

High-quality Primary School Education in the Field of Electrotechnics and Informatics - Beginning of the Development of Successful Engineers

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Abstract – Taking into consideration that education of future electrical and IT engineers starts in primary school through acquisition of the initial knowledge in the field of electrotechnics and informatics, the presented abstract is dedicated that segment of education. It shows that present implementation level of knowledge acquisition and education support in this field by the current educational plans and programmes for primary schools in the Republic of Serbia. It shows the outcome of the undertaken researches based on a poll conducted amongst the pupils and the questionnaire referred to the preference of subjects, teaching and methodical units and other activities related to knowledge acquisition in the field of electrotechnics and informatics. It also explains possibilities, available methods and strategies for pupil education quality improvement in these fields which are supported by the current educational plans and programmes for primary schools in the Republic of Serbia

Keywords – Electrical engineers education, Primary school education, Education quality

I. INTRODUCTION

The education of future electrotechnics engineers starts in primary school through acquisition of the initial knowledge in the field of electrotechnics and informatics. Therefore the quality of teaching and knowledge acquisition of the primary school pupils in these fields is extremely important for future successful education development of quality experts – engineers who will be able to face business challenges of the modern society in which technical development happens very fast. The first part of work is dedicated to the implementation of the knowledge acquisition in the field of electrotechnics and informatics within the new curriculum and syllabus for primary schools in Serbia [1]. It was shown in which school subjects (courses) and with how many classes the education of the mentioned fields was carried out. In the second part of the paper were shown the results of the researches conducted amongst the primary school pupils with the goal to estimate how satisfied they are with the quality of the acquired knowledge in the field of electronics and informatics which are determined with the current curriculum and syllabus, and also to estimate generally how much they are interested for the further education within these fields. The last part of the paper is dedicated to the abilities, methods and strategies for the improvement of the education quality of pupils in the mentioned fields which are supported by the curriculum for primary schools in Serbia [1-14].

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II. IMPLEMENTATION OF ELECTRICAL AND INFORMATICS KNOWLEDGE ACQUISITION IN SERBIAN PRIMARY SCHOOLS

Acquisition of the first terms and basic knowledge from the field of electrotechnics and informatics starts in the first four grades of primary school within the school subjects (courses) *World around us* and *Nature and Society*. In the table I is shown which topics in the field of electro-technics and informatics are taught, within which school subjects and how many classes according to the current curriculum and syllabus for primary schools in Serbia.

TABLE I. ACQUISITION OF THE INITIAL KNOWLEDGE IN THE FIELD OF ELECTROTECHNICS AND INFORMATICS

Grade	Course name	Topics related to eletrotechnics and informatics and teaching hours
1th	World around us	Communication devices (1) Computer and computer components (1)
2th	World around us	Computer and information devices (4)
3th	Nature and society	Electrical properties of materials, Current, Circuit (4)
4th	Nature and society	Electrical and magnetic properties of materials, Electrostatics, Current, Circuit, Experiments in the filed of electrostatics, current, circuit and magnetism (6)

In the upper grades, electrotechnics and informatics topics are mostly covered by the compulsory courses: *Physics* and *Technical and informatics education* and by elective course *Information technology and computer technique* which scores a high percentage in most schools in the Republic of Serbia.

General aim of the *Physics* is for the pupils to familiarise themselves with natural occurrences and principal laws of nature, to get basic scientific literacy, to recognize physical phenomena through research and to apply physics laws in their everyday life and work. Table II shows the curriculum for this course per classes in accordance to the current teaching plans and programmes for primary schools regulated by the Ministry for Education and Science of the Republic of Serbia [1].

TABLE II. PHYSICS - CURRICULUM

Course name: Physics	
6th grade	Course duration in teaching hours: 72 per school years
Introduction (2), Kinematics (14), Forces (14), Measurement (15), Mass and density (15), Pressure (12)	
7th grade	Course duration in teaching hours: 72 per school years
Forces and motion (25), Friction forces (12), Body balance (11), Mechanical work, energy and power (15) Thermal phenomena (9)	
8th grade	Course duration in teaching hours: 68 per school years
Oscillatory motion and waves (8), Liht waves and phenomena (15), Electrical field (10), Current Electricity (19), Magnetic field (6), Basic of atomic and nuclear physics (8), Physics and modern word (2)	

You may notice that topics which in the narrower sense belong to the core field of electro-technics are more present in the 7th class. As this is a more comprehensive subject it requires a solid background in mathematics and other fundamental areas of physics. Almost the entire 8th class curriculum is dedicated to the electrotechnics (Fig. 1). The teaching plans and programmes include laboratory practical drills and experiments with interactive work with pupils as a support in the process of knowledge acquisition of the relevant fields of physics. Learning quality critically depends on the level of the school teaching aids equipment. With regards to the electro-technics teaching, the physics laboratory at primary school “Cele Kula”, Nis is an example of a well-equipped teaching aids school which include: complete electrostatics experiments, influent machine, mathematical and electrical pendulum, Faraday’s cage, electrical car models, alternator, voltmeter, various resistors and conductors, magnetic field, various magnets, magnetic needle, compass, Ersted’s experiment. This is similar in most Serbian schools. Teachers of physics believe that teaching of physics will be more qualitative, interesting and attractive to pupils if the schools had larger numbers of teaching aids, but teaching aids expansion is limited by the budget which is regulated by the authorised state institutions.

Apart from the regulated number of regular class hours, knowledge in this subject is also gained from supplement class hours aimed at less successful pupils and from complementary class hours in the format of young physicist groups. These groups are aimed at pupils with special interest in physics who would like to promote their high level of acquired knowledge by the means of taking part in competitions which are supported by the Ministry of Education and Science of the Republic of Serbia [2].

TABLE III. TECHNICAL AND INFORMATICS EDUCATION - CURRICULUM

Course name: Technical and informatics education	
5th grade	Course duration in teaching hours: 62 per school years
Introduction (2), Traffic (8), Graphic communications (16), From idea to realization (8), Materials and technologies (12), Energy systems (4), Constructive modeling (12)	
6th grade	Course duration in teaching hours: 72 per school years
Introduction to the architecture and construction (4), Technical drawing (8), Information technology (16), Building materials (4), Energy systems (4), Technical resources in construction (4), Traffic systems (2), Housing culture (4), Constructive modeling (22), Technical resources in agriculture (4)	
7th grade	Course duration in teaching hours: 72 per school years
Introduction to mechanical engineering (2), Technical drawing in mechanical engineering (8), Information technology (14), Materials (2), Measurement and control (2), Materials processing technology (4), Machines and Mechanisms (16), Robotics (2), Energy systems (6), Constructors modeling - Modules (16)	
8th grade	Course duration in teaching hours: 68 per school years
Information technology (16), Electrical materials and installation (10), Electrical machines and devices (14), Digital electronics (12) From idea to realization - Modules (16)	

The general goal of the school subject (course) *Technical and informatics education* is to get the pupils acquainted with the technical and technologically developed surrounding through the acquisition of new technical and informatics knowledge and skills, as well as to enable them to apply the

acquired knowledge and skills in the everyday life. In table III is given the curriculum for this school subject signed by the Ministry of Education and Science of Serbia [1]. The school subject *Technical and informatics education* has grown out from the previous school subject *Technical education* which was studied according to the old curriculum. With the new curriculum this school subject leaves more room for studying informatics which is specifically done by introducing some creative elements in the teaching process, which will be more talked about in the section IV [1]. Besides the regular classes, there are also complementary classes held for the pupils who have dispositions for this subject and for those who want to enter the competitions in this field [2].

The goal of the school subject *Information technology (IT) and computer technique* is to enable pupils to use computers, to gain informatics literacy as well as to enable them to apply the use of computers and IT in everyday life and work (Table IV). According to the current curriculum for primary schools, this is an optional subject. Besides the classes which are held as regular classes, there are also complementary classes held for the pupils who have dispositions for this subject and for those who want to enter the competitions in this field [2].

TABLE IV. INFORMATION TECHNOLOGY AND COMPUTER TECHNIQUE – CURRICULUM

Course name: Information Technology and Computer Technique	
5th grade	Course duration in teaching hours: 36 per school years
Computer operating system (14), Text editing (14), Introduction to multimedia (8)	
6th grade	Course duration in teaching hours: 36 per school years
Text editing (10), Internet (4), Computer graphics (10), Computer animation (3) Elective modules (9)	
7th grade	Course duration in teaching hours: 36 per school years
Internet (6), Audio processing (4), Video processing (6), WWW presentation design (10) Elective modules (10)	
8th grade	Course duration in teaching hours: 68 per school years
Computer spreadsheets (10), Elective modules (16), Software programming (14), Computer networks and WWW presentations (14), Development of individual projects in the filed of information technology and computer technique (14)	

Figure 1 shows the percentage of hours per subject *Physics* and *Information technology and computer technique*, which is directly related to the study in the field of electrotechnics and informatics. It can be seen that the presence of of these teaching hours increases from lower to higher grades.

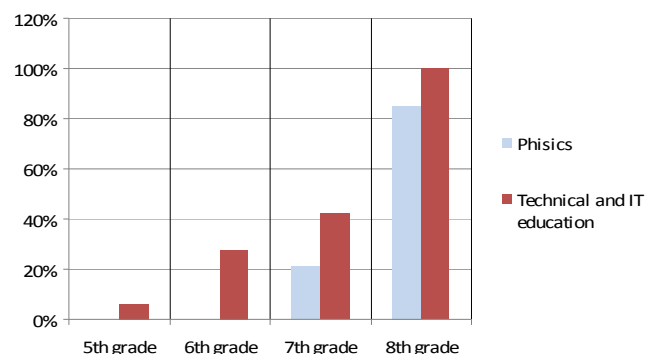


Fig. 1. The percentage of teaching hours in which pupils learn lessons that directly relate to electrotechnics and informatics

Performing quality teaching in the field of IT and Computer Technique requires that each primary school is equipped with specialized IT rooms. This issue will be discussed in more details later in section IV.

III. SOME SURVEY RESULTS AS AN SUPPORT TO THE EVALUATION OF THE PRIMARY CURRICULUM IN THE FIELD OF ELECTROTECHNICS AND INFORMATICS

There was a survey conducted amongst the primary school pupils in the region of Nish in order to give an approximate evaluation how satisfied they are with the way and quality of the acquired knowledge in the field of electro-technics and informatics which are determined by the current curriculum for primary schools in Serbia, and also to find out how much interested they are in the further education in these fields. There were two schools from the closer urban region of Nish chosen for this survey, "Cele kula" and "Dusan Radovic", and one school from the wider rural region of Nish, "Ivan Goran Kovacic" in Nish Spa. In the survey participated 407 pupils in total from 5th to 8th grade, 218 of them from "Cele kula", 102 from "Dusan Radovic" and 87 pupils from "Ivan Goran Kovacic" (observed according to the grades: V-75 pupils, VI-41 pupils, VII-52 pupils and VII-239 pupils). The pupils answered seven questions which referred to education in the field of electrotechnics and informatics.

In figure 2 are shown the pupils' answers to the question how interesting for them are the teaching units in the field of electrotechnics and informatics. Only a small number of the pupils answered that these units weren't interested which speaks a lot about the pupils' interests for these fields. In figure 3 the pupils answers show that the number of pupils who want to continue to attend the lectures on electrotechnics and informatics is much larger than the number of those who don't want that. There is a prevailing wish for attending IT and informatics. Picture 4 shows how big is the interest of pupils for choosing professions such as engineer of electronics, informatics and computers. At least 10% of the pupils would like that their future profession is engineer of electronics, informatics or computers, and the majority of pupils would like to use the knowledge acquired from the fields mentioned above in their future jobs. Answers in figure 5 show that the majority of the pupils think that there should be more practical work in the field of electrotechnics and informatics. That indicates that current equipment and teaching aids aren't in accordance with the novelties in the curriculum and syllabus. So, the teaching aids should be modernized to enable the good quality practical work of pupils. Figure 6 shows that a significant majority of pupils chooses elective course *IT and computer technique* which again speaks about the popularity of IT and computer science. In figure 7 can be seen that almost one half of the 6th grade pupils attends complementary classes or are members of science (physics) section, while this number significantly declines in the 8th grade. This is explained with the increasing number of pupils' obligations in higher grades. Figure 8 shows that there is an evident interest of pupils for competitions in the field of electrotechnics and informatics, but it should be worked even more on making these competitions more participated by pupils.

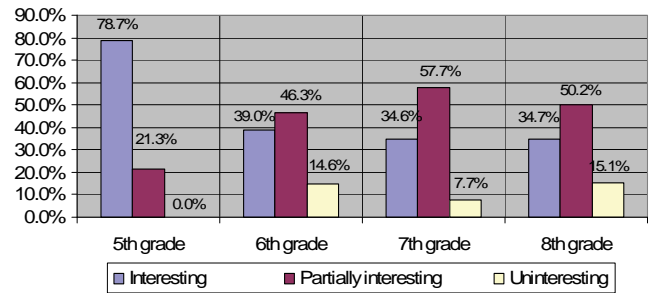


Fig. 2. Pupils' answers to the question of how interesting for them are the teaching units in the field of electrotechnics and informatics

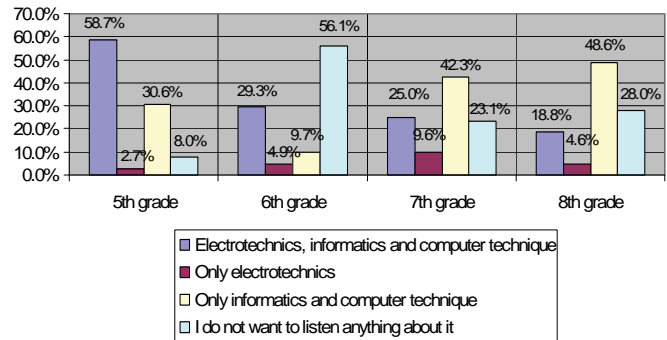


Fig. 3. Pupils' answers to the question of what they want to listen in the courses of future studies

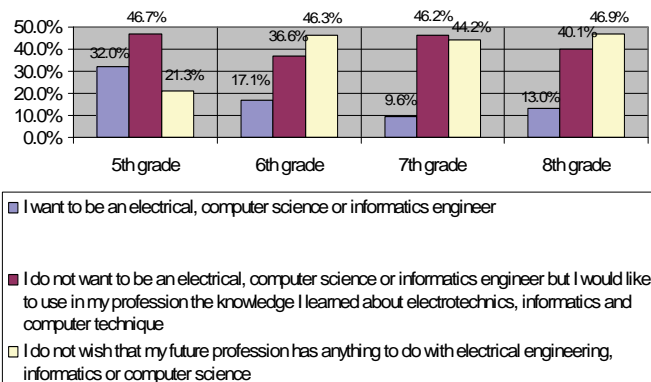


Fig. 4. Pupils' answers to the question of which profession they want to choose after completing their education

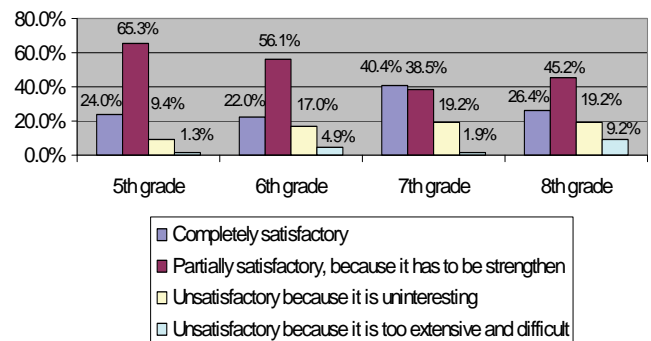


Fig. 5. Pupils' answers to the question how the practical work (work in laboratories and workshops, work with computers, conducting experiments) in the field of electrotechnics, informatics and computer technique is satisfactory

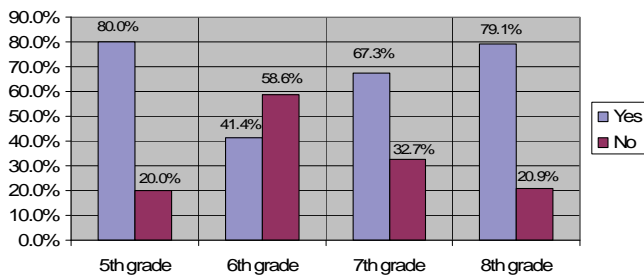


Fig. 6. Percentage of pupils who chose elective course *Information technology and computer technique*

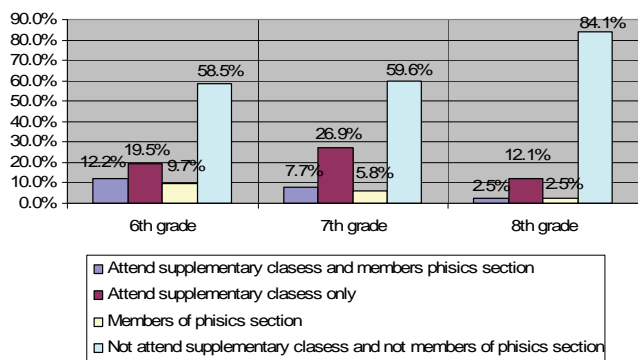


Fig. 7. Percentage of pupils who attend supplementary classes in physics or who are members of physics section

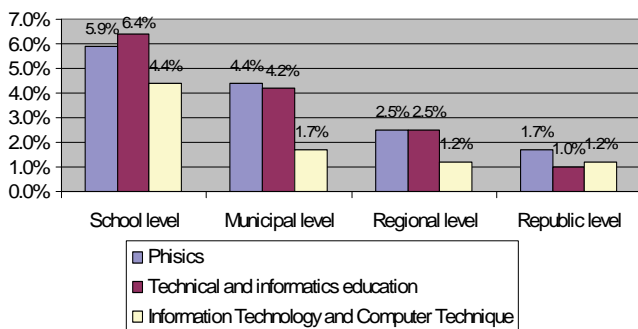


Fig. 8. Percentage of pupils who participated at different levels of competition (overview is given by the subjects and levels of competition)

IV. OPPORTUNITIES FOR IMPROVING THE PRIMARY EDUCATION QUALITY IN THE FIELD OF ELECTROTECHNICS AND INFORMATICS

Beside the Ministry of Education and Science of the Republic of Serbia which is the main and responsible institution for implementing of all levels of education, in Republic of Serbia today there are a few more important state institutions whose work have an influence on pupils' primary education. They are [3-5]:

- National education council of the Republic of Serbia
- Center for improving education and schooling
- Center for assessment of education quality and schooling

The work of these institutions is coordinated and they work very closely with each other. These institutions have the

relevant working mechanism which open doors for different possibilities for pupils' primary education improvement in the field of electrotechnics and informatics. Amongst the activities with significant importance we would like to mention the following:

- Harmonizing of educational plans and programmes with the EU standards and modern tendencies in the field of electrotechnics and informatics
- Improving of the teaching aids in the field of electrotechnics and informatics
- Introducing modern information-communication technologies (ICT) to support new methodologies in education
- Professional development of teachers in the field of electrotechnics and informatics through attending regular lessons for continuous professional development and enabling them to participate in professional conferences and seminars
- Organising seminars, lectures and other activities for pupils with an aim to compliment the education in the fields of electrotechnics and informatics and increase their interest in further education in these particular fields
- Improving the organisation and increasing the general technical and educational level of competition in the area of electronics and informatics in order to attract more pupils to participate in these competitions

Today's rapid development of electrotechnics and informatics and their increasing presence in all areas of social living requires continuous updating of primary school curriculum with the latest news in these fields. Modern plans and programmes in high schools across the EU have the fastest dynamics of adapting to those changes. One of the popular solutions to adapt the plans and programmes to changes in primary schools is their coordination with relevant programmes in high schools [6]. National Education Council in the Republic of Serbia has a vital role in continuous monitoring and analyzing of the state of education on all levels and its coordination with the European principles and values. In accordance with this the council makes decisions on changes and coordination of the primary schools plans and programmes in educational areas of interest [3]. Primary schools participation in TEMPUS projects, financed and approved by the EU, is a great opportunity to get help and support for the process of modernizing primary schools plans and programmes through their coordination with high schools programmes [6].

The improvement of quality of education in primary schools is unthinkable without introduction of certain educational standards which are in coordination with the EU standards. During the last few years the Republic of Serbia has been making huge efforts to incorporate and implement such standards in primary education. As a direct result of those efforts, in 2009, National Education Council has passed an act "the educational standards for the end of compulsory education". Those standards originated from working on project by the Ministry of Education and Sport of the Republic of Serbia named: "Development of schooling in the

Republic of Serbia” and its project component “Standard development and assessment” brought to life by the Center for assessment of education quality and schooling [5]. The basic problem that occurred after adopting these standards was the fact that they only covered 10 subjects in primary education. As far as the subjects containing electrotechnics and informatics were concerned these standards included only the physics while excluding other subjects such as technical and informatics education and information technology and computer technique. In the light of this obvious shortage, today there have been efforts to develop adequate standards of achievements for these subjects so they can give a significant contribution in increasing the quality of education in these subjects [7].

Due to its specific nature implementation of high quality education in the area of electrotechnics and informatics is difficult to achieve if primary schools do not have modern teaching aids required for this particular area. Significant number of schools in the Republic of Serbia is facing a problem of using dated and inadequate teaching aids needed to achieve educational targets in the area of electrotechnics. Constant repairing and upgrading of the old equipment and buying of the new one which will be in accordance with new modern curricula, requires continuous funding. This is particularly relevant for the equipment used in laboratory experiments and training. Finding significant financial means in the time of financial crisis and limited and restricted primary schools’ budgets may be an impossible task. One of the ways to resolve this problem, which has been given more attention lately, is to introduce the concept of digital school, where teaching is delivered in the space of digital cabinets (classrooms equipped with computers and other ICT equipment) [9]. According to this concept, some adequate additional interactive multimedia books will be used to support the increase of quality of schooling in physics, technics and informatics [10]. In accordance with that, instead of buying a complex and expensive equipment for practical training in electrotechnics, an adequate and cheaper interactive programme will be used to simulate the same experiment on the computer screen. Using this method will make it possible for larger number of experiments to be done without the need to expand the infrastructure of the laboratories as practical training will be delivered in the virtual lab. The situation is quite similar when it comes to training in the area of informatics, however we will talk about this a bit later in the part relating to the introduction of ICT in primary schools teaching.

At the beginning of 2011 huge support was given to the concept of digital school, introduction of ICT in teaching and increasing the quality of education in primary schools in general by stating the project named “Digital School” which is managed and funded by the Ministry of Telecommunications and Information Society of the Republic of Serbia. The aim of this project is to fully equip 2910 schools (83%) with digital cabinets in the Republic of Serbia [9]. Including March 2012 digital cabinets were fully established in 2808 schools (80%) in the Republic of Serbia. One of the schools with fully equipped digital cabinet is primary school “Cele kula“ in Nis (Fig. 9).



Fig 9. Modern digital cabinet in primary school “Cele kula“ in Nis realised through a project “Digital School” [9]

Implementation of digital cabinets in primary schools is widely opening doors for introduction of information/communication technologies in teaching which is essential for increasing education to a higher level particularly in the area of computing and informatics. Working within computer networks, access to modern internet services, using multimedia and other information/ communication technologies are opening possibilities for implementation of methodical innovations in teaching such as learning based on working on project and problem orientated teaching, also known as “problem solving teaching” [11]. These innovations are very suitable for improving teaching in subjects such as technical and information education and information technology and computer technique because the knowledge required is based on active participation of pupils in solving the real life problems through team work on chosen subjects. On the other side, the implementation of ICT in teaching has reduced the problem of shortage of adequate literature on problem solving teaching as the information is available on the Internet [11]. With the objective to implement internet services to the majority of schools the Ministry of Education and Science of the Republic of Serbia has signed a contract with the one of the biggest internet providers in Serbia, Telecom Serbia, to install ADSL in primary and secondary schools. The contract aims at installing ADSL in all primary schools in Serbia until 2013 with the speed of 16Mbps which is sufficient for the quality internet access.

Primary teachers’ training to deliver schooling based on the new plans and programmes and application of new methods as well as capability of constant improvement of their knowledge with new scientific resources results in their chosen subject is one more important reason that influences the quality of education in electrotechnics and informatics. According to the legal regulation about continuous professional development, teachers’ training qualification, tutor and expert advisor, accepted by the Ministry of Education and Science of the Republic of Serbia, a teacher is legally obliged to attend 100 hours programme over 5 years while at least 60 hours are dedicated to the compulsory and up to 40 hours to elective curriculum [12]. Every year Center for improvement of education and teaching approves a catalogue of programmes for professional development for teachers [4]. Taking into

consideration that the Minister of Education and Science of the Republic of Serbia has given priority to information – communication technologies in the last 3 years, programmes for professional development in the field of technology and informatics are significantly more present in the catalogues and are available to teachers. Yet another important way of teachers' professional development is their participation in professional conferences and seminars. One example of professional conference which is important for primary school teachers' development who are teaching electrotechnics and informatics is International Conference on Technics and Informatics – TIO organised by the Faculty of Technical Science in Cacak [13].

With the aim to make electrotechnics and informatics more popular among primary school pupils, as well as enable them to widen their knowledge in this area, they are given an opportunity to attend professional seminars, summer schools, lectures and workshops. "Summer school of science" hugely popular among primary school pupils in Serbia, supported by UNESCO, takes place in Petnica and it can offer rich and interesting programmes in the field of electronics and computing [14]. Primary school "Cele Kula" in Nis as well as significant number of other schools in Serbia organise a very popular "Science Fair" where numerous experiments and examples of practical teaching are demonstrated to pupils. Also, the numbers of joint workshops for primary and secondary pupils have been increasing in order to motivate the primary school pupils choose some of the electrotechnics modules in their secondary education.

Improvement of organisation and increase of the general technical and educational level of competition in the field of electrotechnics and informatics is yet another way of widening pupils' knowledge which has the impact on the increase of the quality of education in general. Ministry of Education and Science has been making efforts to find additional finances for improving the organisation of competitions and adequately rewarding the achievements in order to increase the number of pupils – competitors. Engaging financial sponsors outside of education can help resolving this problem.

V. CONCLUSION

New educational plans and programmes for primary schools which are regulated by the Ministry of Education and Science of the Republic of Serbia have been coordinated with modern tendencies in the field of electrotechnics and informatics. They offer acquisition of the latest knowledge in these fields which are developing very fast today and a special attention is paid to the units referring to computers and informatics. A huge interest of pupils for studying and acquiring knowledge from the field of electro-technics and informatics, which is shown in the conducted survey, justifies these changes in the primary schools curriculum. These curriculum and syllabus have established a foundation for acquiring high-quality knowledge in the mentioned fields which represents a beginning of education for successful engineers. The survey shows that a huge number of pupils demand the increase of practical work in the fields of electro-technics and computers, which inevitably leads to the fact that

school aids should be modernized in accordance with the curriculum and syllabus. Serbian Government is making great effort with its ministries to enable such modernization of school aids in primary schools. An example for this is the project "Digital School". As the quality of education depends on how much the teachers are trained to transfer modern knowledge to pupils, special attention is paid to teachers' training in the field of electrotechnics and informatics so that they are constantly involved in special trainings, attending obligatory classes and being able to participate conferences and seminars. Today there are evident efforts being made in order to adopt appropriate educational standards for all school subjects (courses) which are in accordance with EU standards which will lead to the further improvement in quality of primary school education. Special attention is paid to coordination of syllabus and curriculum of primary schools with those in secondary schools and faculties. In the end, it is very important to point out that there are great efforts made to organize competitions, seminars, lectures and other activities for the pupils who want to complement the education in the field of electrotechnics and informatics, which surely leads to an increase in pupils' interest for further education in these fields.

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