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Harmony and Disharmony of General Education in Natural and Technical Sciences

Introduction

In the past twenty-five years in Poland, many major changes were done in the primary schools, gymnasia and secondary schools [Act of 1991]. All changes were subordinated to one of the most important goals of changing the status and importance of the maturity exam as the sole criterion for recruitment for most faculties, excluding faculties requiring arts or health predispositions. Such reform is a long-term process, because it must be introduced from the first grade of education. The first maturity exam, replacing an entrance examination, was carried out in 2001. Since then, experience was gained over time and many errors were corrected by making bigger or smaller changes. The most serious of these is the change of the core curriculum called fourth stage of education in all subjects, i.e. educational stage of secondary school [Act of 2011].

This paper aims to highlight:

- evidence on the need of correlation of education curricula in the area of natural sciences and effects of an absence of such a correlation,
- facts testifying to a lack of interdisciplinary harmony between the subjects in teaching of natural and technical sciences,
- analysis of the current state of core curricula in teaching mathematics, physics and chemistry for the harmony of these subjects.

1. The need for integration in teaching science and technology

How to teach effectively? It is a question frequently asked in the group of people involved in teaching pupils, youth and students. It is a question that teachers, methodologists, designers and developers of education curricula as well as reviewers and strategists of education systems ask themselves. How to teach simultaneously and effectively mathematics, physics, chemistry and technical subjects?

1.1. The interdependence of physics and technology

Physics and technology are interrelated and can not be strictly demarcated. Areas of study physics and technology always overlap each other. Physics enters into new areas of knowledge, and technology takes over areas that were previously penetrated physics. These two disciplines are not strictly determined bor-

der. It is often crossed by both the one-way physicists and engineers in the opposite direction. Physics is a natural science, which main goal is to understand and to describe the properties of matter and the processes at work in the inanimate world. Physics tries to explore the surrounding world in order to describe it in a precise way and to be able to predict the consequences of taken actions. The technology copes with understanding the causes and the consequences to get the desired results. The most important goal of technology is to change the surrounding world in order to make it more practical and more comfortable to live in it, to contribute to increase convenience and comfort of human existence.

It is possible to give countless examples of the interdependence between physics and technology. Examples of the use of science in technology provide a strong motivation for studying young people. Even one example of the application of the laws of physics in technology may facilitate the understanding of the sense of effort devoted to learning and to induce interest. Appropriate coordination of science education curricula and creating harmony between them is essential in preparing for future technical career and in improving skills. The inclusion of certain technical classes for general education gives students an idea of the professional work, directs and shapes the interest, motivates to learn and to broaden their knowledge in the subjects coherent and loosely related to interests. This helps in preparation for a future profession. In addition, this is an important reason for the coordination of technical and natural sciences. While teaching physics, it should be presented the usage of its laws in technology. Teaching technical subjects should refer to the laws of nature explained during the lessons of physics and should be described in possibly the most similar way.

1.2. The relationship between physics and mathematics

There is a great need to introduce coordination and chronology of learning programs between mathematics and physics. Unfortunately, each modification of curricula or education systems makes it worse. There is a lack of integrated educational programs in mathematics and physics, despite the indisputable benefits, originated from such a harmony for both fields. It is not difficult to find the examples of such a polarization also in other countries [Lewis 1984].

Improving their educational programs, mathematicians forget about the practical role of this discipline in relation to other sciences, especially natural sciences. They create a beautiful product „art for art's sake". Scientists and teachers dealing with natural sciences complain that modern programs do not fully take into consideration their needs. You should also be aware of the fact that mathematics has its own structure and the curriculum development in mathematics based solely on the requests of researchers from other disciplines entails negative consequences in the form of program inconsistencies, impossible to teach mathematics. That's why, a compromise should be reached here. For this purpose, it is advised to read textbooks from the sixties [Leitner 1970; Wrona 1969], where many positive examples of this type could be found, or some English textbooks for mathematics.

The second important thing, apart from a program disharmony, is that in the process of teaching mathematics, computational tasks are limited only to the abstract examples, omitting the examples from physics, astronomy, geography, chemistry, biology, economics, technology and engineering.

2. Inter-subject correlation between mathematics and physics in the newest educational programs in secondary schools

The analysis of core curricula of the fourth educational stage of teaching mathematics, physics and chemistry [MatPhysChem 2012] as well as the exemplary proposals of examination topics regarding these subjects was performed [Pilotage 2014]. As a result, it is concluded that subjects such as mathematics, physics and chemistry, once constituting a coherent branch of education, nowadays take separate paths.

These curricula are coherent only within one subject, but there are less and less interdisciplinary elements between them. Mathematics curriculum is cohesive and logical as a whole, but it is not synchronized with the needs of other disciplines. In physics, mathematical skills are needed at the various stages of education. Such skills are provided in the mathematics education program but in too big time difference in relation to the needs of teaching physics. These observations are summarized below in Table 1.

Table 1

Dysharmony of curriculum contents in mathematics and physics in secondary schools

No.	Physical issues described in the core curriculum in physics (PPf)	The mathematic needs for their implementation	Chapter PPf/sem. of realization	Physical issues described in the core curriculum in mathematics (PPm)	Date of realization, PPm/sem.
1.	The movement of the material point	Vectors	1.1/I	Plane geometry	8.7/V
2.	The movement of the material point	Quadratic equation	1.4/I	Functions	4.5–12/III
3.	The movement of the material point	Trigonometric functions	1.13/I	Trigonometry	6.1/III
4.	The movement of the material point	Quadratic inequalities	1.6/I	Equations and inequalities	3.5/II
5.	Mechanics of rigid body	Vector product of vectors	/II	Lack in curriculum	
6.	Gravitation	Functions f(x) = a/x2	4.1/II	Functions	4.13–15/III
7.	Harmonic and wave motion	Trigonometric functions	6.1/II	Trigonometry	6.3–4/III
8.	Magnetism, magnetic induction	Derivative of a function	9.10/II	Differential calculus	11.1–3/VI

The presented analysis clearly indicates too big disharmony in teaching of natural sciences, particularly mathematics and physics. Simultaneously, it should also be noted that in this regard, it is observed a slight trend reversal, i.e. the mathematics curriculum valid for the maturity exam 2015 is less divergent in relation to the needs of other disciplines than an earlier educational program of teaching mathematics.

This program strives for more compliance with the recommendations of the European Parliament regarding the establishment of the European Qualifications Framework (EQF) for Lifelong Learning than a coherence in interdisciplinary education.

When it comes to the needs of education with regard to the maturity exam in physics, the authors of the education curricula began to be more realistic and to keep their feet on the ground. They considered the various possibilities of students, teachers, school and the education system, eliminating from the education curricula in physics, in a secondary school, such topics as:

– relativistic kinematics and dynamics,
– elements of the relativistic theory of electromagnetism,
– a Grand Unified Theory (GUT) and string theory,
– elements of quantum physics of atoms,
– quark and lepton interactions,
– determination of absolute stellar magnitudes,
– analysis of alternating-current circuits, three-phase motors,
– the gyroscopic effect,

which were included in the core curriculum by 2014.

The new educational program in teaching physics for a secondary school, according to which, the first maturity exam took already place, was approved by the Conference of Rectors of Academic Schools in Poland (CRASP). In the resolution of the Plenary Assembly of CRASP of 6 May 2011 [Conference 2011], regarding the new rules of maturity examinations, it was noted with satisfaction that, in terms of physics, the program enables:

– increasing the importance of understanding the phenomena and creating mathematical formulas combining several other phenomena,
– measuring, planning skills and description of performing simple experiments and the ability to analyze their results taking into account measurement uncertainties.

The opinion of rectors would certainly be a little less optimistic regarding creating mathematical formulas if it was preceded by an analysis similar to the one that is the subject of this work.

A verification of such an opinion of rectors probably will be the results of the maturity exam 2015, but in the time of writing this study, these results have not yet been published.

Conclusions

The last reform of secondary education limited to an acceptable level the contents of natural science education programs in terms of the fourth stage of education (secondary school). However, a serious disadvantage resulting in negative educational consequences is the disharmony of the taught contents in the field of natural sciences. It involves:

- lack of merithoric and time coherence in teaching mathematics and physics,
- the dominance of abstract tasks in teaching mathematics over the practical and environmental technical ones,
- lack of situations motivating to perform calculations by the use of a calculator during mathematics classes (this is left only for physicists, chemists and teachers of technical subjects).

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Abstract

The article presents the advantages of the correlation of education curricula in the field of natural and technical sciences, and the consequences of lack of such a program coherence. Based on a detailed analysis of the latest core curricula regarding the fourth stage of education (secondary school), the areas of an evident disharmony are shown in teaching mathematics and physics as the most representative natural science subjects.

Keywords: core curriculum, inter-subject correlation.