Effective Teaching of Physics and Scientific Method

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***Abstract* – Teaching science in modern society shows a lack of efficiency, as well as the discrepancy between goals and the quantum and quality of students' knowledge. Teaching physics in elementary and grammar schools in Serbia is also inefficient. The problem is solved by introducing modern teaching methods, especially the scientific method. Then teaching is not oriented to content, whose adoption allows the student to cope in the same or similar situations, but the method of their application in an unfamiliar situation allows the student to solve the problem. School classes fulfil their mission of quality preparation of students for further education, application of knowledge in the world of work or in everyday problem situations.**

***Keywords* – teaching science, teaching physics, the quantity and quality of knowledge, scientific method**

1. Introduction

Discoveries of natural science, technical operationalized, especially information technology, led to the accumulation of scientific material, its faster processing, and most importantly, relevant to the interpretation of experimental results. Processing of experimental results or theoretical models, which in the seventies lasted several years, the last year of two thousand hours or minutes. Information technologies allow faster communication between scientists, and public availability of information and unscientific circles, so that science becomes part of the ownership of each individual [1].

Physics as a fundamental science leading to discovery, alone or in cooperation with other sciences, ranging from nuclear physics, astrophysics, biophysics, medical physics ... There are few people who have not heard of CERN (European Organization for Nuclear Research), the problems with the launch of the reactor and the possibility of creating black holes, making good use of the media to talk about end of the world! This and similar examples prove the necessity of connecting with one hand, society as a whole with the scientists and the scientific discoveries of the other.

However, studies show that the need for scientific education and direct reciprocal relationship between technology and science, in the sense that the share of technology through experiments and promoting the best evidence of the achievements of Cognitive Science, which the technology becomes available to the general population [2]. Precisely such a situation has led the education policy makers around the world to the program-implemented curriculum developments in science teaching in order to gain knowledge and skills useful in a wider context, and other sciences, as well as in everyday life (STS-project) [3], [4]. Response of the European Union's adoption of the strategic goals of education and training: improving quality and efficiency of education and training, easier access to education systems and training systems, and opening up education and training to the wider population.

Realizing the importance of science for the prosperity of society as a whole, one of the tasks was that the number of students enrolled in the natural faculties has increased, so that Europe followed the development of the U.S. and Japan. In accordance with the objectives, projects that are designed to observe current state-PISA, as well as those starting from the current offer solutions such as the TIMSS curriculum [5]. Essentially it was the European answer to the reform documents in science education and the U.S., of which two are most important: Project 2061-Science for all Americans [6] and the National Science Education Standards-NSES [7].

There are two imperatives contained in two documents, one is to insist on cooperation between scientific disciplines, and teaching based on integrated topics and other courses to be organized in a pedagogical experience and methods that provide a link between the everyday experiences of students and teaching. One of the important principles that are based operationalization of these imperatives was a “less is more”. He included detailed understanding and adoption of the reduced set of carefully selected concepts, which results in the student at the end of the educational cycle (primary school, secondary school or university) scientifically literate. It is necessary and sufficient condition for the

continuation of education, employment or quality daily life [8].

Serbia has participated in PISA and TIMSS projects. The results of these studies show: all the contents and themes in the natural sciences similar to the content and themes in European Union countries, but they are weak (or exist) conceptual structure, that the teaching-oriented content, and not to the merits, that are integrated contents of science, or at least represented almost non-existent (knowledge of the existence of drawers or are deemed to be a teaching concepts related to only one science) that the methods of learning is largely traditional, or directed toward the accumulation of facts. Students in Serbia three Cognitive Domain (knowledge of the facts, understanding of concepts, analysis and reasoning), the most familiar facts, to some extent understand the concepts, and almost never analyze or reason. The question of the usefulness of such knowledge, suggests a need to innovate the existing school system, because only a flexible school, ready to follow the changes, can enable students to acquire the necessary knowledge and skills on which it is possible to learn all their lives, work and create.

2. Teaching physics in primary schools in Serbia

Teaching physics in primary schools in Serbia based on the curriculum of physics that has emerged is 1984-1985. year, has officially been used since 1990. [9]. The adopted goals of physics education are that students learn about natural phenomena and the basic laws of nature form the basis of the scientific method and to be directed towards the application of physics to the life and work. Goals are derived from tasks that involve the students: learn the fundamental laws of nature, learn about the importance of using methods of the experiment; enable the resolution of the qualitative physical tasks and problems, develop thinking and reasoning, develop work habits and interest in physics and natural science, a man familiar position to nature and develop a proper attitude towards the protection of the environment, acquire the basics of technical education, acquire the habit of saving energy, developing a sense of work in working groups and teams, as well as positive traits necessary for constructive cooperation in solving the task. It must be admitted indeed concise, clear, respectable, above all, the modern view of the goals and objectives of teaching of physics! What is the problem and why is it realistic unrealizable? The essence of the problem is in abundant teaching content and a large number of concepts for the anticipated number of classes and untrained teachers to use effective teaching methods. It must be noted that the relatively small number of teachers allowed participation in appropriate training programs to help him overcome the above problem.

Similar problems exist in the educational systems of other countries. But they are, for example in America, recognized as the ”imperative of recruiting and retaining highly-qualified physics teachers through training, as well as of key importance for American global competitiveness” [10]. The Conference of International Commission for Science (ICSU) in Beijing is clearly marked, and today, the objectives of teacher training and education through its continuously:

- Teacher colleges;
- Permanent recruitment through social and economic status;
- Coherent curriculum [11].

The teacher is placed by a professional dilemma that, if he wants to realize all the courses and concepts, to opt for ex-chair monologue method that is often prescribed for repeat classes, determination or experimental activities into lessons ”teaching materials”. In this way the teacher gets only scant or almost no information about the level of student achievement. Another possibility is that the teacher chooses, to put effort and introduce other teaching methods. Their realization is more demanding, but then the teacher gets constant information about the level of student achievement and possible adjustments in teaching. Of particular importance is the introduction of scientific method in everyday school practice [12], which started in Serbian primary schools introducing optional subject ”The hand in the pastry”, from first to fourth grade of primary education 2003rd year. ”The hand in the pastry” is a relatively short implementation time, showed that teaching is based on experiments in natural science, which can be derived in unequipped schools, resulting in students who graduate from primary school when able to find their rightful place in a society dominated by science and technology. In short, students are trained for the future and life in it.

Various studies show that students have the innate inclination towards natural science, because they are closer to them, palpable, and the problems faced everyday: ”Most students have a positive attitude toward science at the age of 10, when the interest falls abruptly, and at the age of 14 their attitude and interest in studying science is largely formed” [13]. So if we want to increase the population of students oriented towards the natural sciences, who later entered grammar school and college of natural orientation, more attention to motivating students, and teachers must be paid.

3. The teaching of physics in grammar schools

Grammar school (Gymnasium) is at the root of the education system. In ancient Greece, ”gymnasion” is represented in public practice site for young men over 18 who have shaped their body (gymnos-naked). As in ancient Rome they are also the meeting place of philosophers. Humanists in the fifteenth and sixteenth-century began to use this name for a school facility [14].

In Western Europe, it has evolved from grammar school and monastery kathedral School and has been in some sense ”Latin School” (school Latin). The first grammar school was established in Strasbourg 1537th year by Johannes Sturm (1507-1589). At the time of humanism and the Renaissance in the fifteenth and sixteenth-century, grammar school was focused on the spiritual, scientific, artistic and ethical ideals of antiquity. Personality is the center of attention, and the goal of education is an independent and critical thinking of students. Time when a new humanism makes a departure from the ancient principles, and the establishment of high schools in the education columns. Secondary education at the time meant the absence of any expediency, the priority of the whole personality of specialization in one direction and conception of Greek antiquity as the highest ideals of humanity. The curriculum subjects prevailed linguistic character. Humanistic gymnasium ignored the industrial revolution, cherishing not expediency were practically useless, and in preparation for the practical exercise of a call, it was precisely ”the school curriculum to play”!

Today's grammar school in Europe, has natural-mathematical or linguistic orientation. Educational activities are more firmly connected with life in modern society, primary enabling students to continue their education, but also to enter the world of work.

In our country, in the Austro-Hungarian monarchy, after 254 years since the founding of the first grammar school in Europe, in Sremski Karlovci was founded in 1791 The grammar school, based on humanistic principles. The grammar school had a classic character, but the curriculum included natural subjects.

In Serbia, the first grammar school opened in 1830. in Belgrade, and in 1833 it was moved to Kragujevac. At the same time in, 1836. year were established grammar school in Sabac, Cacak and Zajecar. Later, the grammar schools for its programs and facilities was somewhat different. Success in science achievement, expanding the horizons of knowledge of the world, travel, expedition and research are necessary learning and knowledge of modern languages, and social programs and projects of transformation of society reinforce interest in the social sciences, which produces a change of educational content. As a basis to take real discipline and knowledge of empirical reality and that is how the real grammar school or School (in Latin realia-thing of importance for practical life). In the late nineteenth-century grammar school represent a base from which faculties grow and it becomes a stable system of secondary education, leading to further education, but also its practical character and work. In the early twentieth-century grammar school in the program are divided into classic (read language), real (common type) and School (now the vocational school). After World War II, the first professional school, was established aimed at work, a grammar school definitely left school general education aimed at further education. Since 1967. in Serbia have been legalized directions of socio-linguistic, mathematical and natural-grammar school. In 1974. The resolution is adopted which is challenging all schools whish do not prepare for work, so in 1979. The grammar schools involved in the vocational education system. The original name of the role of returning to grammar schools 1992nd , but the directions are introduced with the revised programs and facilities.

In essence, the basic lack of grammar school consisted, and a hundred years ago as now, to replace students' interests, freedom and spontaneity of the prescribed curriculum and fixed terms of content, which at the time the mass introduced into schools in Europe, making a fundamental contradiction the ideal of freedom and creative development of students' personalities. So it was that grammar school is not a major problem arose as a random effect of unexpected circumstances, but was grounded in the organization of schools. In Europe, the answer to that contained in weaken rigid internal structure, the introduction of internal differentiation profiles and modular teaching [15]. In grammar schools in Serbia motivation of students for mastering the material organized by the outdated principles is very unsatisfactory, just as was the case a hundred years ago in other parts of Europe.

From the nature of the circumstances in which we are now, meaning that the grammar schools in Serbia today, as a rule, largely focused on the traditional method of learning and realization of solid, under the modern curriculum. In fact, nearly all interested teachers, parents and students know and feel intuitively that grammar schools must have some purpose other than the one I see and experience. It should help the young to think freely, to become an autonomous person with confidence in their own knowledge and skills, capable to continue their education or realize the world of work. It should be noted a responsible attitude towards the period of four years, that young people spend in the grammar school at the peak of their intellectual abilities. The

time is mostly spent lightly. A large number of absences due to poor organization or lack of motivation school teachers ("white strike"). Lost time due to lack of compliance programs, giving up the thematic approach to teaching and not existing cooperation between teachers. Students are required to spend much time learning the content for which they do not see the sense, nor are they relevant to anyone in the education process to explain the same. Often insist on a mechanical learning that few students know how to synthesize in a form of knowledge. The end result, after four years, is that the student does not have enough knowledge of security neither for further study, nor was sufficiently qualified to perform an occupation. These facts confirm the results of analysis of interest of students for enrollment in grammar school.

The main characteristics of students in higher grades, especially in the socio-linguistic direction, is primarily a good verbal communication and liberal spirit. But with the "loudest" there has been a fatigue based on the previous application of traditional methods of learning, blended with the growing obligations conditioned upon completion of schooling and enrollment in college preparation. Students are misplaced between obtaining the final score and individual saving for university entrance exams. From professors, a professor of physics in particular, reduced the required homework assignments. The teacher is professionally, but personally, is the dilemma of how to realize the required programming, and that the students sufficient time for the increased activity! The teacher is in a position to solve the problem of education as an individual and in most cases decided on a compromise, so that reduces the volume of some thematic parts. In such cases, the essential role of teacher experience, studies show that experienced teachers are better adapted to these requirements, whether it is already implemented educational topics or new.

One possible solution is to introduce the scientific method, which is an integral part of the physical or natural, concepts of reality and that is the essential difference between blind faith and the discovery of truth. The good results shown by the use of constructivist methods, based on Piaget theory cognitive development [16] or meaningful-receptive method according Ausubel meaningful learning [17] whose results are shown in the example of the application of teaching chemistry [18]. New research shows that in that way acquired knowledge, skills and skills show higher quantum, quality and retention. When students actively participate in class and learn about the scientific process of discovering the truth, better understand the process of education and their role in it [19].

Many teachers follow guidelines from various institutions (Society of Physicists, Subject Committee for Physics, Community Grammar School) and perform the reorganization and improvement of teaching physics. The results of these efforts resulted in the establishment of new directions including the IT department realized the first time grammar school academic year 2006/2007. year as an experiment in ten schools in Serbia, as well as in grammar school Sabac. The interest of students has increased, so that after four years, twice as many candidates applying in relation to the number that is received in that direction. However, teaching contents and methods of teaching information technology subjects have changed, but the other items were taken from the existing grammar school majors, so the others are traditional. Classes should be organized thematically, with the insistence on the integrated themes and between the subject cooperation. In modern education there are individual examples of good practice, and complete projects based on integrated topics that primarily prepare teachers: "... because of the theme is often beyond the scope of a scientific discipline, such as energy, sustainability, and its changes, its structure ... "[20].

World experience shows that schools and science must be in close connection, in fact, despite the great effort and investment in education and the relationship of science and school, research shows that young people continue to mobilize naive understanding of science, and that they do not see connection with everyday life and science they learn school [21]! Available in the schools, both thematically and methodologically, should be such that students perceive, to practice and acquire knowledge and skills that are useful in their daily lives, but to give it to them and respond to technical, technological and sociological development of society as a whole.

Teaching physics in grammar school, characterized by problem ampleness content that is less pronounced in the natural-mathematical direction, because of the larger number of classes (2+3 +3 +5, from grade I to IV, respectively), compared to the socio-linguistic direction in which the smaller classes (2+2+2+2, from grade I to IV, respectively). Although the level of content in the socio-linguistic direction is slightly relaxed compared to the natural direction, not interested students for teaching physics-oriented social group of cases, often resulting in the issue of whether the contents of physics in general they need? Yet despite the initial orientation toward social objects, often happens due to the activities of teachers to modernize the teaching of physics, students socio-linguistic direction enroll faculties of natural sciences,

including the directions on the physics of a natural-mathematical faculty. Therefore, the education of students in physics in secondary schools, especially in grammar school pay special attention because they represent the recruiting base for university students in science and technical colleges. Professors at universities" can clearly see the difference in the quantum and quality of the acquired knowledge of students from different backgrounds and the profiles of schools" [22].

4. Conclusion

Modern society requires efficient methods of learning, with emphasis on scientific method, not based primarily on the teaching of scientific findings [23], but the constructive development of new knowledge based on empiricism and research. Such knowledge leads to the exact reasoning necessary to solve the problems posed by modern life [24].

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