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The future of physics teaching: Features of the new Hungarian National Core Curriculum and curriculum frameworks

Sándor EGRI, Gábor HORÁNYI and Péter ÁDÁM

Education 2030 Research Group in Learning Science Eszterházy Károly University, Eger, Egyetem tér 1 H-4033, Hungary

Abstract. The new Hungarian National Core Curriculum was announced in January 2020, and the curriculum frameworks became available soon after. The authors took part in the development of the curriculum of physics. In this communication we present the main features of these new curricula. The learning outcomes of the core curriculum, the learning contents and the arrangement of the topics in the frameworks have been renewed in order to promote a more efficient way of physics teaching. The curriculum relies on the methods of active and phenomenon-based learning, it includes up-to-date contents, focuses more on practical topics, and follows the principles formulated by the OECD.

1. Introduction

It is a common experience that digital technology evolves and spreads rapidly leading to the fundamental transformation of our living conditions: the channels of communication, our entertainment, the way we work or do the shopping. This constantly changing environment necessitates the fundamental change and transformation of education as well [1]. The essence of these changes is summarized by Andreas Schleicher, the Director for Education and Skills at the OECD, as: “Education is no longer about teaching students something alone; it is more important to be teaching them to develop a reliable compass and the navigation tools to find their own way in a world that is increasingly complex, volatile and uncertain. Our imagination, awareness, knowledge, skills and, most important, our common values, intellectual and moral maturity, and sense of responsibility is what will guide us for the world to become a better place. [2]”

According to new surveys [3] the popularity and the knowledge level of physics amongst pupils are low in most schools in Hungary. Moreover, there is an increasing shortage of physics teachers because only a few teachers graduated and started teaching in the past 20 years. The mere fact that the number of physics lessons decreased in the past decades does not explain the recently experienced negative tendencies. In our opinion, the problems rather stem from the fact that in the last decade the content and methodology of teaching physics has not been relevantly reformed according to the changes of the society and the technology. This content and methodology do not meet the expectations and attitude of the pupils and do not result in useful scientific literacy and skills that can be applied in the future. Accordingly, reforming the content and methodology of physics teaching by applying international experiences can be essential to overcome most of these issues. Firstly, the employment of student-centered, active learning pedagogy and interactive engagement methods can help to motivate pupils and to improve their conceptual understanding [4, 5]. Besides traditional lab exercises and problem solvings in the course of physics teaching, interactive lab activities [6], smart phone-based measurements [7],



online quizzes based on polling applications [8] or workbooks developed for self-paced learning [9] might be used to increase the activity of the students.

Secondly, in the last decades, a wide range of materials and curricula were developed that use contexts and applications as a starting point for developing an understanding of scientific ideas. These approaches are known as 'context-based' [10] and 'applications-led' learning, and 'Science-Technology-Society' (STS) education [11]. Application of these approaches in general has good effect to the motivation and understanding of the students. "Findings suggest that there is moderate evidence to indicate that context-based/STS approaches promote more positive attitudes to science in both girls and boys and reduce the gender differences in attitudes [12]." Another study indicated –amongst other similar findings - that less talented pupils in classes using a context based/STS approach developed a better conceptual understanding of science and held significantly more positive attitudes to science than those taking conventional courses [13]. The starting point of the context-based approach is the finding that less motivated students become discouraged during learning the theoretical basics and they never will be able to apply this knowledge to solve practical problems. It is more profitable for them to organize the learning process around those questions/topics that really interest them [14]. A promising novel learning method that is also suggested by the Hungarian National Core Curriculum issued in 2020 (NCC2020) is called phenomenon-based learning [15] that was originally introduced in the Finnish NCC [16]. The starting point of this method in science education is the comprehensive observation of a natural phenomenon (e.g., the sunset or the operation of an instrument or a toy). The development of the related scientific concepts and models is realized, often in an interdisciplinary approach, during the description, characterization and explanation of the chosen phenomenon [17].

The NCC and the variation A of the curriculum frameworks for physics issued in 2012 made the first steps towards this new direction by integrating novel learning topics connected to everyday life. The course-book for variation A outlined the way of successfully implementing the ideas of more practical and up-to-date physics teaching by concentrating the material around important practical applications in a context-based fashion [18]. The positive feedback from the teachers who have tested the new course-book motivated us to continue the developments in this direction. In this communication, we present the main features of the NCC2020 and curriculum frameworks for physics [19,20], the development of which was partly performed by us as the members of the Education 2030 Research Group.

2. Features of the new National Core Curriculum

The National Core Curriculum and the related curriculum frameworks together regulate the education for educational institutions. The NCC2020 defines the general principles and aims, and it formulates the learning outcomes in general for the different subjects. The developmental tasks, the elements of knowledge and main concepts required for the realization of the learning outcomes are explained in the curriculum frameworks in a comprehensive manner up to a certain level of specification. The question regarding "what should I teach" can be fully answered by the overview of the related course-books.

According to the NCC2020, pupils learn fundamental concepts of science firstly within the frame of an integrated subject in the 3rd - 6th years of the primary school. Physics, as a separate subject, is present in the years 7 and 8 but the curriculum allows the schools to teach physics as the module of an integrated subject as well. In secondary school, physics is taught in the years 9 and 10 as a separate subject.

The chapter of the NCC2020 describing the physics subject is comprised of three parts. The first part formulates the general principles and aims of physics teaching, the second part lists the main topics and the learning outcomes are presented in the third part, grouped according to the development areas for the years 7-8 and 9-10, respectively.

2.1. Principles and aims of physics teaching

The chapter of the NCC2020 describing the physics subject first declares that physics literacy is a fundamental cultural value, its preservation and augmentation are prominent tasks for the succeeding generations, and it is the manifestation of the commitment towards the future. The principles and aims of physics teaching are described in this section in accordance with the current educational principles

and learning methods described above in the Introduction. Accordingly, it is recommended here that during the teaching of physics the emphasis should be put on developing the physics mindset and its applicability in everyday life. Application of phenomenon-based learning [15] and active learning pedagogy [4, 5] is also recommended. The NCC2020 emphasizes the importance of experience-based learning [21] that is facilitated by the appearance of certain social and economic relations in the curriculum that are linked with physics, establishing the possibility of context-based learning [10]. All these educational methods might help eliminating the antipathy against physics that can be observed in several pupils.

A further important concept that also appears in the programme of the OECD [1] is that despite the accessibility of the digital contents and programs the personal human knowledge will never become obsolete, the fundamental professional skills and professional knowledge will not become superfluous. In the case of physics, this is especially important for those planning a career in natural sciences or in engineering.

After the section of the principles the general objectives of physics teaching are listed. These goals are grouped around three main areas: making the students learn the fundamental knowledge of the given discipline, getting the students acquainted with the physics aspect of the natural phenomena and widely used technologies that are part of our everyday life, and achieving the scientific literacy in physics including the social and economic aspects of physics and the connection with other natural sciences, and its role in realizing sustainable development.

2.2. Main topics of physics teaching

In the next section of the NCC2020 for physics the main topics are enumerated. The topics present a possible and recommended arrangement of the knowledge and development.

Main topics in years 7-8:

1. Observation and simple interpretation of physical phenomena.
2. Motions in our environment, traffic and transport
3. Air, water, solids.
4. The working principles of our major mechanical, thermodynamic, electric and optical devices, heating and lighting in the household
5. Forms of appearance of energy, energy conservation, power generation, utilization and consumption
6. Earth, the Solar System, the Universe; the future and protection of Earth

Main topics in years 9-10:

1. Observation of physical phenomena, modeling, interpretation, scientific reasoning.
2. Motions in our environment; kinematic and dynamic aspects of traffic and transport
3. States of matter and their interconversion; properties of gases, liquids and solids
4. Elements of the physics of the human body
5. The working principles of our most important mechanical, thermodynamic and electric devices; heating and lighting in the household
6. The role of the waves in recording and forwarding pictures and sounds
7. Forms of appearance of energy; energy conservation, power generation, utilization and consumption
8. The structure of the atom, light emission, radioactivity
9. Earth, the Solar System, the Universe; the future and protection of Earth; results of space exploration

As it can be seen from the lists, the topics follow a spiral-like structure. Topics discussed in the primary school appear in an expanded and improved way in the next educational stage at secondary school. These topics correspond to the principles and aims of physics teaching and the recommended

educational methods described previously. They give guidance to the teacher to focus on those topics that are most useful from a practical point of view. They can be the possible titles of the chapters of a "science-type" course-book or the main topics of a local curriculum frameworks in the years 7-8 and 9-10 that follows the logic of e.g. the "A" curriculum frameworks for physics issued in 2012 [20]. We note here that these topics are not arranged according to the traditional topics in physics teaching that follow the scientific logic as it was e.g. in the "B" curriculum frameworks for physics issued in 2012 [20]. Nevertheless, these newly introduced main topics do not forbid the use of the traditional logic.

2.3. Learning outcomes and development areas

One of the novel features of the NCC2020 is that the desired results of learning is presented in the form of learning outcomes. Most of the learning outcomes realized during the teaching of physics are listed by the NCC2020 by categorizing them into so-called main development areas and development sub-areas. The main areas are the same in both primary and secondary schools, however, the system of sub-areas of development is wider in the latter case.

The development areas in years 9-10 are as follows:

- Scientific methods of physics
 - Observations, performing and interpreting experiments in physics
 - Physics as a science, novel results and methods in physics
 - Scientific reasoning and dispute/discussion, presenting the results
- Social aspects of physics, natural awareness and environmental consciousness
 - Role of physics in protecting the environment
 - Physical aspects of energetics
 - Physics background of global issues
 - The importance of physics for the society and economic growth
 - Life and work of notable physicists
- Physics of natural phenomena, technology and devices
 - Physical basics of the most common natural phenomena
 - Physical basics of the frequently used technological devices
 - Physical aspects of a healthy lifestyle
- Professional knowledge in physics
 - Motions in our environment
 - Energy
 - Matter and the states of matter
 - Electric and magnetic phenomena
 - Atoms and light
 - The Universe
- Application of digital technologies
 - Using physics-related databases and interactive simulations
 - Critical thinking in web search to acquire physics-related information
 - Preparing computer presentations to present and share information on physics
 - Computer-based analysis of measurement data, creating tables and graphs

As we can see from the list, aims are not restricted to the core concepts of disciplinary physics knowledge. In accordance with the concepts presented in the previous sections, pupils are more motivated in learning topics connected to everyday life such as health problems, usage and operating principles of the electronic devices and problems heard and seen in the media. It is essential to have enough information about the science of physics: how it works, what the role of physics in the changes of society and technology is, the way a physicist is doing scientific research.

The appearance of global problems among the development areas is important to improve the awareness of pupils and to awake their feelings for responsibility. In this way we can help the future generation to solve or to deal with the challenges ahead.

Learning outcomes are statements that describe the skills and/or the knowledge pupils should acquire by the end of a particular educational period. They generally focus on the context and potential applications of the respective knowledge and skills. This application can take place during a scientific discussion, critical analysis or during an innovative process of creating a new design. Here we are giving some examples of learning outcomes:

- The student understands the working principle of nuclear reactors and problems of storage of radioactive isotopes.
- The student knows the changing of the air pressure and understands its connection with weather changing.
- The student applies Ohm's law to calculate the current in a simple circuit.
- The student explains why an airplane can fly.
- The students measure some physical quantities with mobile phone sensors.

As can be seen, these learning outcomes are somewhat general and closely related to everyday phenomena.

3. Features of the physics curriculum frameworks

Curriculum frameworks have been developed to help teachers to follow the way of teaching outlined in the NCC2020. The physics curriculum frameworks for primary and secondary schools start with a general introduction about physics teaching. In this section the principles of the NCC2020 are reformulated in more detail and in relation to the given educational period. After this part the list of topics and recommended number of classes are given. As an example, we present the list of topics at secondary schools here:

Table 1. Topics of the curriculum framework for secondary schools.

Simple motions	12
Periodic motions	12
Physics of sport and transportation	12
The energy	10
Consequences of warming and cooling	12
Water and air in our environment	10
Machines	9
Sparkles and thunders	10
Electricity in the environment	14
Generators and motors	10
Waves in communication	14
Pictures and the way to see them	10
Atoms and the light	9
Keeping the health of the environment	12
Discovering the Universe	14

It is easy to see from the table that there is a strong connection between the topics and everyday life. To explain the content related to each of the topics in more detail, a list of knowledge and skills is provided in a similar fashion as learning outcomes are presented in the NCC2020. One row of this list can serve as one possible topic of a single class.

Some examples from the topic of periodic motions:

- Simple circular motions: generation, observation, interpreting its formation through the concepts of centripetal force and acceleration

A single development task contains the student activities (creation and observation of circular motions), the concepts to be taught (centripetal acceleration and force) and their application in interpreting the circular motion. This approach prevents the undesirable process in which the creation and observation of the phenomenon is canceled due to lack of time while the definition of concepts still remains.

- Interpretation of the physical background of common circular motions in everyday life (e.g. clothes centrifuged in a washing machine, valve of a bicycle, point on the surface of Earth)

Based on the choice of the teacher, the task is the physical interpretation of a well-known everyday application that is suitable for realizing a context-based class.

- Recognizing various swings in the surroundings: swinging children, acrobats on trapeze etc.
- Observation of damped vibrations, oscillations and swings in the surroundings, their characterization with respect to amplitude, frequency and the rate of damping.

These are two development tasks that support phenomenon-based learning, they require the observation of real phenomena occurring in the real world.

As a further help to the teachers, we are giving the list of main concepts and plenty of possible activities to apply in the classes. The teacher can choose from these activities according to the local possibilities and requirements.

Suggested activities in the topic of repeated motions:

- Write a report on the importance of rotational speed (Revolutions per minute, rpm, speed of revolution) in the case of centrifuging clothes or drilling. Finding (Searching, looking up) data on the characteristic values of the rotational speed.
- Create a presentation on grandfather clocks: structure, tasks of the various parts, the operation of these clocks.
- Create a pendulum with a period of 1 second; verify it.

Examples from the topic of transport and sports:

- Discovering the structure and physical background of one or more sports equipment such as skis, balls etc.; sharing the results with the classmates.
- Experimental observation and analysis of influencing the friction between two sliding surfaces by the application of a small amount of contaminating material such as powder or oil. Building a suitable experimental device (e.g. a slope with variable inclination angle)
- Present the pressure reduction of an air stream using simple demonstration devices.
- Studying slow-motion recordings of collisions or deformation of balls taken by high-speed recording cameras.

Part of the proposed activities can be performed by conventional lab devices, but generally they only require the use of the materials available in the surroundings. These tasks are mostly homework activities, or they can be realized as school projects.

4. Summary and conclusions

The chapter of the new Hungarian NCC2020 concerning physics has been developed to correct the present imbalance and frustration in physics teaching that comes from teaching “old-fashioned” content and applying passive learning methods in most of the physics lessons in the schools. The aim was to create a curriculum that ensures Hungarian pupils to have an up-to-date knowledge and the possibility to improve the important skills for a successful life in the 21st century, like collaboration, communication, creativity, critical thinking. It is also important to improve the awareness of the global challenges of mankind, like climate change, energy issues, and pollution.

The areas of development and the learning outcomes of the new NCC2020 in physics have been developed in support of the introduction and application of novel methods including active, context-based, and phenomenon-based learning. They cover three important constituents of modern curricula: disciplinary and theoretical knowledge, improvement in attitudes and main competences, and supporting knowledge transfer and application.

According to the main idea of the newly developed curriculum frameworks, the teaching of physics starts by observing and experiencing the phenomena that are frequent and important in everyday life and in practical applications. Starting from this firm basis and avoiding any unnecessary abstraction and mathematical formalism, pupils can become familiar with the main laws and concepts of physics in an efficient way by using modern methods and applying different ways of active learning. The incorporated novel methods and the context-based organization of the topics in the NCC2020 and the physics curriculum frameworks can lead to a more efficient teaching of physics and they can contribute to forming a positive attitude towards learning this discipline.

5. Future issues

A good curriculum framework alone is not enough to improve work in schools. It is essential to create new materials that help the work of the teachers: course-books, collection of examples, collection of check-point questions, sample plans for the classes, presentations, interactive materials, and handbooks. Their dissemination is also important: these materials should reach the schools and the teachers easily.

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