

Upper secondary education in Belarus: A case study

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This report forms part of a collection of six case studies commissioned by the Royal Society in 2017 examining upper-secondary education reform in different jurisdictions. The case studies are designed to give the reader an understanding of the trends in upper secondary curriculum reform and, in particular, the recent moves that certain jurisdictions have made towards a broader and more balanced curriculum.

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About the author

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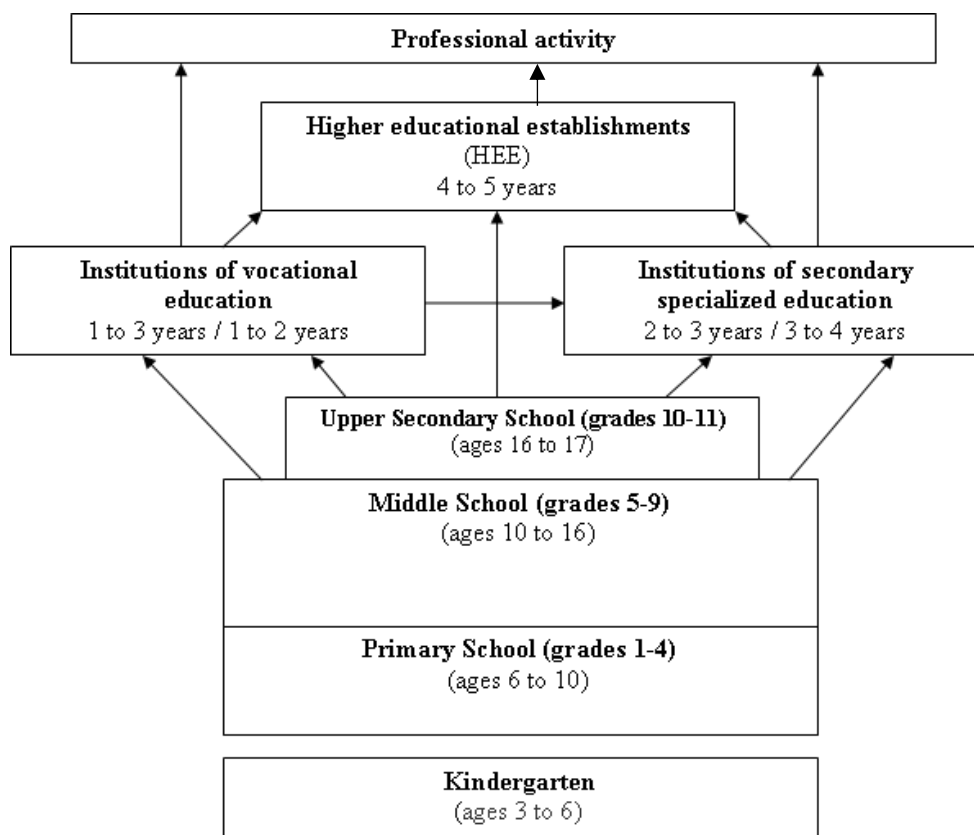
Introduction

Belarus offers a case of a post-Soviet country searching for an effective balance between a state-centred, standardised, top-down, theoretical, academic subjects based model, focused on mathematics and science, and a student-centred, decentralised, flexible, interdisciplinary, competences-based model, focused more broadly on humanities subjects. Both models have their strengths and weaknesses. Other lessons can also be learnt from Belarus's recent educational reform in its aim to improve the pipeline of high-skilled graduates to fuel the needs of the growing IT industry in the country.

Belarus is a country with a highly developed education system. The adult literacy rate in Belarus is 99.8%, and the country has a high primary, secondary and tertiary gross enrolment ratio (98.7% according to the UN Human Development Report). The Human Development Index ranks Belarus among the top developed countries, and along with Russia performs best among the 12 countries that make up the Commonwealth of Independent States (CIS). As regards the Education Index, the composite indicator of the UN Development Programme (UNDP), Belarus is ranked 21st (Russia, 32nd; Ukraine, 36th; Kazakhstan, 37th; Armenia, 68th; Azerbaijan, 69th; Moldova, 70th; Kyrgyzstan, 72nd; Uzbekistan, 82nd; Tajikistan, 91st; Turkmenistan, 108th [1]).

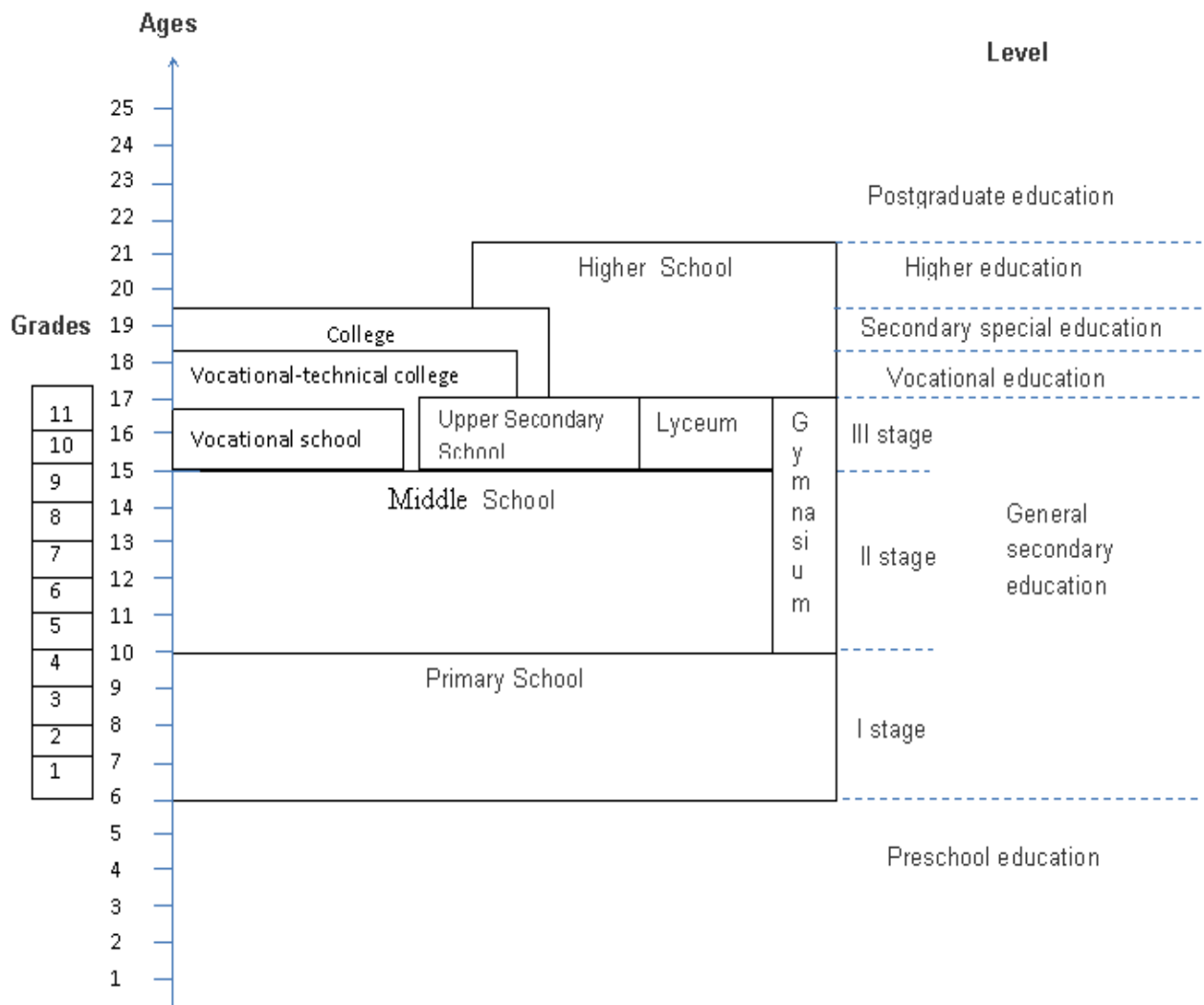
The Belarusian educational system includes 3,951 preschool institutions, nearly the same number of comprehensive schools, colleges and lyceums, and 51 higher educational institutions, of which 9 institutions are private.

Structure of Belarus's educational system (as of January 2017)



General secondary education in Belarus starts at the age of 6 or 7 years and includes three levels: primary, middle and upper secondary schools.

Levels of education in Belarus



The basic school course is compulsory and lasts for nine years, from age 6 to age 15; the upper secondary lasts for one or two years. On successfully graduating from basic school, young people can continue their education at college, high school or vocational school, simultaneously receiving upper secondary education and professional training. Those interested can continue at their school and take general upper secondary education in grades 10 and 11. The Certificate of General Secondary, or Secondary Special Education if continuing study at college, is the basic document enabling young people to enrol in a higher education institution.

Establishments of general secondary education are allowed to set up gymnasia classes, classes with a profiled curriculum (advanced subject study), to introduce optional subjects and courses, and to hold 'sustaining' and 'stimulating' types of classes. Sustaining classes are for students with learning difficulties who lag behind the rest of the group, for example, those who have not passed a test on a particular topic and need additional teacher support. Stimulating classes are activities aimed at developing the creative abilities of gifted and talented students.

Gymnasiums provide comprehensive humanities education, often centred on the study of foreign languages. They are expected to have highly qualified teaching staff, use innovative textbooks, and to have modern methods of teaching. There are also lyceums which offer

professionally oriented education and are usually affiliated with higher education or research institutions.

Technical-vocational educational institutions include technical-vocational schools and colleges, provide general secondary and specialised secondary education integrated with technical-vocational education.

Educational programmes of specialised secondary education are available at most types of school and college and in some cases at higher education institutions. The most popular specialties among applicants to technical-vocational and specialised secondary institutions have been the same for several years. These are ICT, automation of production processes, wood-working, tourism and hospitality, foreign languages, and office work [2].

Belarus is the leading country within the CIS for the ratio of university students (330 students per 10,000 people as of 2017). There are over 310,000 university students in Belarus. In May 2015, Belarus joined the Bologna process. This step has increased the attractiveness of Belarusian universities for foreign students. Over 19,000 foreign students from 98 countries currently take courses at Belarusian universities.

Belarus produces over 16,000 technical graduates annually and the level of brain drain is comparatively low, mostly due to the special state programme of support to young professionals [3]. It is also important that, in accordance with the labour laws, graduates who study at the expense of the state budget are provided with their first workplace. The state also provides social and financial guarantees to employees sent by their employers to vocational training, retraining, advanced training and internship (maintaining the average salary at the place of work for the period of study, payment for travel to the place of study, travel, subsistence, accommodation, etc).

Belarus ranks highly in the number of scientists and engineers per capita. As of 2015, the total number of organizations and institutions conducting scientific research was 439, with approximately 26,200 scientists and engineers being involved in applied and fundamental research. Of the total scientific population of Belarus, about 20% have a postgraduate academic degree, 648 are Doctors of Science (equivalent to Professor) and 2,822 are Candidates of Sciences (equivalent to PhD). Young people under the age of 29 years make up a quarter of Belarusian researchers.

The projects of Belarusian scientists are recognised at technical fairs. Over recent years, Belarusians have featured prominently in the Google Code Jam rankings, Google Hash Code, Yandex.Algorithm, TopCoder Open, Kotlin Challenge, VK Cup, and Facebook Hacker Cup.

The National Academy of Sciences of Belarus is the leading scientific centre of Belarus. The Academy scientists have achieved significant success in R&D activities in the fields of mathematics, physics, chemistry, biology, and Earth science. The staff of the Academy and affiliated institutions amounts to 8,700 specialists and comprises 30% of the total number of R&D experts in Belarus. Intergovernmental agreements on cooperation in science and technology have been signed with 60 countries, including Great Britain, Germany, India, China, Russia, the US and Japan.

1. The main features of the upper secondary curriculum

1.1. What type of breadth is featured?

Belarus's secondary school curriculum is very broad and standardised at all levels of secondary school education. The standards are developed by the Ministry of Education and include an obligatory list of subjects and the number of hours assigned to each of them. In primary school, students are expected to master 12 subjects, while in the basic curriculum, from Years 5 to 9, they study 22, and in the upper secondary, there are 17 mandatory subjects [4].

The authorities put high pressure on schools that in their turn exert high pressure on students so that everyone meets the state curriculum requirements.

Until recently, Belarus's secondary school curriculum was mainly focused on a systematic study of theories and encyclopaedia-style knowledge. The new Code on Education adopted by the Parliament in 2011 changed this focus to a competence-based approach stressing the importance of competences such as communication in the Belarusian and Russian languages (the mother tongues), communication in foreign languages, mathematical competence and basic competences in science and technology, and digital competence, as well as the more transferable skills, such as learning to learn, social and civic competences, initiative and entrepreneurship, and cultural awareness and expression [5]. However, there is still a long way to go to make the competences-based approach a reality in Belarus's schools.

Primary school studies (4 years) are devoted to acquiring basic skills and habits of writing, reading, numeracy; mastering primary knowledge of nature, society and man; and getting acquainted with principles of personal hygiene and a healthy way of life. The main objective of the primary school is not only the development of physical and intellectual capabilities of school children, ethical and moral properties of a personality, but also the development of children's steady interest in studying.

The basic school curriculum (5 years) includes the social-and-humanitarian stream (the Belarusian and Russian languages and literatures, foreign languages, history of Belarus and world history, man and society, social sciences), the natural and scientific stream (mathematics, informatics/computer studies, geography, biology, physics, chemistry, technical drawing), aesthetic stream (music, fine arts, world artistic culture), physical education and health, basics of safe living, and labour education.

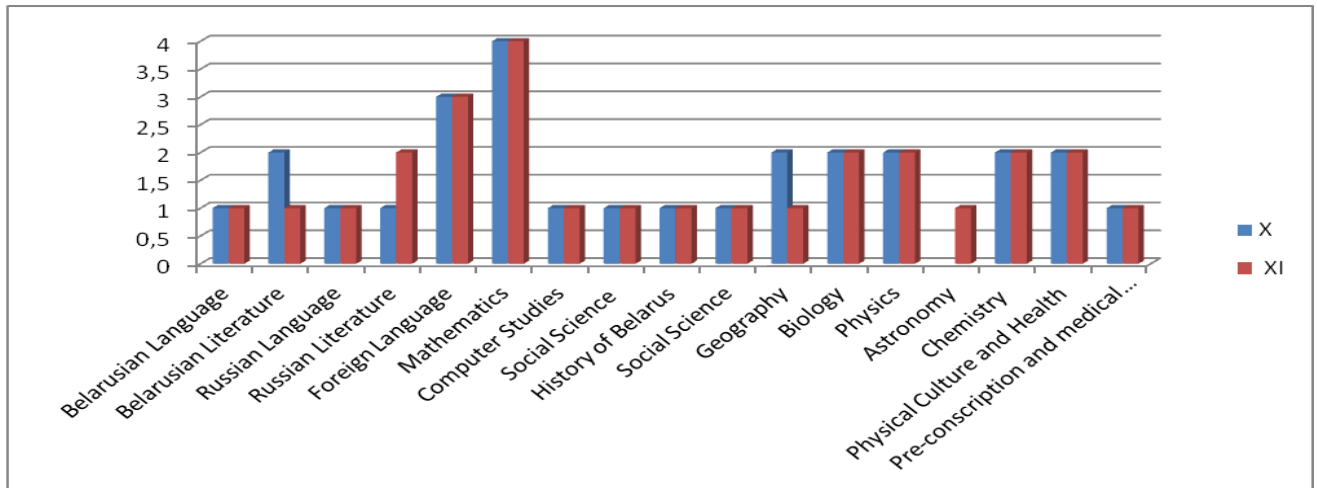
The upper secondary school curriculum (2 years) includes mathematics, physics and astronomy, informatics/computer studies, chemistry, biology, geography, Belarusian language and literature, initial military and medical training, Russian language and literature, world history, foreign languages, Belarus's history, social sciences, physical education and health. Students representing national minorities additionally study their national minority's language and literature.

Since Belarus gained independence in 1991 there have been several decentralisation and diversification curriculum reforms aimed at providing upper secondary school students with greater choice. The most recent of these allowed upper secondary school students to study the mandatory subjects either at basic or advanced (profiled) level [6].

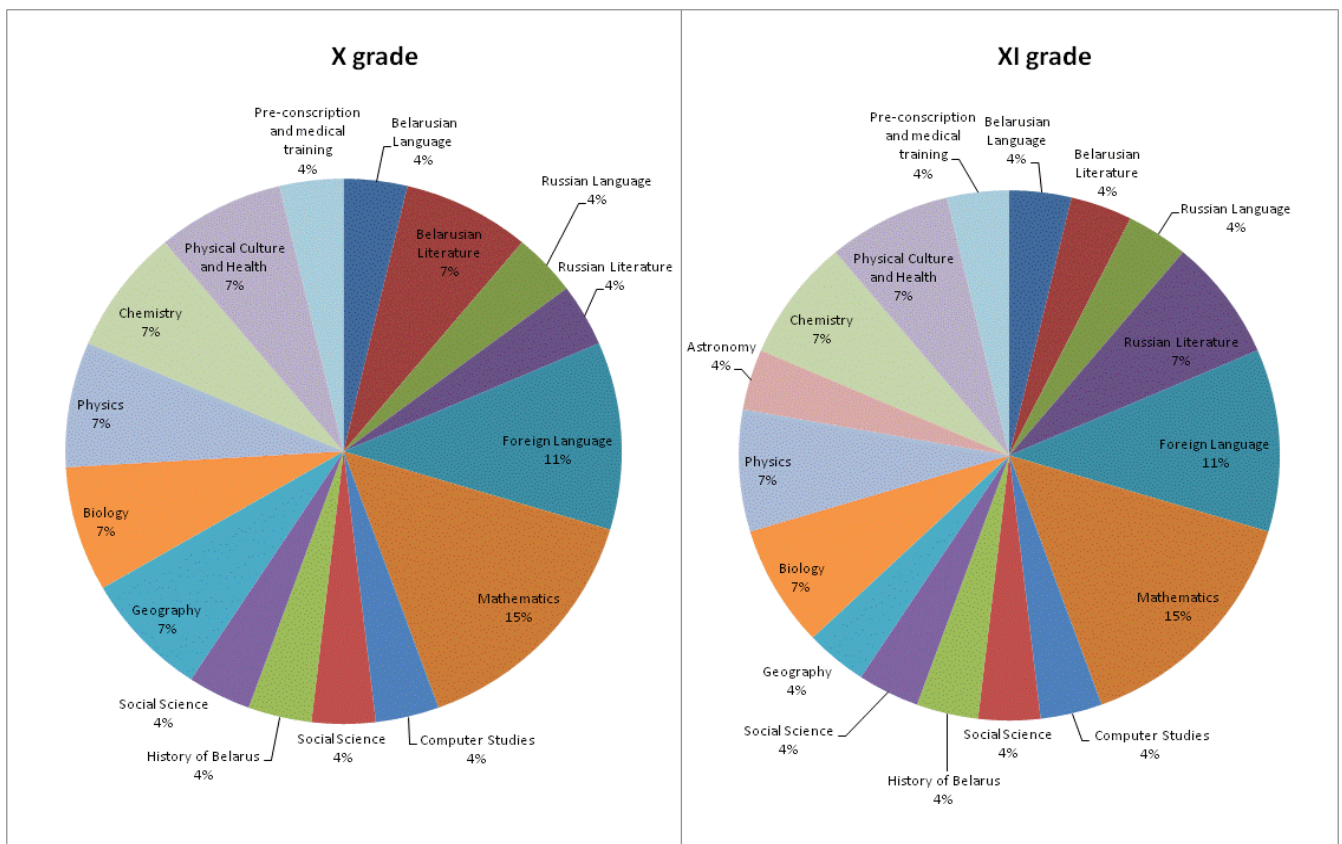
In line with the new curriculum, the weekly number of taught hours allocated for all subjects studied at the basic level in the 10th grade is 27 hours, 48% of which are allocated to studying mathematics and science (mathematics, 4 hours; physics, 2 hours; computer studies, 1 hour; chemistry, 2 hours; biology, 2 hours; geography, 2 hours). This is the same weekly number of academic hours allocated for all subjects studied at the basic level in the 11th grade. The percentage of hours allocated to studying mathematics and science in this

grade is also the same – 48% (mathematics, 4 hours; physics, 2 hours; astronomy, 1 hour; computer studies, 1 hour; chemistry, 2 hours; biology, 2 hours; geography, 1 hour).

Weekly academic hours allocated for subjects studied at basic level in 10th and 11th grades



Percentage of hours allocated to subjects studied at basic level in 10th and 11th grades



Number of hours spent on subjects in upper secondary school/gymnasium/lyceum

(Note: The first figure shows the number of academic hours per week allocated for a subject’s study at the basic level and the one after hyphen – at the advanced level.)

I. Compulsory subjects	Hours per week			
	Upper secondary school		Gymnasium / lyceum	
	X	XI	X	XI
1. Belarusian language	1-3	1-3	1-3	1-3
2. Belarusian literature	2/1-3	1/2-3	2/1-3	1/2-3
3. Russian language	1-3	1-3	1-3	1-3
4. Russian literature	1/2-3	2/1-3	1/2-3	2/1-3
5. Foreign languages	3 - 5	3 - 5	3 - 5	3 - 5
6. Mathematics	4 - 6	4 - 6	4 - 6	4 - 6
7. Computer studies	1	1	1	1
8. World's history	1 -2/3	1 -3/2	1 -2/3	1 -3/2
9. History of Belarus	1 -3/2	1 -2/3	1 -3/2	1 -2/3
10. Social science	1 - 2	1 - 2	1 - 2	1 - 2
11. Geography	2 - 3	1 - 3	2 - 3	1 - 3
12. Biology	2 - 4	2 - 4	2 - 4	2 - 4
13. Physics	2 - 4	2 - 4	2 - 4	2 - 4
14. Astronomy		1 - 2		1 - 2
15. Chemistry	2 - 4	2 - 4	2 - 4	2 - 4
16. Physical culture and health	2	2	2	2
17. Pre-prescription and medical training	1	1	1	1
Total	27 -31	27 -31	31	31
II. Optional sustaining, stimulating and other types of study conducted after regular lessons	12 - 8	12 - 8	9	9
Maximum allowed academic load on a student	34	34	34	34

The weekly academic load on students who select the advanced (profiled) level is 31 hours in both the 10th and 11th grades. An additional 4 hours are provided for advanced study of two subjects, for example, mathematics and physics, mathematics and foreign language, mathematics and chemistry, chemistry and biology, Belarusian and foreign languages, foreign languages and social science, biology and geography, Russian language and Russian literature, social science and history of Belarus, history of Belarus and world history.

For example, in the case of a student selecting advanced study of mathematics and physics in the upper secondary school, s/he may have 10 hours of these subjects a week (32% from the number of hours allocated for all subjects) instead of 6 hours (22%) provided for students taking these courses at the basic level. In this case mathematics and science subjects make up about 55% of the total number of hours allocated to teaching all subjects. Students can also develop additional skills through taking optional subjects and courses, sustaining, stimulating and other types of study conducted after regular lessons as an extra-curricular activity. However, their overall weekly academic load above the number of hours allocated for study at the basic level should not exceed 9 hours. Thus, if they already have 4 additional hours for advanced (profiled) study of mathematics and physics, they may still have 5 more hours that can be used for the development of additional skills in these or other subjects.

There are three models for grouping students who select advanced (profiled) study of subjects at upper secondary school.

Model 1: combining in one class students studying the same subjects;

Model 2: combining in one class students studying at an advanced level different subjects;

Model 3: combining in one class students studying subjects at an advanced level and others studying all subjects at a basic level (with the exception of gymnasiums and lyceums in which all students study subjects at an advanced level).

Enrolment of students in profiled classes of secondary schools is conducted on a competitive basis based on the results of their studies at the second stage of general secondary education. As for students' enrolment in the upper secondary schools, in which all subjects are studied at a basic level, it is carried out without profiling.

In the 2016/2017 academic year, profile classes were opened in 1,343 general secondary education institutions and involved 28,917 (49.7% of) 10th grade students and 26,336 (46.5% of) 11th grade students [7].¹

The introduction of the profiled curriculum component in upper secondary school has made for a more focused education in senior classes of schools of general education, gymnasiums, lyceums and colleges, directed to further education at appropriate educational institutions or to a certain sphere of employment. According to the Belarus Minister of Education, 'the results of the centralised testing of students who study academic subjects at an advanced level are traditionally higher than of those who study them at the basic level' [8].²

The content of the mandatory science subjects studied in upper secondary school is focused on a systematic study of theories and is currently being revised to provide more space for the competences' development through practising the application of these theories in standard and non-standard situations. For example, the mathematics curriculum includes such modules as: numbers and calculations; expressions and their transformations; equations; inequalities; coordinates and vectors; function; trigonometry; geometrical figures and geometric values; mathematical modelling of real objects; combinatorics and probability theory; and derivatives. The content of the mandatory algebraic component in the 10th–11th grades provides for the study of trigonometry, power, exponential, logarithmic expressions, equations, inequalities, functions; also, learning about the concept of derivatives. At the advanced level students study these topics in greater depth and also study the elements of probability theory, mathematical statistics, basic methods for solving probabilistic problems, operations with polynomials, equivalent systems, basic methods for solving systems of equations and inequalities. The content of the geometry component in these grades covers the mutual arrangement of straight lines and planes in space, the basic geometric bodies, their properties and the corresponding geometric values [9].

1.2. The relationship between academic and vocational tracks

The content of the mandatory science subjects studied in Belarus's technical-vocational and specialised secondary education institutions that provide general secondary education is the same as in the upper classes of secondary school so students could freely move between the academic and vocational tracks.

Full-time specialised secondary education can be obtained by persons who have basic education, general secondary education or vocational education with a general secondary

¹ Unfortunately, there are no statistics available on the number of students who are enrolled under each model.

² There is no publicly available data about impact of the profiled classes on student outcomes.

education, as for the daytime (evening) or correspondence courses – by persons with a general secondary or vocational education with general secondary education. Enrolment of students who have basic education in specialised secondary education is conducted through competition based on the results of their study at basic school. On average, studies last from 2 years 10 months to 3 years 10 months. These students have an advantage over their peers who study in secondary schools because in addition to obtaining the same secondary education certificate they receive a professional diploma. As for those who already have general secondary education enrolment in the specialised secondary education institutions is conducted through the same competition as for universities – based on the results of the centralised testing conducted by the Republican Institute for Knowledge Control [10].

2. What was the political and policy context behind reform of the curriculum?

2.1. The main political debate and justification of the model

Belarus's strategic goal of sustainable development includes the dynamic improvement of public welfare, enrichment of culture and morals of people on the basis of intellectual and innovative development of economy, social sector and spirituality, conservation of environment for the present and future generations. The key sources of sustainable development outlined by the Belarus Government in the National Strategy for Sustainable Development are: human capacity, scientific production and innovation potential, natural resources, advantageous geographical location of the country, while 'high intellect – innovation – prosperity' constitute the top priorities [11].

For the transition from a Soviet-centralised, state-centred system toward more innovative development, systematic reforms to the economy and society are considered as essential tasks for sustainable development in Belarus. A strategic goal is to create a system of education that would meet the requirements of individuals, society and state, create conditions to develop education further and prepare new generations for life and work in the civil society with a sustained people-centred market economy. [11].

In line with the National Strategy, the following tasks need to be addressed to achieve this goal:

- create an enabling environment for meeting the needs of people in education, acquisition of profound and comprehensive knowledge, harmonious development of human personality and creativity;
- ensure access to free general secondary vocational and, on a competitive basis, specialised secondary and higher education, ensuring the succession and continuity of education levels and stages;
- raise the intellectual and cultural potential of the population through the improvement and optimization of the national education system;
- ensure the national education system corresponds with the global education environment.

During this period, the leading development of education and its orientation toward the needs and values of the future postindustrial civilization becomes particularly important for Belarus. In this context, the substance and methods of teaching needed to be adjusted to develop individuals' creative qualities, their capacity to make decisions and act independently, to continually develop knowledge and improve their professional competence.

The main political debates regarding educational reforms required by the National Strategy for Sustainable Development in Belarus are about the right balance for Belarus between the state-centred, standardised model, focused on mathematics and science, and a more student-centred, decentralised, flexible, interdisciplinary, competence-based model, focused more on the humanities, as both of them have their strengths and weaknesses.

In the process of curriculum transformation and implementation educational policy-makers, curriculum developers, school administrators, teachers and other educational stakeholders in Belarus are confronted by ethical dilemmas about what is 'good' and 'bad' in education.

- According to Zagoumenov (2011), these dilemmas are as follows [12]: Meeting each individual student's educational needs versus meeting standardised requirements set by the central authorities.

In the traditional, centralised, Belarusian educational system this belief conflicted with the leadership and teaching practices where students were expected to meet standardised requirements and where standardised methodologies aimed at an 'average' student were applied. The new assumption shifts the focus to creating an educational environment tailored to each individual student's needs, interests, and personality. The current Belarus upper secondary education curriculum better reflects a balance between what the individual student needs and wants to learn with what the society needs to transmit for its preservation. But, so far, Belarus has particularly advanced in creating a favourable educational environment for talented and gifted students and the challenge now is to make this inclusive and favourable for other groups of students as well.

- Competence-based approaches versus mastering theories and encyclopaedic knowledge.

The focus of education in Belarus has been mainly on the mastery of theories and encyclopaedic knowledge. However, in a world where information is expanding rapidly, mastery is an impossible goal. Instead, each student needs to develop key competences including the ICT skills to master new information as it is created, and the flexibility for continuous learning. Higher order thinking skills that allow students to evaluate the worth of new ideas should be also a major goal of the curriculum. So far, Belarus has been particularly advanced in the development of students' ICT competences. As for the opponents of the key competences approach, they are concerned that competences development in Belarus will be narrowly restricted to mastering skills and attitudes at the expense of the systematic study of theories. They also doubt the ability and expertise of the existing curriculum developers, school leaders and teachers to adopt and use the new paradigm in a way that a reasonable balance between theories and practices is achieved in Belarus's schools.

- Educational quality versus equity.

Balancing quality and equity is a very topical issue reforming education in Belarus and in many other countries. Until recently, streaming and tracking students based on their abilities and behaviour has been the major pedagogical method for responding to diversity in secondary schools in Belarus where 'classes and groups are streamed based on recommendations by psychologists and medical workers' [13]. The efforts by Belarus to raise educational quality by segregating students based on their abilities and promoting 'elite' classes and schools have conflicted with providing equity of opportunity in education. In 2008, the supporters of the 'equity' approach managed to convince the Belarus political authorities to stop streaming in schools so that all students receive equal access to the same quality of education [14]. The curriculum reform in 2016 returned advanced (profiled)

courses in the upper secondary school and is viewed as a compromise reached by adherents of 'equity' and 'quality' approaches. Currently at least two of the three models of grouping upper secondary school students who select advanced (profiled) study of subjects are inclusive.

- High academic pressure versus caring about students' physical and mental health.

According to the opinions of parents, students and school administrators, while teachers are formerly expected to take care of students' health, in reality they are not able to do so because they lack time and understanding. They strongly object to caring about students' health as their primary responsibility and would rather blame healthcare institutions for doing nothing. Some university-oriented upper secondary schools promote informal entrance health requirements by warning students and their parents that high academic pressure in these schools may lead to health problems. Still, there are many adherents of 'academic pressure' who truly believe that this approach is the major factor in Belarus's educational achievements.

- Democratic versus authoritarian schooling.

In Belarus, an authoritarian, top-down system of curriculum management has been challenged by the process of democratization. The new belief is that all stakeholders in a school should have input into the design of the curriculum of that school. The principle of consensus should govern the input of the eight stakeholders: students, parents, teachers, administrators, staff, community, higher education and government policy makers. New democratic structures involving these stakeholders have been set up in schools to manage curriculum and other issues in line with the new Educational Code. However, little has changed in reality as a cultural shift is still required, changing the values and attitudes of educational stakeholders.

According to Zagoumenov, all the listed dilemmas are interrelated. They have already had and will continue to have implications for education policy makers, curriculum developers, school leaders and teachers in Belarus in the near future.

Russia and other CIS states are confronted by similar dilemmas. But unlike Belarus, which adheres to a more incremental approach, these countries have often moved to a Western-style decentralised model too fast without a proper understanding of its essence and ignoring national traditions in education. No wonder that, for example, in Russia, the decentralisation reforms have led to considerable difficulties and the government has since had to restore order to the system by giving some control back to Russian educationalists [15].

2.2. Other key policy drivers for reform

The recent development of Belarus's closer economic and political relations with Western countries in line with the government's 'multi-vector policy' was a key driver for curriculum reform. As stated by one of the Belarus's top government officials, Belarus's relations with Europe must be built on shared values, not only on economic pragmatism [16]. And education is one of the key factors in this respect. This new trend in Belarus's foreign policy has allowed the supporters of curriculum reform represented in the Public Advisory Council under the Aegis of the President of the Republic of Belarus to promote strategic decisions concerning national curriculum reform such as the inclusion of the competences-based approach in the Educational Code of Belarus, which in turn led to radical changes in the national curriculum, including the revision of educational standards, textbooks and teaching methodologies as well as the decision by the government of Belarus to participate from 2018

in the Programme for International Student Assessment (PISA) [17]. These strategic decisions have already had a positive impact and will continue to impact on curriculum development in Belarus in the near future.

3. How do the scientific subjects and skills feature within the curriculum?

The study of mathematics and science in upper secondary school is mandatory, meaning the take-up of scientific subjects in Belarusian high schools is universal. However, assessment of subjects in centralised testing is only compulsory in either the Russian or Belarusian language.

There is no official data available about the number of upper secondary school students who study maths and science at an advanced level. Based on the figures below, the number and proportion of students with a General Secondary Education certificate willing to continue the study of these subjects in university or at a specialised secondary institution is fairly high, suggesting the subjects are popular choices. To be well prepared for centralised testing, it is likely that most students take up the scientific subjects in upper secondary school at an advanced level.

In line with the Belarus regulations for enrolment in university and specialised secondary educational institutions, students are required to pass centralised testing conducted by the Republican Institute of Knowledge Control [18]. Testing in one subject is mandatory and it is either the Russian or the Belarusian language, as communication in these languages is a key competence students are expected to have mastered in schools. The choice of other subjects depends on the profile of university programme a person wants to be enrolled in.

Data on the trend in participation in centralised testing by subjects over the last 3 years

Subject	2015		2016		2017	
	persons	%	persons	%	persons	%
Belarusian language	23,183	23.6%	21,717	22%	27,144	27.1%
Russian language	74,979	76.4%	75,832	78%	72,894	72.9%
Mathematics	49,719	50.6%	45,623	46.8%	49,088	49.1%
Physics	27,001	27.5%	26,091	26.7%	28,022	28.0%
Biology	20,688	21.1%	22,606	23.2%	28,448	28.4%
Chemistry	11,710	11.9%	11,770	12.1%	15,069	15.1%
Geography	1,273	1.3%	1,029	1.1%	1,694	1.7%
Foreign languages	26,506	27.0%	25,086	25.7%	30,649	30.6%
Social science	10,253	10.4%	10,940	11.2%	16,362	16.4%
History of Belarus	16,437	16.7%	17,948	18.4%	23,375	23.4%
World history	1,115	1.1%	1,184	1.2%	1,584	1.6%

As seen from the participation results, candidates prefer to take the centralised test in Russian rather than in the Belarusian language. Belarusian and Russian are both considered official languages of Belarus, but only 23% of the 9.67m population speak the former, whereas more than 70.2% speak the latter. No more than 10% of Belarusians say they communicate in Belarusian in their day-to-day lives [19].

Participation in mathematics comes next after the Russian language as mathematics competence is also considered as key, laying the basis for the development of the competences in the sciences.

Physics comes next. Physics, along with mathematics, is important for programming and engineering, which are the most favourite professions among young people in Belarus.

To meet this demand as well as the needs of the Belarus economy in 2017, the government is expanding its financial support to universities for mathematics and science so that more students receive higher education free of charge in the fields of energy, biotechnology, robotics, automation, physics, mathematics, astronomy, space technologies, 3D technologies, nanotechnologies, pharmaceuticals, ecology and other promising areas. However, Belarus's universities are not able to accept all candidates wanting to study these subjects. For example, in 2017 there were three candidates for each place to study mathematics and information technology and competition was even stiffer to study computer science at the Belarus State University. According to the Ministry of Education, along with IT in 2017, there is a considerable growth of entrants wishing to study technical and technological subjects [20].

One of the most powerful external drivers for a take-up of scientific subjects in upper secondary school is rapid development of the Belarusian software services sector as a part of the global IT business. The country's reputation for scientific and IT excellence complemented by the competitive labour market has attracted the interest of numerous IT-intensive companies. Over the last five years, the compound annual growth rate (CAGR) of the Belarusian IT industry constituted 30%. IT service exports rose by 20% in 2016. The growth rate of imports was 7%. Belarus is one of the world's leaders in terms of IT outsourcing. The country's IT companies rank high in global ratings. Six Belarus-based developers (Ciklum, EPAM, IBA Group, Intetics, Itransition and Bell Integrator) were ranked in the 2016 Global Outsourcing 100 by IAOP. In 2015, ten Belarusian IT companies were mentioned in the Software 500 rating published by Software Magazine, one of the most influential periodicals in global hi-tech industry.

As acknowledged by representatives of the Belarus IT business community, high quality mathematics and science education is one of the key factors that contributed to their success. In turn, the success of IT industry and high salaries of professionals involved in this business in Belarus are among the key factors that motivate young Belarusians to study mathematics and science in Belarus's schools, colleges and universities.

The other factors that have contributed to the popularity of mathematics and science education in Belarus are the traditions of the Soviet system of education that valued mathematics and science as the priority areas for study. Existing values and beliefs of parents emphasise the importance of mathematics and science education for successful professional careers for their children. Within lower and middle tiers of schooling, the compulsory standardised mathematics and science curriculum, aided by top-down academic pressure on students, has tended to encourage uptake of these subjects in upper secondary school, along with the system of quarterly and annual testing of students' achievements in mathematics and science and the centralised testing on these subjects required for enrolment in universities and secondary-specialised education. The profiling of educational programmes and grouping of students in high school based on their interests and their ability to master the advanced mathematics and sciences curricula may also be contributory to their popularity, along with systems of motivation to study mathematics and the sciences at advanced levels, including selection of and social and financial support to gifted and talented students in mathematics and science.

4. What evidence is there impact of the broad nature of the curriculum on student outcomes?

Along with the self-assessment of students' academic achievements conducted by every school through the system of quarterly and annual testing, the impact of the secondary school curriculum is measured through monitoring conducted by the National Institute of Education of the Belarus Ministry of Education.

In 2013/2014 the monitoring of quality of general secondary education was carried out in 90 institutions including high schools, gymnasiums and lyceums located both in urban and in rural areas. It involved 9,200 students, 980 parents and 1,750 teachers. Students were put forward to take tests that included tasks with different level of complexity.

The percentage of upper secondary school students who passed the tests at the average, sufficient and high levels were as follows: the Belarusian language, 90%; the Russian language, 58%; mathematics, 57%; physics, 44%; chemistry, 67%; biology, 72%. The remainder passed the tests at either satisfactory or low levels. The majority of students did not cope with the tasks of the fourth and fifth levels of complexity. Tasks at these levels required the demonstration of competences in solving new problems in unfamiliar, non-standard situations. There is hope that the recent shift to a competences-based approach in curriculum design and implementation will improve attainment.

About 50% of students in upper secondary schools confessed that they had trouble in studying the above subjects (up to 70% of them in mathematics). They complained the subjects were too difficult and that the educational material in textbooks was not always presented in ways that were easy to comprehend [21].

Other evidence of the impact of the curriculum on students' outcomes is provided by the Republican Institute for Knowledge Control, which conducts annual centralised testing required for holders of secondary education certificates' enrolment in universities and specialised secondary educational institutions. In 2017 there were 56,681 graduates of general secondary education institutions, of whom 48,481 (85.5% of all graduates) took part in the centralised testing seeking to continue their education at universities.

In 2016, the percentages passing the centralised testing were as follows: Belarus language, 94.0%; Russian language, 92.8%; mathematics, 64.6%; physics, 64.1%; biology, 93.7%; chemistry, 87.6%; geography, 82.0%; and foreign languages, 78.8%.

As seen from the above figures, Belarus's students demonstrate good command of native languages: both Belarusian and Russian. This is a result of the broad nature of the curriculum in which languages are viewed as key competences students are expected to have mastered in schools. Recently, a particular focus has been on mastering foreign languages, which are considered highly important by the government for ensuring Belarus's integration into the global market.

The following information could also serve as an evidence of the impact of upper secondary curriculum on students' outcomes, namely on outcomes of gifted and talented students who are famous for winning medals at science Olympiads and other contests, as well as international programming competitions and championships, including ACM ICPC.

In 2016 at science Olympiads and other contests Belarus school children won 42 medals, including 5 gold medals, 17 silver medals and 20 bronze medals (in 2015, 37 medals were won, including 1 gold medal, 15 silver medals and 21 bronze medals).

For example, at the XXIII international conference of young scientists in physics, mathematics, informatics and ecology held in Romania in April 2016, Belarus students won two gold medals, one silver medal and three bronze medals, and received a special prize for the best report presentation.

At the XIX International Youth Physics Tournament held in Russia in June 2016, the team of the Republic of Belarus won bronze medals.

At the VIII international tournament for young mathematicians in July 2016 in Russia, the Belarus team won silver medals.

One gold and three bronzes were brought home by Belarusian schoolchildren from Stuttgart in 2017, where the XXIV international conference of young scientists was held, at which 150 students from 26 countries represented their research in physics, mathematics, informatics and ecology.

The Belarusian team won one gold, one silver and four bronzes at the International Mathematics Olympiad held in Brazil in 2017. In the team competition Belarus took 14th place. Teams from 111 countries took part in this competition.

Belarusian school students won three silver medals and one bronze medal at the International Chemistry Olympiad, held on July 17 2017 in Thailand. Students from 76 countries took part in the competition.

All members of the Belarus team were awarded medals at the International Young Physicists Tournament held in Jakarta, Indonesia, in July 2017 (two silver and three bronze medals).

Belarus's team received the gold medal at the Young Mathematicians Tournament held in Romania in July 2017 and won the absolute first place. For all years of participation in this international tournament, the Republic of Belarus has won five gold, three silver and four bronze medals – the best result among all member countries of the international tournaments of young mathematicians.

5. What financial and practical applications have there been as a result of the curriculum model adopted?

The major financial and practical challenges faced by Belarus as a result of the curriculum model adopted are connected with the implementation of the competences-based and inclusive educational approaches. The National Institute of Education was assigned by the Ministry of Education to develop new educational standards for each school subject taught in the upper secondary schools, and then based on these standards to develop and publish new textbooks which, in line with the Belarus regulations, are distributed to students. New teaching methodologies and guidelines for teachers on how to implement new approaches were also to be developed.

The implementation of the new curriculum model had implications for training and retraining of teachers so that they could apply the new approaches at the classroom level. In line with the Belarus regulations, teachers are to take in-service training courses every third year of their service, with the costs of these covered by the government. Finally, since the curriculum reform was initiated and implemented, the major challenge was to change the mindsets of school leaders, teachers and parents as many of them still believe that the Soviet curriculum model to be better than the new one, particularly for teaching mathematics and science.

Concluding remarks

The example of curriculum reform in Belarus reveals how effective teaching of scientific subjects in the upper secondary schools is about the need to find the right balance between a state-centred, standardised, top–down, traditional and theoretical approach and a more student-centred, decentralised, flexible, competences-based approach, as both models have their strengths and weaknesses.

The ‘golden point’ of this balance is particular to each country and depends on a country’s political, economic, social, cultural and educational traditions as well as on the values and beliefs of the key educational stakeholders. Belarus’s incremental approach in shifting from a centralised to a decentralised curriculum could serve as a lesson for those countries that have either too narrow or too broad a curriculum model, especially in instances where implementation has occurred too swiftly and without proper understanding of the consequences.

The example of Belarus could also be of use for countries with a more longstanding decentralised model of education, which may have led to a loss of control over the curriculum or an unwillingness to reform, potentially leading to a narrow and outdated programme of study in upper secondary school where too few students study mathematics and science beyond the age of 16 and gain the skills needed for key STEM sectors, as seen by the development of the IT industry in Belarus. The rapid development of the software services sector as a part of the global IT business and its influence on the upper secondary school students’ enrolment in mathematics and science programmes could serve as an example of how industry can help shape the take-up of particular subjects.

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