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THE DIFFICULTIES IN INTEGRATING MATHEMATICS WITH OTHER TEACHING SUBJECTS

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Abstract. In contemporary concepts of school education one suggests a far-reaching integration of teaching contents. The integration is aimed to help school children to gain a comprehensive world picture, stimulate their activeness, develop some creative attitudes of the school children toward mathematics and elaborate various forms of organizing classes. According to the experience with integrating mathematics with other teaching subjects, there are difficulties in realizing the aims mentioned above. In this article some reasons for these difficulties will be discussed at large.

1. The main assumptions of integration

The term "integration" in its broadest sense suggested by *The Dictionary of Foreign Words* means to build a whole from separate parts. The "integration" is a process of joining something to one whole, bringing together, completing. In turn, the integration of teaching according to *The Popular Encyclopedia* is a teaching method aimed to highlight the relations between all the teaching subjects and to present science as a whole.

The concept of integration in teaching is not new. Its development was made due to a new breeding trend in the 19th and 20th centuries which was opposed to *The Herbart School of Pedagogy*.

A new concept, called *integrated teaching*, which canceled the traditional division of teaching into teaching subjects and the lesson system, was elaborated for the needs of elementary education. The assumptions of the concept were premises to a new approach to the system of teaching contents relying on the main-topic centered integration of teaching stuff.

The first attempts of teaching integration on a larger scale were made in Poland after the World War II. In 1990s A. Szyszko-Bohusz introduced the term of holistic pedagogy [6].

According to the holistic teaching one needs to understand oneself in surrounding reality rather than to gain encyclopedic knowledge. This leads to a change of subject-based teaching into searching for correlations between teaching subjects. As a consequence, the overall concept of reality instead of partial knowledge of single phenomena is to be presented to school children.

The introduction of the concept of fully integrated teaching in the curriculums of 1–3 levels and block teaching in 4–6 levels of elementary education has been in progress for more than 10 years. The idea of realizing the integration of teaching by intersubject educational paths is suggested to be applied to all educational levels. Correlated subject-based teaching is an appropriate base for transsubject teaching [1] which relies on getting the borders between the classical branches of science disappeared and focusing on the analyzed problem, phenomenon or process.

The theoretical assumptions of integrated teaching are properly elaborated and fully acceptable. The other thing is their factual, not only declarable realization.

2. Mathematics and the concept of integrated education

Mathematics is a subject which is seriously difficult to be integrated with other teaching subjects.

- Although the introduction of integrated teaching in 1–3 levels has been in progress for 10 years, some publishing houses keep publishing separate course books for the stage of education.

- The Great-Poland's gymnasium and high school students realized some chosen topics as projects within the program e-Szkoła Wielkopolska for one year [7]. Basically, the projects were to integrate mathematical-natural subjects. Only 16 out of 350 completed projects partially concerned mathematics. Moreover, the so called "mathematical" projects, on the contrary to the so-called "natural" projects, enriched students' mathematics knowledge to a minimal extent. They regarded some well known problems presented in a more attractive form, e.g. symmetry in architecture, fashion and art, percentages in everyday life, our neighborhood in numbers.

- The project "Preschoolers" including some very interesting suggestions of educational paths integrating the contents of natural sciences for 6-year-old children was one of the three rewarded projects of e-Szkoła Wielkopolska. What is symptomatic, the project lacks mathematical contents despite of its authors' creativity. Apparently, the authors claim that teaching mathematical terms cannot be correlated with other contents in an attractive way for children.

- The connection of mathematical and natural contents offers difficulties even to the authors extensively describing their correlation [3]. Although the authors note that there is a number of intersubject relations within mathematical-natural subjects, they directly mention only physics, astronomy, chemistry, biology, and geography.

3. The reasons for the difficulties

Why is mathematics not prone to integration with other subjects? It seems that there are several reasons.

First of all, mathematics is formal on the contrary to all natural subjects, i.e. physics, chemistry, geography, and nature.

One can describe it in the following literary form:

Let's imagine a crazy tailor who keeps sewing all possible clothes. He knows nothing about people, birds or plants. He isn't interested in the world and its exploration. He keeps sewing clothes. He doesn't know for whom, he doesn't think of it. The tailor takes care of only one thing: he wishes to be consistent. Every time he starts sewing a new piece of cloth, he makes certain assumptions. They aren't always the same but he proceeds according to the assumptions and wishes not to make them contradictory. There always have to be clothes, not bunches of blindly sewed tatters. He brings ready clothes to a big storage. If we could get there, we would find the clothes for people, centaur, unicorn and for the creatures which haven't been invented yet. The great number of clothes would be of no use. Everyone admits that the never-ending job of the tailor is sheer madness. Mathematics works as the tailor does. Mathematics builds structures, but no one knows for whom. Perfect models, but a mathematician doesn't know of what the models are. He isn't interested in it. He does what he does because such an activity is possible (...) [4].[1]

[1] Author's individual translation of Stanisław Lem's quotation.

Therefore, both the subject of the research and the methods used in mathematics and natural sciences are completely different. The essence of mathematical creativity is to operate in the world of abstraction. A physical experiment, observations and conclusions are sufficient only in the elementary stages of mathematics teaching and then they can be used to a limited extent. Eventually, one always needs a formal explanation.

Secondly, mathematics is a language. The statement *The world of nature is written in the language of mathematics* formulated by Galileus nearly four centuries ago is presently considered to be obvious. Nevertheless, one needs to have at least a very basic command in a language to be able to speak it. Besides, the knowledge of the language is prior, not simultaneous, to its use in describing various phenomena, whereas the school children mathematics knowledge is little. What is more, mathematical contents get reduced in every change of the general education curriculum. High school final year students do not know, e.g. that *a velocity is the derivative of distance with respect to time* because they do not know the term "derivative". Student can get to know numerous impressive examples of fractals, but their knowledge is reduced to the ability to recognize the shapes because the school knowledge of mathematics is insufficient to enable them to understand the rules of constructing fractals.

Another difficulty in the integration defined as a correlation of mathematics with other teaching subjects is a construction of the school children mathematics knowledge. In mathematics one constructs "new terms by means of the previosly introduced terms". It resembles a construction of an inverted pyramid. One should systematically build floor by floor and it is time-consuming. School children need to know some mathematical terms, e.g. in physics or geography, much earlier than they learn them during mathematics lessons.

The terms which school children use in everyday life, e.g. binominal numbers and percentages, are also discussed in more advanced stages of mathematics teaching at school. Real everyday needs and school mathematics are closely related in early educational stages. Four basic operations on rational numbers, measuring, weighing, time calculations, calcualting the area and the perimeter of a simple geometric figure, percentages and proportions are necessary skills in everyday life. The mathematical operations mentioned above tend to be often done with calculators. The applications of mathematics to everyday life are numerous but trivial. In more advanced stages of mathematics teaching there is a larger discrepancy between school mathematics and everyday needs.

In everyday life one makes no use of e.g. polynominals and quadratic equations. On the other hand, the mathematics knowledge of school children remains too little to show its more complicated applications. The real applications of mathematics generally require much more advanced mathematics tools than the ones of a final year high school student. Therefore, the possibilities to motivate school children to learn mathematics by showing its applications are confined.

Aside from the problem-centered and teaching-content-centered integration, one also considers a key-competence centered integration [5]. Mathematics is traditionally thought to be leading in teaching logical reasoning, whereas the role of mathematics in teaching creative attitudes is unappreciated.

The literature concerning creativity is confined to present literary, plastic, music or technical creativity of school children. The manifestations of such creativity are much easier to be documented and exposed than the manifestations of mathematical creativity. The rule is to regard mathematical creativity as an area of advanced competences. It is mentioned at the very end of the list of achievements of mathematical education, whereas creativity cannot be the end of mathematics learning but the way of handling it. Unfortunately, the requirement of mathematical creativity is not often respected by specialists in mathematics education, authors of course books and teachers [2].

4. Conclusion

The specific nature of mathematics as a formal branch of science is partially reflected in the specific nature of school mathematics among the group of mathematical-natural subjects. This specific nature causes numerous difficulties in integrating mathematics with other teaching subjects. Nevertheless, one should not refrain from supporting the integration because it is the only way to overcome innumeracy.

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