* or until reaching the age of 17 in the case when students fail to complete the primary school before that age[20].

Studying in secondary schools covers grades 10-12. After completion of the primary school, the teenager may choose between a general secondary school (*gümnaasium*), a vocational school (*kutsekool*) and a vocational secondary school (*kutsekeskkool*). Students at the secondary stage of education (both vocational and general) are, on average, aged 15 to 19.

Completion of the general secondary school enables taking up higher studies.

17 URL: http://www.msmt.cz/vzdelavani/skolstvi-v-cr/skolskareforma/ramcove-vzdelavaci-programy.
18 Rámcový Vzdělávací Program pro gymnázia, p. 82 – http://www.msmt.cz/vzdelavani/skolstvi-v-cr/skolskareforma/ramcove-vzdelavaci-programy.
19 Appendixes no. 3, 8, 13, 18.
20 *Systemy edukacji w Europie. Stan obecny i planowane reformy*, Estonia. Eurydice. September 2011.

The state standard of primary education is determined by the "State core curriculum for primary school" introduced in the Regulation of the Council of Ministers. The general part of the Estonian core curriculum[21] includes:

- a description of the basic values to guiding primary education,
- curricula, teaching content within subjects, list of subject blocks,
- programmes of leading topics, that is issues that integrate teaching within subject blocks, e.g. the science-technology block, and which are delivered in the form of a project, research work, or artistic project (e.g. technology and innovation),
- a list of obligatory and optional subjects,
- a list of subjects taught at specific educational stages,
- a definition and list of subject blocks,
- general and subject-specific education goals,
- general and subject-specific education competencies,
- a description of what should be understood by a teaching process and teaching environment,
- fundamentals of organisation and teaching,
- a description of mutual relationship between school and students with their parents, including ways of notifying and counselling,
- a description of the differences in educational activities, to be applied to students with special educational needs,
- a description of the assessment system,
- a description of the recommended conditions and ways of delivery.

The state core curriculum for the primary school determines the educational stages of the primary school. In addition, it contains a description of the *School curriculum*, the basis for drafting it and its structure.[22]

5.1.5. Finland[23]

The current Finnish education system is a result of many changes and reforms.

The Ministry of Education and Culture[24] in cooperation with the Finnish National Board of Education, determines the aims, content and methods of teaching for the level of primary and secondary school,

21 State core curriculum for primary school of 06.01.2011 - https://www.riigiteataja.ee/akt/114012011001.
22 State core curriculum for primary school of 06.01.2011 § 24 – Internet address as above.
23 Appendixes no. 4, 9, 14, 19.
24 *Systemy edukacji w Europie – stan obecny i planowane reformy, Finlandia*, November 2001, Eurydice, January 2012, p. 1.

as well as adult education. In each of six Finnish provinces, the issues of education are managed by the Education and Culture Department. Management of education at the local level belongs to the responsibilities of local authorities (at the municipality level), which play an important role as the organisers of education.

A provision of the Act on education (628/1998) stipulates that education in the country must be consistent with the National Core Curriculum for Basic Education.[25] The law stipulates that education shall be compulsory between the ages of 7 and 16, and there is the right to free pre-school and primary education. Most of the other forms of education and obtaining qualifications is also free of charge.

Grades eight and nine are the key period of studying, as they end the primary education stage; in that period, students develop skills necessary for responsible functioning in the society and professional career. At the end of the primary education stage, students decide on the directions of further education. Completion of primary education by a student is tantamount to ending compulsory education.

After the nine-year-long period of primary education, the student may start further studies at the secondary level, either in a general secondary school, or a vocational school, after which he or she may continue education at a technical higher education institution or a university.

By the decision of the Management Board of the Finnish National Board of Education, the National Core Curriculum for Basic Education 2004[26] has been in force since 16 January 2004.

The National Core Curriculum for Basic Education constitutes the national framework, on the basis of which local study plans are developed, for which the organiser of education takes responsibility.[27] The organiser of education makes a draft and approves the local curriculum consistent with the provisions of the National Core Curriculum for Basic Education, supplying details and supplementing its objectives and the basic content.[28] The organiser also decides about possible adjustment of the curriculum to the specificity of a given region or school.[29]

The exceptional nature of the education system of Finland lies in the right of the local government body, fulfilling the function of the school management body, to create an additional, tenth grade of primary school. The additional, non-compulsory year of studying is organised for students who want to improve their grades. The additional year of studying may increase the students' chances of entering a secondary school.

The National Core Curriculum for Basic Education includes:

- a list of school subjects,
- distribution of hours into specific subjects,
- educational aims,
- teaching content,

25 The names of documents binding in the Finnish education system are provided in English, as the authors used their English versions, available online.

26 The names are provided in English, as the authors preparing the analysis used documents in their English versions, available on the official websites of the Finnish educational administration.

27 URL: http://www.oph.fi.

28 *National Core Curriculum for Basic Education 2004*. Finnish National Board of Education, 2004, p. 6 - http://www.oph.fi/english/publications/2009/national_core_curricula_for_basic_education.

29 *National Core Curriculum for Basic Education 2004*. Finnish National Board of Education, 2004, p. 7 – Internet source as above.

- student assessment criteria,
- a description of the mission of primary education,
- the structure of primary education.

5.1.6. France[30]

School system in France remains under strict state control, and the most important decisions are made by the Ministry of National Education *(Ministère de l'éducation nationale*[31]). All curricula are established by ministerial decrees. French education poses as its main aim formation and education of social service.

Primary school is obligatory for all students from the age of 6. Studying in primary school lasts four years (between the ages of 6 and 11). It is aimed at development of a degree of autonomy appropriate for the age and achievement of basic social competencies.

The secondary stage of education covers lower and upper secondary level.

- Lower secondary level (*collège*)

  Children aged 12 to 16 attend the *collège*, from grade 6 (*sixième*) to 3 (*troisième*). The diploma is awarded after successfully passing the exam at the end of grade 3. It testifies to completion of the *collège*.

- Upper secondary level (*lycée*)

  Teenagers aged 16 to 18 attend the *lycée*, from grade 2 (*seconde*) to the final (*terminale*) one. The *lycée* offers a broad range of possibilities of obtaining education and learning an occupation. There are two types of *lycée*: a general *lycée* and a technical *lycée*, both end in a general school leaving exam (*baccalaréat*). Vocational *lycée* additionally ends in obtaining the *certificat d'aptitude professionelle* (CAP – confirming obtaining specific occupational skills), *brevet d'études professionelles* (BEP), confirming completion of an appropriate occupational internship in the scope of technical skills in the specified commercial, industrial or social field or an 'occupational' secondary school leaving exam (*baccalaréat*).

In 1985, France approved new curricula for primary and lower secondary schools *(colleges),* and in 1992 launched an educational renewal plan for *lycees* (upper secondary school). The curriculum reform, to a certain extent, also resulted from the new organisation of the education stages, concerning primary schools.

The comparison of the core curriculum for pre-school education and general education for biology at the ISCED 2 educational level with the corresponding core curriculum from France adopted for the study concerns the fragment of the education system in which students are at the lower secondary level. That fact concerning the school systems in Poland and in France – compulsory education is divided into two separate stages, i.e. education at the primary and secondary level and (usually) delivered in two different types of schools – is the common feature of both systems.

30 Appendixes no. 5, 10, 15, 20.
31 URL: http://www.education.gouv.fr.

5.1.7. Summary

- In each of the studied countries, there is an overarching document issued by an institution at the ministerial level, which constitutes an equivalence of the Polish core curriculum.
- Just like in Poland, the respective parts of the document are attributed to a relevant educational stage and relevant teaching subjects/subject blocks.
- The structure of the documents in the examined countries is diversified, but it always incorporates educational aims and teaching content. In some countries, it additionally determines criteria of assessment of student progress (Finland, Estonia) or determines expected achievements of the student at specific educational levels (England).
- The degree of details of the provisions of the core curricula differs, from a very detailed description of educational aims and teaching content, constituting at the same time the basis for formulation of exam standards in the system of external exams (e.g. England, France) or constituting the standards (e.g. Poland), to general formulations of content constituting the basis for formulation of school or regional curricula (e.g. Finland, Estonia, the Czech Republic).
- The education system in each of the studied countries assumes a period of compulsory education, which may last for instance, until the age of 16 (England, Finland), 17 (Estonia) or 18 (the Czech Republic, Poland). Compulsory education is implemented at the basic educational stage, organised differently in the studied countries.
- The goal of secondary education/upper secondary education is to prepare students for a professional career or further education in the system of higher education institutions.

5.2. Similarities and differences – synthesis of the results of comparative analysis

The synthesis presented below is based on the comparative analysis of the Polish document with each foreign document taken for the study. The aim of the study was to identify the existence or lack of existence of differences between the Polish document and each foreign document taken to analysis, not a comparative analysis of educational documents from 6 European states. Thus, it was not possible to develop a tabular set of comparative elements and comparison of each country with one another, which would certainly simplify the conveyance of information.

5.2.1. Comparison of the core curriculum in England with the core curriculum in Poland

Similarities:

- Both core curricula are similar in terms of the form of educational aims, which are recorded as general requirements by means of operational verbs. [partial report, chemistry]
- Specific requirements are formulated by means of operational verbs. [partial report, physics]

- In both documents, there can be found a contemporary trend present in European school systems concerning science – teaching in an integrated form of the natural science at lower ISCED levels (in Poland, nature at ISCED1, in England, science at ISCED1 and ISCED2). [partial report, biology]

- Neither document determines the time dedicated to implementation and completion of the content and curriculum objectives – in Poland, it is determined in the Regulation of the MNE on framework curricula, while in the English system it is determined at the school level. [partial report, physics]

- Both documents pay attention to formation and development of practical skills through observation, experiments or field classes. [partial report, geography]

- Both documents recommend teaching in well equipped classroom (full with teaching aids), enabling the student's individual work, and thus his or her active participation in the learning process. [partial report, geography]

Differences

- In England, 2 subjects are implemented – science and geography, whereas science may be at the school level separated into specific constituent science subjects (partial reports, biology, chemistry, physics).

- The English core curriculum clearly indicates, using detailed descriptions of levels of skills and knowledge of the student (Key 1 – Key 8), that it is the teacher's obligation to adjust the requirements to the student's level, ensuring the conditions for individual work, and thus achieving success by the student, regardless of his or her abilities. In the Polish core curriculum there are no such details, although the requirement of differentiation of the approach to teaching (depending on the ability of each individual student) is strongly emphasised and described in seven Regulations of the MNE on working with students with special educational needs. [partial report, geography]

- The levels of attainment, described in the English National Curriculum, serve to identify precisely the student's progress by assigning specific skills, and thus determination of the student's level of skills. In the Polish core curriculum, there are no such provisions, only the level of mastering knowledge in compliance with the provisions of the core curriculum at various educational stages can be diagnosed. [partial report, biology]

- Among the skills described in the English core curriculum, extraordinary skills can be found – an equivalent of the Polish requirements for the excellent grade, which is not included in the Polish core curriculum. [partial report, geography]

- The English core curriculum, due to the structure and somewhat hermetic way of conveying information is dedicated mainly for the people who develop the teaching resources (textbook, workbook, others), the Polish one is a document which is supposed to be clear and understandable both for the creators of the teaching resources, and the school environment – teachers, students and their parents. [partial reports, physics, geography]

- The content of the English core curriculum offers no specific examples to guide implementation. In the Polish core curriculum, sometimes specific examples are provided, which are to help deliver the content. [partial report, geography]

- Specific requirements in the Polish core curriculum are identical with the teaching content, while in the English one the teaching content and specific requirements (described by levels from 1 to 8) are separated.[partial report, physics]

- Teaching content in the Polish core curriculum is organised into sections, which roughly correspond to the classic divisions of natural sciences, while the English document organises them under problems. It often assumes the form of hypotheses, which require verification, thus application of the scientific method. [partial report, biology, chemistry, physics]

- The English core curriculum features a section entitled 'How Science Works?', absent in the Polish document, which concerns knowledge and understanding of the scientific method and using it both in studying science subjects, and in everyday life. There is no such section in the Polish document, only some educational aims refer to such issues. [partial reports, chemistry, physics, biology]

- The English core curriculum contains a broader than the Polish document coverage of key competences – there can be found a provision concerning applications and implications of (natural) sciences, ethical and moral problems related to the use of science in social processes and understanding of cultural diversity, and thus different approaches to the practice and achievements of natural sciences. [Appendix no. 6, chemistry]

- The core curriculum in England imposes as its main goal making the student curious, stimulating his or her interest in science subjects, while the Polish one poses requirements – general and specific. [partial report, chemistry] It should be added that the educational aims at the 2nd educational stage include a provision concerning developing the student's *ability to learn as a way of satisfying the natural curiosity of the world, discovering one's own interests and preparation for further education*, which in accordance with the adopted accumulation principle, is also binding at the higher educational stages, but it seems that it is poorly emphasised in comparison to the educational requirements, described with operational verbs.

5.2.2. Comparison of the core curriculum in the Czech Republic with the core curriculum in Poland

Similarities

- In both core curricula, educational aims are described in the form of general requirements by means of operational verbs [partial report, chemistry].

- Teaching content in the scope of science subjects, contained in the core curricula are recorded by means of operational verbs. The scope of content is also similar [partial report, chemistry]

- The Polish core curriculum, as well as the Czech one provides for the possibility to work with students in small groups, performing experiments and educational projects. [partial report, chemistry]

- There is a convergence of educational activities resulting from the core curricula binding in the Czech Republic and Poland, concerning protection of the natural environment, anticipating the consequences of practical people activities on nature. [partial report, chemistry]

- The main recipients of the core curriculum in the Czech Republic, just like in Poland, are schools, and teachers in them, who have a lot of freedom in choosing the version of curriculum adopted for implementation, the forms and methods of teaching, and even – within set limits – distribution of hours. [partial report, physics]

- In both countries, the **way of teaching science subjects** is very similar; they are taught as independent subjects. [partial report, physics]

- Both core curricula leave a lot of freedom to schools, teachers (including authors of textbooks) in the choice of **teaching forms and methods**. [partial report, physics]

- Neither core curriculum contains differentiation into study levels. [partial report, geography]

Differences

- The Czech core curriculum contains sections resulting from the idea of combining knowledge on the human body with other fields of science or areas of man's activity – e.g. man and nature, man and health. There is no such order in the Polish core curriculum. [partial report, biology]

- Teaching content in the Czech core curriculum is formulated in a more general way than in the Polish document. [partial report, geography]

- The Czech core curriculum defines comprehensively in minute detail the key competences, differentiating among them: studying competences, problem-solving competences, communication competences, social and personal competences, civic competences, entrepreneurial competences. [partial reports, biology, chemistry, geography]. The Polish document provides a list of key competences in the general part, which include scientific reasoning.

- The scope of expected skills and competences is smaller in the Polish core curriculum than in the Czech one. The Polish one is definitely dominated by expectations related to repeating and understanding information, while the Czech one is dominated by expectations related to the broadly understood processing of information, with a significant share of creation and evaluation of information (point 7 in part II). [partial report, physics]

- The Czech core curriculum places special emphasis on understanding that each science subject is a science of discovery, that explains the law of nature and constitutes an integral part of the section *Man and nature*. There is no separated common element in the Polish document, which would combine the two subjects directly, showing their coherence. [partial report, chemistry]

- The Czech core curriculum, to a much higher degree than the Polish one, stresses the need to develop and use cross-curricular skills, e.g. the ability to use mathematical tools in chemistry, biology, physics or geography. [partial reports, chemistry, geography]

- The Czech core curriculum places greater emphasis on practical use of the school scientific knowledge than the Polish document. [partial reports, chemistry, geography]

- The Czech core curriculum draws attention to students' misconceptions – it contains references to pseudo-scientific or anti-scientific information, which is absent in the core curriculum for science subjects in Poland. They appear only in the core curriculum of the supplementary subject nature at the 4th educational stage. [partial report, chemistry]

- It should be noted that the Czech core curriculum contains as its element [2; pp. 51-56] a "Glossary of terms", which clarifies and interprets "...words (...) used in the RVP-G (...) in the context of this document." The glossary is supposed to be used, most of all, by school principals and teachers who, based on the RVP-G, will be creating their own school curricula. The Polish document does not contain that element. [partial report, physics]

- The Czech core curriculum identifies the names of the authors who developed it; such information is not present in the Polish document. [partial report, physics]

- The Polish core curriculum includes a few general references to individualisation of working with the student with special educational needs (referring in this point to other regulations), while the Czech document dedicates two separate chapters to it, in a comprehensive way covering the tasks of the school in these areas. [partial reports, physics, geography

- Material and organisational conditions of teaching, including science subjects, are determined in the Czech core curriculum in a more spacious and comprehensive manner than in the Polish core curriculum. Special attention should be paid to the unequivocal provision present in the Czech document concerning the necessity to divide students into small groups during workshop classes in science subjects [partial report, physics]. It should be added that the recommended conditions and ways of delivery of chemistry in the Polish core curriculum are as follow: *For education in the field of chemistry to be effective, it is recommended to conduct classes in not too big groups.*

5.2.3. Comparison of the core curriculum in Estonia with the core curriculum in Poland

Similarities

- In both countries, there is implemented teaching of separate science subjects – biology, chemistry, physics and geography.

- Both, the Estonian and the Polish core curricula, formulate the educational aims in the language of educational requirements (operational verbs). [partial report, biology]

- Both core curricula are dedicated especially for the school environment – they are understandable both for the teacher and the student and his or her parents. [partial report, physics]

- The core curriculum from Poland and Estonia contain a significant divergence between the teaching content and the educational aims. The intended student achievements (learning outcomes) are determined in detail in the operational form. [partial report, chemistry]

- Both, the Estonian and the Polish core curricula, contain a list of experiments which should be performed in class. They are to draw attention to the need to use activating methods, which determine obtaining positive learning outcomes. [partial report, chemistry]

- Both core curricula pay relatively little attention to the forms and methods of teaching, leaving thus a lot of freedom to authors of textbooks and teachers in selecting them. [partial report, physics]

- Both core curricula emphasise mainly scientific skills. [partial report, geography]

- Both core curricula manifest a significant convergence of the general educational aims. Students are, most of all, to understand the functioning of natural systems and processes occurring in nature and the relation man – nature, and, on that basis, anticipate the course of analysed natural processes, formulate and verify hypotheses concerning problems existing in the geographical environment, apply the obtained knowledge and skills in practice, as well as use various sources of geographical information utilising contemporary technology. [partial report, geography]

Differences

- The record of competences in the Estonian core curriculum constitutes a guide for the recipient on the set of knowledge, skills and attitudes. The record of competences is also a reflection of the interdisciplinary spirit of that document. In the Polish core curriculum, there is no clearly formulated idea of interdisciplinary teaching, development of cross-curricular skills, lack of common, coherent structure in the parts concerning specific science subjects. [partial reports, biology, geography]

- The specific requirements of the Polish core curriculum are recorded jointly with the teaching content, while the record is separate in Estonia, but each section of learning contains both specific requirements and content [partial report, geography]

- The Estonian core curriculum combines subjects into subject blocks, thus underlines the importance of interdisciplinary teaching, there are no such provisions in the Polish document. [partial report, biology]

- The major aim described in the Estonian core curriculum is the formation of a responsible member of society, while in the Polish one, the major aim is acquisition of a certain level of skills and knowledge. [partial report, biology]

- In the Estonian core curriculum, there is a detailed list of lead topics which are cross-curricular and bring forward in the course of study those fields of science, which are indispensable for life in the developing and changing society, there are no such provisions in the Polish document. [partial reports, chemistry, geography].

- In the Estonian core curriculum the problem of *creative work* is included. It concerns directly the *Lead topics* (which integrate teaching science subjects). Creative work is, put otherwise, creative approach to solving problems which imposes a specific form of work and expression, the closest to the project method. In the Polish core curriculum, there is no direct reference to that method [partial reports, physics, geography]. The exception is the core curriculum for chemistry, where working with the project method is indicated as recommended conditions and

ways of delivery. It should also be added that in Poland, students of the third grade of lower secondary school are required to implement a project, which is a condition for obtaining the lower secondary school certificate. However, this recommendation is conveyed in a separate Regulation of the MNE.[32]

- The Estonian core curriculum emphasises high importance of natural sciences, understanding them, as well as the ability to analyse the environment as a holistic system. The Polish document lacks such provisions. [partial report, chemistry]

- The Estonian core curriculum, in comparison to the Polish one, places more emphasis on the use of ICT in natural sciences. For each section of study, its applications are provided. [partial report, geography]

5.2.4. Comparison of the core curriculum in Finland with the core curriculum in Poland

Similarities

- The Finnish core curriculum formulates educational aims in the form of the language of requirements, just like the Polish one. [Appendixes no. 4, 9, biology, chemistry]

- The educational aims refer, to a high degree, to experience as the source of data, and thus the way to verify a hypothesis, and underline the connection between natural sciences and everyday life. [Appendix no. 9, chemistry]

Differences:

- The Finnish core curriculum contains a description of competences for the good grade, which lacks in the Polish one. [partial reports, biology, physics] The Polish core curriculum is aimed at unspecified, 'average' student, and educational requirements for specific grades should be determined by the teacher

- The number of curriculum sections is limited in the Finnish core curriculum, as well as issues related to science of primary importance are brought forward, with reasonable attribution of hours to their delivery. In the Polish document, there are more sections and no key problems are emphasised. [partial reports, biology, chemistry]

- The Finnish core curriculum features health education as a separate subject, which constitutes supplementation of biological education, which does not occur in the Polish document. [partial report, biology]

- The Finnish core curriculum can be seen to diverge from the typical teaching of e.g. biology – from the molecular level to the supraorganismal level in favour of problem-based approach. The hierarchical arrangement of content is still dominant in the Polish document. [partial report, biology]

32 Regulation of the MNE on the conditions and method of assessment, classification and promoting students, and on carrying out tests and exams in public schools of 30 April 2007, as amended.

- The Finnish core curriculum is strongly grounded in the tradition, culture and history of Finland (e.g. in biology, there are emphasised sections such as ecology, sozology in relation to intensely developing forest and wood industry), there are no such reference in the Polish core curriculum for biology, but they are perceptible in geography. [partial report, biology]

- The Finnish core curriculum formulates the teaching content in a more general way, while the Polish one as specific requirements. [partial reports, chemistry, geography]

- The core curriculum in Finland pays special attention to cross-curricular teaching, related to IT and the use of online data. There are no such references in the Polish document. [partial reports, physics, geography]

- In the Finnish core curriculum, the approach to the role of experiment in teaching physics is rather different: in Poland, experiments have an auxiliary role, though indispensable, while they are pointed out as the starting point for teaching a natural science, such as physics, in Finland. [partial report, physics]

- The Finnish core curriculum contains provisions referring to working with a student with special educational needs, the recommendations in Poland are included in educational documents other than the core curriculum. [partial report, physics]

- Both compared documents present different approaches to the student. The Polish student is supposed to accommodate and obtain information and skills, while the Finnish one is supposed to possess motivation and skill of managing his or her further education. [partial report, geography]

5.2.5. Comparison of the core curriculum in France with the core curriculum in Poland

Similarities:

- The educational aims are written in both core curricula in the form of requirements – with operational verbs [partial report, geography].

- The core curriculum binding in France, just like the Polish one, underlines the importance of the experimental method in teaching science subjects [partial report, physics].

Differences:

- The French core curriculum is characterised by a clear, three-stage, hierarchical arrangement of the basic documents included in it: the common core curriculum for all subjects, based on which there is a joint introduction into mathematical, scientific and technical subjects, and then the curricula of science subjects, having a descriptive and tabular form. In the Polish document, there is no such structure, curricula can be developed on the basis of the core curriculum by teachers. [partial report, physics]

- The French core curriculum contains subjects like ‘Discovering the world’ for level ISCED1, while, at level ISCED2, subjects ‘Life and Earth science’ covers content from biology and physical geography, ‘Physics-chemistry’ and ‘History-geography-civic education’ including content from human geography (not included in the study). In the Polish core curriculum, at level ISCED1, subject nature is taught, four different subjects of science exist at level ISCED2. [partial report, biology]

- The French core curriculum lists information and competences which should be possessed by the student at the end of learning at a given educational stage, while information is combined in the Polish document with general skills and specific educational requirements. [partial reports, biology, geography]

- The subjects included in the French core curriculum remain in close correlation and supplement one another, the Polish core curriculum lacks such correlation. [partial reports, biology, chemistry, physics]

- The French core curriculum contains a direct reference to key competences, described in the documents of the European Council, while there is no such direct reference in the Polish document. [partial reports, biology, chemistry, geography]

- The French core curriculum describes in minute detail the research procedure/scientific method, while the Polish document has no such comprehensive provisions. Particular provisions concerning the research procedure are broken down into educational stages. [partial reports, physics, geography].

- The scope of content in the French core curriculum is smaller than in the Polish one [partial reports, physics].

- The skills and competences entered in the Polish core curriculum are dominated by skills related to recalling and understanding information. On the other hand, the French core curriculum is dominated by skills referring to obtaining, processing and presentation of information. [partial report, physics].

- The provisions of the Polish core curriculum attribute an auxiliary role to experiences and observations, although indispensable, while in France, in accordance with the binding core curriculum, experiences, observations and measurements are the starting point for acquiring knowledge. [partial report, physics]

5.3. Missing elements

In conclusion, six points that describe the elements which are present in the studied foreign core curricula and which are missing or insufficiently emphasised in the Polish core curriculum for science subjects are presented.

1. The idea of combining science subjects, formulated clearly and distinctly in the core curriculum, constitutes at the same time the overarching direction of science education (England, Estonia, France).

2. Individualisation of work with the student, described directly in the core curriculum (England, the Czech Republic, Estonia, Finland).
3. High degree of integration and coherence of science subjects, stronger cross-curricular nature (England, the Czech Republic, Estonia, France).
4. Modern, interdisciplinary, problem-based coverage of teaching content (England, Estonia, Finland).
5. Greater emphasis on application of ICT and the project method, as well as mathematical skills in science subjects (England, the Czech Republic, Estonia, Finland).
6. The compared documents present different approaches to the student. The Polish student is supposed to accommodate and obtain information and skills, while the English, Estonian, Finnish students are to have motivation and skills to manage their further education [England, Estonia, Finland]. That difference in approach to student could also be observed in practice during the study visits to England and Finland.

6. Conclusions and recommendations

It must be stressed that neither the conclusions formulated herein nor the recommendations resulted from them are aimed at criticising the Polish document. As the comparative analysis revealed, the Polish core curriculum for science subjects is a document suitable for the 21st century and does not diverge from the standards adopted in the documents of other European states.

The conclusions and recommendations presented in the report should be read as an attempt at identification of directions for perfection of the document, for, as Antoine de Saint-Exupery wrote, "perfection is achieved not when there is nothing more to add, but when there is nothing left to take away".

6.1. Final analysis and conclusions

1. The analysed materials differ in terms of structure, content and recommended approach to the student.
2. The identified differences concern mainly the degree of integration of teaching science subjects and correlation of their content and attention paid to formation of key competences, including social ones, and the use of ICT in science education.
3. The analysed foreign core curricula for science subjects contain many elements that refer to development of competences related to scientific reasoning and using the scientific method, which are missing or represented to a limited degree in the Polish document.

   These are:

   a) determination in the core curriculum of the common central idea, guiding the science education, bonding science subjects, based on creation of an environment good for learning science subjects, in which the primary role is played by: direct experiencing of nature, scientific reasoning, using the scientific method, proximity of science and everyday life, as well as formation of social competences – communication, cooperation, sharing the results of work. Such an idea, bonding science subjects together, is clearly perceptible in the core curricula in England, Estonia and France. Those are countries, where 15-year-old students obtained high scores in the PISA survey in the area measuring the use of the scientific method;
   b) a high degree of integration of the teaching content of science subject, greater cross-curricular nature of the teaching content of science subjects, showing that science subjects are in fact one, common enquiry into the world of nature (England, the Czech Republic, Estonia, France);
   c) problem-based approach to teaching content (England, Estonia, Finland), rather than studying separate topics resulting from the 19th-century arrangement of natural sciences (cytology, histology, botany, zoology, etc.).

4. In the analysed core curricula the presence of sections/teaching content was found which does not exist or exists to a limited degree in the Polish core curriculum. These are:

   a) section on science and application of the scientific method as common for physics, biology and chemistry (England) or specific description of the scientific method (France),

b) content concerning ethical and moral issues, related to scientific research and broadly understood science, as well as concerning understanding of cultural diversity and the various approaches to practice and achievements of natural sciences (England),
c) content dedicated to the history of science (England).

The issues are presented in the Polish document to a limited extent, in single points of the teaching content, that is the specific requirements. Thus, this makes a difference in terms of the weight of these provisions.

5. Greater emphasis was revealed in the provisions of the core curriculum on using ICT and the project method in science subjects, as well as mathematical skills (England, the Czech Republic, Estonia, Finland).

6. The principles of individualisation of work with the student are described directly in the core curriculum (England, the Czech Republic, Estonia, Finland), which may facilitate the teachers' use of the principles in practice.

7. The difference in the pedagogical approach to the student – the Polish student should learn information and acquire skills, the English, Estonian, Finnish students should develop motivation for studying and form the skill of managing their further education (England, Estonia, Finland).

Referring to the study questions presented above, it can be stated that the study enabled acquiring answers to the questions posed. It can be stated that:

- the compared core curricula contain provisions which – perhaps – may influence the formation and development of the skills of scientific reasoning and using the scientific method to a higher degree than in Poland. It seems that the structure and content of the core curriculum may affect the efficiency of formation of the skill to use the scientific method in various countries, measured by the international PISA survey. The observed differences regarding the weight of the provisions concerning development of the broadly understood scientific reasoning can be found in documentations of the countries with significantly higher results obtained in scientific reasoning in the PISA test;

- the Polish core curriculum differs from the core curriculum of France, which obtained significantly higher results in the PISA survey, in the area of diagnosing the *ability to recognise scientific issues* and *ability to interpret and act on scientific results and evidence;*[33]

- in some of the analysed documents, great importance is attributed to formation of social competences of the student, as well as developing in him or her responsibility for his or her own education.[34]

6.2. Recommendations

Thus, can it be expected that adding – by way of revision – the elements listed above, valuable and absent or present in a different way in the Polish core curriculum for science subjects could contribute to the improvement of the quality of the basic science education?

It seems that this document gives grounds for a positive reply to the above question.

33 More in section VII.1. Final analysis, conclusions, verification of hypotheses, point 3 a.
34 More in section VII.1. Final analysis, conclusions, verification of hypotheses, points 4 b and 7.

It should be kept in mind that in Poland (similarly as in other countries) there is some discrepancy between the *intended* and the *implemented* curriculum. Authors of the report were aware, formulating the recommendations to supplement the document, that parallel actions should be undertaken to diminish the differences between the provisions of the core curriculum and the school practice, including the structure and content of textbooks, which (as revealed by the studies of the PPP IBE) constitute the basic teaching aid in the teacher's work. It could also be beneficial to add a recommendation to introduce solutions in the educational system, making it easier for principals to plan and implement a flexible framework of aneducational schedule in their schools, which would certainly increase the chances of working with the scientific method or doing outdoor research. It should be emphasised how important the educational aims and the introduction are to the core curriculum in the science part. The teachers' primary focus on teaching content may result in lack of understanding of the idea which guided the authors of that document.

The recommendations presented below are aimed mostly at the Ministry of National Education, as the institution responsible for the shape of the core curriculum.

The recommendations are of general nature, each of them may and should be extended with detailed recommendations concerning its implementation methods. For substantive reasons, the recommendations concern the core curriculum for science subjects at three educational stages (II, III and IV), as well as basics of natural science education in grades 1-3.

Based on the analyses of the results and conclusions from the study presented above, the following changes are recommended:

1. **Formulation of a common idea of teaching science subjects**, based on formation and development of the skills of scientific reasoning and using the scientific method.
2. **Creation of a catalogue of skills common for science subjects, that is scientific cross-curricular**. The leading skills are using the scientific method and scientific reasoning. The catalogue should be common not only for science subjects (nature, biology, chemistry, physics, geography, nature in upper secondary school), but also for all educational stages – from early years education (even pre-school) in the science part to upper secondary school. Such a catalogue of cross-curricular skills would determine the main direction of science education and would enable moving the emphasis from teaching content (encyclopaedic learning) to educational aims (formation and development of skills). It will ensure a high degree of integration of teaching science subjects.
3. **A change of the place of the recommendations regarding carrying out experiments and observations** (as fundamental elements of the scientific method) by placing them beside specific problems in the teaching content for all science subjects. This would enable moving the stress from teaching content to experiment and observation as the starting point for science education, just like it is done in the core curricula in England, Estonia and France.
4. **Modification of the provisions of the teaching content of science subjects towards:**

- problem-based approach, which would ensure a high degree of coherence of the teaching content of those subjects by integrating the content with problems, rather than with specific objects, phenomena or processes. Hierarchical arrangement of the content would enable, at the same time, retaining a high degree of detail, necessary for fulfilling the role of exam standards;

- adding sections of the content (it would be best if they were common for those subjects) concerning:

- science and application of the scientific method as common for physics, biology and chemistry,
- ethical and moral issues, related to scientific research and broadly understood science,
- history of science.

A good example is offered by the provisions of the exemplary teaching content of the core curriculum for *nature* for the 4th educational stage.

5. Changes to the provisions in the core curriculum concerning approach to the student by supplementations which:
   a) suggest how to make a student interested in the world of nature and his or her attitude towards nature – especially in the area of climate change, nature conservation and environmental protection;
   b) identify how to form and develop the student's responsibility for his or her own education in the field of science subjects.

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Schedule 21
Template for Preparation of Core Curricula Comparison

1. The comparative analysis does not only constitute a breakdown of information included in the examined documents. Its most important part is the author's (Expert's) comments determining and clarifying, in a systematic manner, the differences between the compared core curricula and conclusions drawn on the basis of the comparison.
2. A hierarchy of significance should be maintained for every aspect of comparison, i.e. most important differences and similarities between the compared core curricula should be emphasized and discussed in detail rather than less important detailed issues.
3. All statements regarding any of the compared documents should be supported by quotations or references to specific fragments of source materials, enabling their clear identification and verification.
4. It is very important to divide the information resulting directly from the content of analyzed documents from the information deriving from other sources or based on the Expert's own knowledge.

The study comparing Polish core curriculum with a foreign core curriculum consists of the following parts:

- **Introduction**, which specifies and compares, in a brief descriptive form, information of general nature, not referring to a specific subject.
- **Part I**, which contains a synthetic comparison of basic characteristics of core curricula in the section referring to specific subjects, of systemic (structural) character, presented in the form of tables. The tables are, at the same time, a list of content of part II (descriptive part) of the comparison.
- **Part II**, basic one, where the theses contained in the prior part are elaborated upon. The description should refer, primarily, to the content (substantive and didactic) of the core curriculum. Structure of part II is enhanced and elaborated upon in comparison with the structure of the table.
- **Recapitulation**, in which the Expert presents remarks and theses not included in two prior sections. The structure of recapitulation is not determined in detail.

The term "Polish core curriculum" is to be understood as the proper core curriculum, enhanced by the documents provided by the Ordering Party and determining the compared features of the educational system in Poland, important for the needs of the study (e.g. the commentary to the core curriculum). The term "foreign core curriculum" is understood in an analogous manner. Science courses such as biology, chemistry, physics and geography are described with the abbreviation b-c-p-g.

Introduction

In the introduction, the Expert describes and compares general issues, discussed in general sections of core curricula, i.e. not specified with respect to individual courses. Typical information which the Expert discusses in this part is provided below.

1. Documents used for preparation of the comparison; their rank.
2. Description of the compared fragment of educational system, age of pupils; information whether there are any external examinations which pupils have to take, etc.
3. Indication and comparison of selected (by the Expert) elements of core curriculum in its general section, referring to the teaching of b-c-p-g (each time, the Expert decides whether they contain course-specific information):
   - general teaching objectives and competences acquired by pupils;
   - desired attitude shaped in pupils;
   - tasks of the school and manners of implementing these tasks;
   - guidelines for teachers, regarding forms and methods of work with pupils;
   - other elements.
4. Other general issues, important for the study.

Part I. Core Curriculum b-c-p-g: Comparison of Formal Structure

The Expert compares core curricula, completing the second, the third and, potentially, the fourth column in the table below. The Expert's statements in this section are brief – there is little freedom with respect to choice of the form and the content of comparison. Part II of the study is the proper place for elaboration, commenting upon and justification.

The list of features of the formal structure provided below for the Polish core curriculum should stay, as far as possible, unchanged (common for comparisons prepared by individual Experts) with the exception of situations in which the specific nature of a core curriculum of a given course results in the fact that it is necessary to introduce certain changes (e.g. for physics, "interdisciplinary requirements" were provided, not present in the core curricula of other science subjects).

Sample statements of the Expert are provided for the foreign core curriculum in italics, in order to provide a good sample of the degree of detail expected in the first part.

Element of structure	Polish core curriculum	Foreign core curriculum	Remarks
1. How is the teaching of the course organized? Does the pupil have to learn during the course? Is differentiation in the teaching levels proposed?	This is an autonomous course. This is a mandatory course for all pupils. It is taught on one level, determined as basic.	*The course is taught within the scope of the "Science" module. The pupil has to learn "Science." The issue of teaching levels is not applicable.*	

Element of structure	Polish core curriculum	Foreign core curriculum	Remarks
2. What is the time assigned for teaching the course?	There is a four-year teaching cycle, encompassing three years of middle school and the first class of "general high school"[1]; the number of hours of training assigned for teaching is determined in another document as at least 5 hours of practice in a teaching cycle, which corresponds to 150 hours of teaching at least.	*A two-year teaching cycle, compliant with the two-year middle school cycle; the teaching of "Science" encompasses 8 hours in this cycle, which corresponds to approx. 250 hours of teaching where approx. 25% is devoted to b-c-p-g.*	
3. What is the educational basis on which the pupil is learning the course? What is the continuation for this course?	The educational basis is provided by the issues from " Basics of natural science" in elementary education and the subject "Science" in grades 4, 5 and 6 of primary school. In general high school, the pupil may choose extended version of the course; if the pupil does not choose it then, depending on other choices, there is "Science" in the general high school or the pupil does not follow the course of science at all.	*The educational basis is the integrated subject "The World Around the Corner" taught in the primary school. Subsequently – no information.*	
4. Have the general objectives of the course and the school tasks in this respect been provided? If yes, what is their form?	The list of teaching objectives was provided in the form of a declaration; specific tasks of the school were not provided.	*The list of teaching objectives is given in the form of a declaration; the list of school tasks was also provided.*	
5. In which form are the detailed objectives of teaching the course provided?	In an operational form, along with detailed teaching content.	*In an operational form, along with detailed teaching content.*	
6. In which form is the teaching content of the course provided?	In a mixed form: general content, corresponding to the teaching division, is provided declaratively; detailed content, corresponding to core curricula keywords, is provided in an operational form.	*In a purely operational form: each division is linked to the set of pupil's skills related to this division. Selection of detailed core curricula keywords is determined by the author of the textbook.*	
7. In which form are the course-specific skills of pupils entered in the core curriculum? Are there any other competences (if so, which) of pupils, beyond the scope of skills entered in the core curriculum?	Specific (course-related skills) of pupils are divided into three areas: Related to the learning content; "Interdisciplinary" skills; Skills in the area of observation and experiment, combined with a list of mandatory experiments and observations. No specific competences beyond specific skills were entered.	*Skills of pupils are connected to the teaching division; therefore, they are, in a substantial degree, independent from the learning content.* *An extensive set of competences not related to a specific course, but related to the use of Internet and other sources of information was provided.*	

Element of structure	Polish core curriculum	Foreign core curriculum	Remarks
8. Does the core curriculum suggest/ impose the sequence of implementing the learning content?	The sequence of implementation is suggested in the core curriculum; teaching of a specific set of content assigned for general high schools is imposed. Apart from it, authors of textbooks and teachers are vested with the right to choose the sequence of teaching.	*Sequence of teaching is mandatorily imposed in the core curriculum.*	*Details in part II of the study.*
9. Does the core curriculum suggest/ impose forms and methods of teaching?	They are suggested in the commentary to the core curriculum (in various manners for ...)	*They are imposed in the core curriculum.*	*Details in part II of the study.*
10. Does the core curriculum determine (minimum) conditions in which the subject is taught?	The possibility of dividing the class into two exercise groups was specified.	*Typical equipment of a b-c-p-g laboratory was specified. The number of pupils in the class should not exceed 20.*	
11. Is the system of grading the pupils' accomplishments within the scope of the course on the school level imposed?	The core curriculum imposes establishment – on the school level – of a course-related system of grading and a school system of grading.	*The core curriculum does not determine any grading system on the school level.*	
12. Does the core curriculum impose a system of external grading on the level of the region or the country? Within this system, is there an "external" examination? Are standards of requirements for such examination determined?	Every pupil completing middle school takes a mandatory mathematics and science examination. The requirements for the examination are identical to expected skills of pupils.	*Every pupil who wants to choose b-c-p-g on the next stage of education as a specialist course, takes the state examination. The standards of requirements are determined in the syllabus, which is identical for the entire country.*	
13. Does the (foreign) core curriculum contain elements of the structure which are worth emphasizing and which are absent in the Polish core curriculum?	Not applicable.	*In a separate part of core curriculum, a set of school obligations and teachers of b-c-p-g within the scope of cooperation with pupils' parents, including exchange of information about pupils' progress was determined.*	*Details in recapitulation of the study.*

Part II. B-c-p-g Core Curriculum: Descriptive Comparison of Content

This part is assigned for elaboration on the comparison of foreign and Polish core curriculum. The elaboration runs along points described in the table in Part I.

Sample descriptions in comparison to part I are shown below – the final decision in this case is made by the Expert who, in this part, may freely choose the scope of the answers, depending on the specific nature of the core curriculum of a given course and a given country.

1. Organization of b-c-p-g teaching.
    a) Teaching of b-c-p-g vs integrated science teaching.

b) Possibility of selecting the manner of learning b-c-p-g by the pupil.

c) Varied teaching levels.

2. Time devoted to the teaching of b-c-p-g.

a) Cycle of teaching.

b) Determination of the number of hours of teaching devoted to b-c-p-g.

c) Comparison of the number of hours of teaching for b-c-p-g with the time assigned for teaching of other subjects.

3. Basis / continuation of teaching of b-c-p-g.

a) B-c-p-g as continuation of teaching in primary schools.

b) B-c-p-g as a basis of further education.

4. General teaching objectives and school tasks within the scope of b-c-p-g teaching.

a) Common section of teaching objectives and school tasks in both curricula.

b) Role and significance of objectives and tasks present in only one core curriculum.

5. Detailed teaching objectives of b-c-p-g.

From the point of view of the Polish core curriculum, separation of this section is not necessary – it is contained in section 7. However, it may turn out that on account of the educational basis, this section has to be separated and prepared independently.

a) Common part of objectives in both curricula.

b) Role and significance of objectives present in only one core curriculum.

c) Evaluation of "distribution of emphasis" on individual groups of objectives.

6. Learning content.

a) Teaching divisions (core curriculum keywords) present in the Polish core curriculum and absent in the foreign core curriculum.

b) Teaching divisions (core curriculum keywords) not present in the Polish core curriculum but present in the foreign core curriculum.

c) Evaluation of "distribution of emphasis" on individual teaching divisions (core curriculum keywords).

d) Content referring to mathematics and/or other sciences (in two aspects: "I use" and "I offer").

e) Content referring to areas of science which do not constitute school courses.

f) Content referring to "every-day life practice."

7. Pupils' skills and competences:

a) skills related to learning content – evaluation of "distribution of emphasis" on individual areas;

b) "interdisciplinary" skills, specific for b-c-p-g;

c) competences shaped within the scope of b-c-p-g teaching.

In this part, we adopt a division of pupils' skills into four categories:

- reproduction/ understanding of information;
- searching for/ reading of information;
- interpretation/ processing/ transfer of information;
- evaluation and creation of information.

8. Sequence of implementing the curriculum.
9. Forms and methods of teaching; objective meeting procedures.
    a) Mandatory or preferred forms and methods of teaching.
    b) Use of scientific terminology at various stages of pupils' activities.
    c) Role of experimental teaching (in particular, inquiry-based science education) in the teaching of b-c-p-g.
    d) Searching for and using source data.
    e) Application of IT in the process of teaching b-c-p-g.
    f) Activating teaching methods.
    g) Implementation of the process of outdoor teaching.
    h) Methods of teaching addressed to talented pupils and pupils with special educational needs.
    i) Pupils' projects.
10. Teaching conditions.

    It is important to note whether these conditions are described in the core curriculum, in a commentary to the core curriculum, or whether they can be concluded upon on the basis of requirements (e.g. the ones regarding mandatory experiments). Additionally, it is also important whether these conditions are imposed or suggested.

    a) Organizational conditions.
    b) Material conditions (laboratory, equipment).
11. Supervising pupils and grading their accomplishments within the scope of b-c-p-g on the school level.
    a) Course-specific grading system.
    b) School system of evaluation.
12. Out-of-school evaluation of pupils' accomplishments. Standards of requirements.
    a) External grading system; external exams.
    b) "Integrated" exams vs. "course-specific" exams.
    c) Structure and content of standards of requirements.
13. Other elements of a foreign core curriculum, absent in the Polish one.

Recapitulation

Neither the structure nor the content of the recapitulation are predetermined – the Expert has significant freedom in choosing the content and the form. Below, sample elements are listed:

1. Characteristics of compared core curricula, not included in parts I and II:
    - groups of recipients of a core curriculum: pupils and parents, teachers, educational publishing houses, teams preparing standards of requirements (if applicable), teams preparing "beyond-school" examinations, other entities;
    - degree of "feasibility" of a core curriculum from the point of view of each of such groups of recipients;
    - degree of "flexibility" of a core curriculum from the point of view of each of such groups of recipients;
    - other characteristics (drawbacks and advantages) noticed in the course of curriculum comparison.
2. Remarks and general ascertainment, conclusions.