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Proffesional article

EXTRACURRICULAR ACTIVITIES IN THE FUNCTION OF IMPROVING PRACTICAL SKILLS OF FUTURE STUDENTS IN THE FIELD OF ELECTRICAL ENGINEERING AND COMPUTING

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Abstract. *This paper is based on the authors' many years of experience in teaching, organizing special courses and one-day workshops for different groups of students, as well as IEEESTEC students' project conferences. The manuscript contains a brief description and results of the implementation and evaluation of the special course "Let's put knowledge into practical work" for grammar school students. In order to continue their study and provide students with additional knowledge, the Arduino course was designed. Since 2018, by attending the course as an extracurricular activity, students gain new knowledge in the field of electronic components and microcontroller programming. Based on the conducted analyzes and evaluations, as well as current pedagogical trends, the authors give recommendations on how to overcome problems that may arise due to a lack of practical knowledge and increase students' self-confidence and indicate the importance of a course designed in this way for those freshmen who want to acquire some new skills and knowledge.*

Key words: *practical work, Arduino, workshops, IEEESTEC*

1. Introduction

Since the adoption of the Bolognas Process in Serbia and the adoption of the new Law on higher education in 2005, the education process in Serbia has undergone many phases. The first problems appeared immediately after the implementation of new documents. The first generations of students who graduated from technical faculties under the new regulations did not achieve the expected results. This can be seen in university and company conducted surveys as well from the students' own experience. According to

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these sources, the main skill that was not obtained during the studies is knowledge about practical work that failed to follow theoretical knowledge. The analysis of this problem suggested that realization of practical exercises was expensive, but also the lack of the required level of quality and competence on the teachers' part. To tackle these crucial problems, the Ministry of Education, Science and Technological Development of the Republic of Serbia firstly founded the Centers for the Promotion of Science (CPS, 2022) throughout the country, including the one in Niš in 2010 (RCPDEE, 2022), with the aim of increasing the level of the quality of teaching and promoting teaching and science.

The review of the educational system in Serbia made by National Education Council of the Republic of Serbia in 2011 addresses the lack of the practical work (NECRS, 2011), not only at the level of higher education, but at the secondary level of education as well. Therefore, the Strategy for Education Development in Serbia 2020 which was adopted in 2012 (GRSMESTD, 2012) envisages that to tackle the problem of the lack of the practical knowledge of the students, some basis of the work should be covered on a high school level too. Mainly, because of the absence of this type of work, but also because students weren't prepared enough to comprehend this type of knowledge. It was clear that for a comprehensive solution of the problem, participation of multiple educational stakeholders was needed.

It is important to note that many state institutions in Serbia were involved in providing measures and solving this problem in education, and they will be presented in detail in this manuscript.

1.1. Literature review

In the next chapter, some of the results of the other research groups will be presented, which illustrate the importance of practical work during regular classes at faculties or at high schools. Namely, the significance and the comparison of circumstances pre- and post-course which attended the electrical and electronics engineering undergraduate students in performing complex computer programming tasks represented in manuscript (Kittur, 2020). The importance of computer programming as an essential skill that all engineers must possess, as is expected by most companies, has been seen as practical knowledge in our case. The motivation of an individual student to believe in his/her ability to complete a certain task successfully is the same in both events. An individual with higher motivation was more likely to have higher confidence levels to complete the task successfully with increased performance.

The importance of practical work is clearly highlighted in manuscript (Yilmaz, 2011) which investigates the effect of a Web-based mixed learning approach model on mechatronics education. The model combines different perception methods such as reading, listening, speaking and practice methods. It was shown that perception methods differ among individuals. Some individuals learn effectively only by using reading materials, while the others need practical experience. However, psychological research indicates *that people generally remember approximately 10% of what they read; 20% of what they hear, and 90% of what they try and realize* (Yilmaz, 2011). Moreover, practical experience is of prime importance in effective learning, particularly in engineering and science disciplines. A similar study is presented in manuscript (Jing, 2011), and it is also related to students' skills. Namely, it was shown that lecture-centered educational methodologies are one of the effective ways for knowledge learning, but they do not help students to transform their knowledge into skills. That is the main reason why combined lecture-laboratory methodologies have been adopted in some curriculum designs for skills training. It was shown that laboratory work can consolidate the learned knowledge and transform some of this into skills through practice.

The importance of practical and direct work, an important aspect in the development of young people, can be seen in the work of author Spasić (2022). Namely, the application of modern multimedia technology as an assistive tool in working with children with learning disabilities is described in the paper. In addition to its great sociological significance, the accompanying multimedia video game was designed and developed as a learning tool especially for this occasion.

During the learning process, students react differently to certain situations, so it is completely clear that the individual is motivated by the activity driven by internal factors. Cenić (2018) points out on some more significant aspects of the motivation for successful learning and try to answer to some crucial questions like as: why motivation is crucial in the teaching process, how does the social environment affect motivation, where is the place of assessment as motivation and how encouragement affects successful learning.

Also, Vojinovic (2020) noted that ways of organization and realization of teaching is important pointing out on an example of introducing the model of tiered-lab in the field of engineering. This model of lab programming sessions is suitable for the organization of flipped teaching and learning. However, the lack of research focused on the effects of in-class organization is remained.

Based on abovementioned research as well as valuable experiences of authors in the field an initiative was launched for implementation the new course "Let's put knowledge into practical work" at the beginning and the Arduino course in the following years.

1.2. National strategy of the Republic of Serbia in previous period

At the state level, despite all the measures that had been introduced to 2015 and regardless of the positive progress, no significant progress has been made in terms of practical work among grammar school students. The Ministry of Education, Science and Technological Development of the Republic of Serbia also acknowledged that problem, which is reflected in the introduction of a new elective subject in the third and fourth grade of the practical classes at grammar school. The Institute for Evaluation of the Quality of Education and Training (IEQEU, 2022) was responsible for the incorporation of these subjects into the high school education system.

The programs that lead to the improvement of practical knowledge and skills at the high school level have been outlined as one of the specific goals of the National Youth Strategy of the Republic of Serbia for 2015-2025 (NYSS, 2015). The problems that have arisen are that high school students do not have the knowledge and the skills required at the job market even though those skills are included in the expected outcome of formal education. Therefore, this Strategy provides support to the programs as this one, that enables young people to acquire practical knowledge and both technical and soft skills required in the world of business. To develop and improve these skills, educational institutions like faculties and high schools are marked as key stakeholders. According to the Action Plan of the Development of the City of Niš for 2015-2020, organization of programs on the topic of promoting practical education and possible cooperation between high schools' students and educational institutions as faculties is marked as one of the specific goals (DSCN, 2014).

1.3. Exact situation at the Faculty of Electronic Engineering Niš in last two decades

Even before the adoption of the Strategy for Education Development in Serbia 2020 (GRSMESTD, 2012), the Faculty of Electronic Engineering Niš, had noticed the problems in the education system. Namely, 15 years ago, the Faculty of Electronic Engineering Niš enrolled only 70% of the planned number of students, and some of them were with only 51% of maximum points, which were and still are the legal minimum. In other words, neither the quality nor the number of students was at the appropriate level. On the other hand, during this period there was a great interest in studying at technical faculties at universities all over the world.

To solve this problem, in 2008 the Faculty of Electronic Engineering Niš adopted measures with the following goal: to find a way to improve the quality of the educational process in the first year of study, as well as to improve the success of students in the first year of study. A detailed analysis found that it is necessary to improve the quality and number of high school students enrolling in the Faculty. It was found that in those years, 70% of professional high school students and 30% of grammar school students enrolled at the Faculty of Electronic Engineering Niš. More years of lecturers' experience from the Faculty of Electronic Engineering Niš shows that students who come from grammar schools show better results, and the goal is to enroll a larger number of them. On the other hand, more practical work should be provided for high school students, so that they would be better prepared for studying at the Faculty.

The following measures were planned: Organize competitions in the field of hardware and software for high school students and university students; provide prizes for students' projects; promote as much as possible the awarding of the best students and the best graduate theses during the celebration of the Day of the Faculty. In addition to the entire above, one of the motivating measures regarding the enrollment at the Faculty of Electronic Engineering Niš was to enable high school students to enroll without taking the entrance exam if they won one of the awards at National competitions in physics and mathematics or an engineering subject.

As a result of these efforts and proposed measures, three very important things can be observed that were realized in the years that followed. The first of them was the *IEEESTEC Conference*, the second was the introduction of new subjects at the first year of study, and the last was the implementation of special course "Let's put knowledge into practical work" for grammar school students.

Students and high school students that have the ambition to participate at the *IEEESTEC Student's Project Conference* first go through the process of learning how to write a manuscript. For that, they need scientific results. Some of them write exclusively theoretical manuscripts, but most of them also have the practical realization of their projects. In this way, with the help of their professors, they gain a lot of experience, and it is a great opportunity to promote IEEE manuscript template which is used for conference proceedings. This conference enables the promotion of teamwork, technical sciences, as well as the studies themselves at the Faculty of Electronic Engineering Niš.

After establishing cooperation with high school students through the *IEEESTEC Student's Project Conference*, it was concluded that a small number of grammar school students participated and that they had little practical knowledge. The latter placed them in a disadvantaged position at the Faculty. The goal was to introduce them to that practical work right at the beginning of school, to raise their self-confidence. The Faculty of Electronic

Engineering Niš noticed the low threshold of freshman student's practical knowledge. As a result, the Accreditation in 2013 introduced new subjects that made this possible.

The step forward in promoting practical classes among grammar school students was reflected in the organization of a special course "Let's put knowledge into practical work". Besides, it is recognized as a possibility for the successful promotion of the Faculty of Electronic Engineering Niš.

The results of such implemented projects are presented in detail in (Danković, 2022), based on which the idea of the Arduino course was developed and implemented, which represents *the core* of this paper. The importance of the course and its syllabus will be briefly mentioned in the next chapter. It should be pointed out that course directly enabled the best grammar school students to gain self-confidence and enroll in the Faculty of Electronic Engineering Niš. The monitoring during their studies confirmed the benefit of additional hands-on learning. At this point, we will look at the significance of this additional effort.

2. "LET'S PUT KNOWLEDGE INTO PRACTICAL WORK"

The professors and assistants associated by the Faculty of Electronic Engineering Niš tried to raise the level of practical knowledge among high school students by implementing workshops, and under the auspices of City of Niš Youth Office, a project "Let's put knowledge into practical work" was created.

2.1. Motivation for work with high school students

The Smart Specialization Strategy of the Republic of Serbia for the period from 2020 - 2027 (2018) in all priority areas emphasizes the necessity of practical knowledge building, bringing the academy closer to the economy, which has already found its place in the educational process, as well as developing academic skills necessary for successful cooperation with the other stakeholders. This can also be seen with the new Law on higher education (2017) and the new Law based on the education system (2107) that was adopted in 2017, which encourage start-up and spin-off companies.

Hence, providing more experiences to high school students every year in the different programs and activities will enable growth of their confidence and motivation in practical classes' tasks. With this, the high school students at each level in the class standing will be relatively more confident in their abilities in performing well in practical tasks related to different problems in science. The goal of this manuscript is to present a systematization of long-standing activity and effort in this field, which will be accompanied by numerous analyses that indicate the importance and the impact of practical work at all levels of education.

During four years of high school education in Serbia, especially in grammar school, high school students need to acquire thousands of terms, definitions, formulas..., but the level of their practical knowledge and skills is low. In their higher education, lack of practical skills can put high school students in unequal and inferior position. Even highly motivated high school students that put greater effort often do not achieve as much as they initially expected. As acknowledged by the professors on subjects on the first year at the Faculty of Electronic Engineering Niš, this can lead to lack of motivation and struggle in further education.

It is well known that practical work and application in modern engineering sciences require and unite knowledge from various scientific disciplines. Often, it is not possible to tackle these needs using only a standard classroom lecture-based approach often leading to student's dilemma as: *Where and how am I going to implement these materials*.

Based on these facts and all previously mentioned, the authors created a syllabus for a course intended for grammar school students.

2.2. Syllabus of the course "Let's put knowledge into practical work" for grammar school students

Contrary to the traditional deductive teaching approach, where material is presented to the grammar school students and it is expected that they understand and reproduce presented material, this course puts an inductive approach into use. Grammar school students aren't bound to reproduce circuits (for example on the breadboard), but to make one as they see it. This leads to discussion between team members about possible solutions, which expand their knowledge, thereby boosting both technical skills and skills for teamwork. When grammar school students practically apply their knowledge to solve a problem, their motivation for work and their confidence grow. Also, if the grammar school students have no success in developing appropriate practical solutions at first, they try to reinforce their theoretical knowledge by learning necessary materials until a better solution is found. In this way, the whole engineering cycle is adequately emulated. Also, the presence of both simulations and practical work can more easily express possible lack of understanding of certain materials or a certain topic. This can help professors to identify these misunderstandings and to clarify needed theoretical facts. Based on the above, the basic learning objective of the course is to acquire applied knowledge of applications of electronic components in modern electronic circuits.

The course was held for 15 weeks, having 2 classes per week. During the course, grammar school students worked with two simulators (LTspice and LogiSim) and practically with breadboards and electronic components. Handbook and PowerPoint presentations for each week are provided, as well as homework assignments for some terms. Two individual tests and one group test were conducted. Individual tests were done after 10 weeks of the course and at the end of the course. These tests were done using an online application. On the other hand, the group test was done only at the end of the course, and it was conducted in a written manner.

Two additional surveys were done, one after 10 weeks of the course, and a second at the end of the course. The syllabus of course consists of adapted materials of basic engineering sciences such as physics, electrical circuits, algorithms and programming, analog electronics, and digital electronics. Systematized timeline of all activities is shown in Fig. 1.

Some results of the post-survey questions taken by high school students are in Table 1. Answers are graded from 1-lowest to 5-highest.

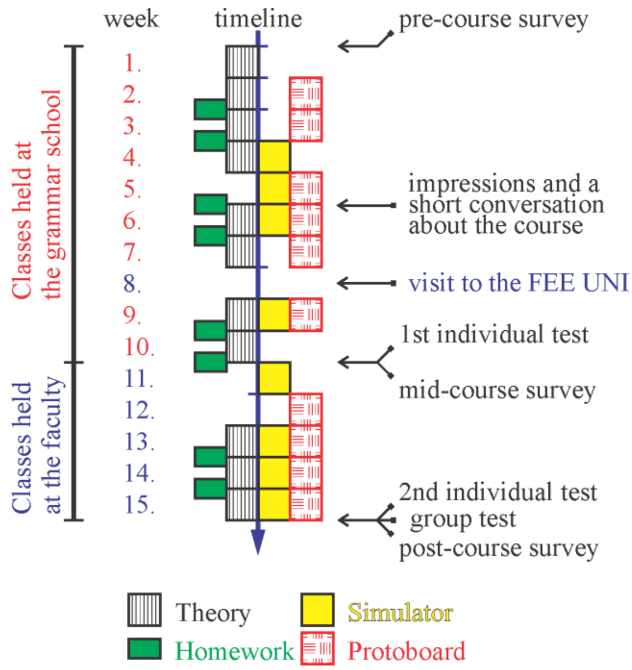

Fig. 1 Course timeline

Table 1 Part of survey done after the course "Let's put knowledge into practical work"

Q. No.	Question	Answer
1	I prefer between practical work and simulators	1-Using the simulator (0%) 2-Practical work (100%)
2	I am satisfied with the knowledge gained during the course.	1(0%) 2(0%) 3(7%) 4(63%) 5(30%)
3	I think that the length of the course is quite adequate.	1(0%) 2(0%) 3(7%) 4(63%) 5(30%)
4	I don't think the course is too difficult.	1(0%) 2(0%) 3(7%) 4(63%) 5(30%)
5	It would be good to continue with the realization of this course.	1(0%) 2(0%) 3(7%) 4(63%) 5(30%)
6	I recommend the course to others.	1(0%) 2(0%) 3(7%) 4(63%) 5(30%)

3. Arduino Course

Some of the impressions of the students, which they expressed through the survey after the course "Let's put knowledge into practical work" were: "*I warmly recommend other generations to be part of the course*" or "*I'm sure I'd attend a continuation of this course*". These statements from course participants, as well as the results of the survey shown in Table I, motivated us and gave us an idea for the implementation of a new course, the *Arduino* course. The *Arduino* course is intended for freshmen attending the Faculty of Electronic Engineering Niš. The course has been implemented since 2018.

The participants of the course were in their first year of study at the Faculty of Electronic Engineering in Niš. Data on students who attended the *Arduino* course is given in Table II. The table shows the number of those who previously attended the high school course “Let’s put knowledge into practical work”, as well as their gender structure was present. In addition to the students at the high school “Bora Stanković” who were part of the high school course, students from the grammar school “Svetozar Marković” Niš, as well as grammar schools from Sokobanja and Leskovac participated in the *Arduino* course.[1] The diversity of the displayed data by gender, school, and by previously attended the course, proves that the analysis of the results after the *Arduino* course will be successful.

Table 2 Information about the participants of Arduino course

Number of students: 13	Male	Female
Students who already finished “Let’s put knowledge into practical work” course	4	2
Students without any experience with practical work	3	4

3.1. Syllabus of the Arduino course

The core of the course is the practical realization of electronic systems based on open-source microcontroller platform *Arduino*. Table III shows the syllabus of the *Arduino* course. The course walks participants through the basics in a hands-on way, with creative projects which they build by teach (Fitzgerald, 2017). Compared to the course “Let’s put knowledge into practical work”, the *Arduino* course has a smaller fund of classes, consisting of 7 two-hour workshops. We decided on this duration of the course (half of the semester) keeping in mind that we are dealing with freshmen. It is very hard to acquire the legal condition for the second year of studies, as shown by numerous analyses. Namely, only 55% pass the second year of studies, while in the higher years it is about 85%.

In addition to practical exercises at the workshops at the Faculty, course participants had homework assignments, and after the Course they worked on group projects for the *IEEESTEC Student’s Project Conference*.

It should be noted that this concept of working with students has only recently come to life within the professional association IEEE Solid State Chapter Society. Namely, it is planned to organize lectures and workshops on this topic in 2023 (Arduino, 2022), as well as competition for high school and undergraduate students throughout the USA and Canada.

[1] Note that: A total of 11 course participants “Let’s put knowledge into practical work” attended the *Arduino* course. 6 participants attended in 2018, as shown in the Table II, and 5 participants in 2019 (which is not included in the analysis of this paper).

Table 3 Syllabus of the Arduino course

Lesson	Subject	Description
1	Introduction	Introduction to the Arduino development board and Arduino IDE. LED blink program.
2	LEDs and buttons	Control LEDs with buttons and Arduino. Connecting buttons and LEDs on breadboard. Pull-up and pull-down resistors. IF statement. Arduino functions: pinMode(); digitalRead(); digitalWrite(); delay().
3	Keyboard and buzzer	Realization of a mini-piano using a piezo buzzer and Arduino. Voltage divider. Piezo buzzer. Realization of keyboard on breadboard. Array in Arduino. Arduino functions: analogRead(); tone().
4	Serial communication and LDR	Light dependent resistors (LDR). Determination of illuminance using LDR and Arduino. Analog-to-digital conversion. Serial communication between Arduino and computer. Arduino function: Serial.print().
5	DC motors	Starting a DC motor using an Arduino. DC motors. MOS transistors. Serial communication – start and stop DC motor via the computer keyboard.
6	Temperature sensors and LCD display	Display of the measured temperature on the LCD display using Arduino. Temperature sensors. LCD display. Arduino functions for LCD displays.
7	Project tasks	Some of the projects that the students realized were: distance measurement using an ultrasonic sensor, control of the opto-coupler using Arduino, Arduino calculator, Arduino height measurement system.

One of the project tasks after the *Arduino* course was the realization of a device prototype for measuring distances. The project task corresponds to the STEM concept and combines several fields: physics, mathematics, hardware, and software. The system consists of an *Arduino* and an ultrasonic distance sensor SR04 (2022). The novelty in this project to the previously learned electronic devices was the ultrasonic sensor, which required the students to study the operation principle of this sensor module. The ultrasonic sensor module emits ultrasound, with a frequency of 40 kHz, which travels through the air, bounces off the object, and returns to the sensor module (Fig. 2). Based on the measured time and speed of sound, it is possible to determine the distance. The SR04 sensor module (Fig. 3) has four pins: two for power (5 V, GND), a sensor trigger pin (TRIG), and a time readout pin (ECHO). To perform a successful distance reading, a 10 μs pulse must be sent to the trigger pin of the sensor. After that, the sensor module from the transmitter emits eight ultrasonic pulses that propagate through the air and the ECHO pin is set to the logic one state. The ECHO pin remains in the logic one state until the ultrasound travels to the object and returns to the sensor module, which is detected by the sensor receiver. The microcontroller measures the time that the ECHO pin spent in the logic one state. Note that the measured time is the total time required for the signal to go from the module to the object and back to the module, the obtained value should be divided by two. The real-time that the ultrasound traveled from the sensor to the object is:

$$t = \frac{t_{measured}}{2}. \tag{1}$$

If the sound speed moving through the air is known as c = 340 ms^{-1}, the distance is:

$$s = ct. \tag{2}$$

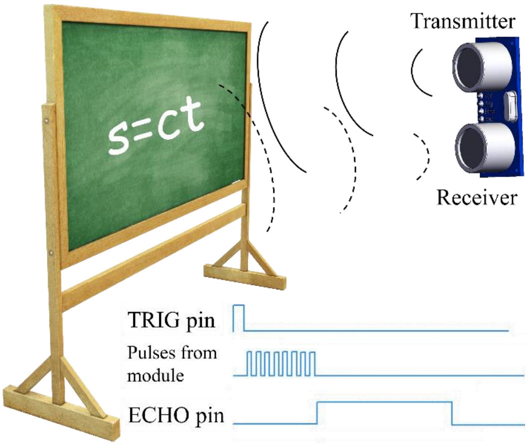

Fig. 2 Explanation of the operation principle of the ultrasonic sensor module SR04

After studying the operation principle of the sensor module, the practical connection of the sensor with the *Arduino* follows. Only jumpers are required for connection. *Arduino* digital pins 2 and 3 were chosen to connect the sensor's TRIG and ECHO pins, respectively. After connecting, the students should write a simple code for the *Arduino* that will read the distance from the sensor and display the measured results on the PC serial terminal. All the used *Arduino* functions were learned and applied during the course. The code is provided below.

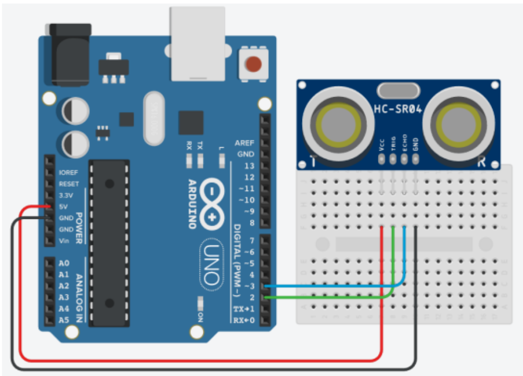

Fig. 3 Schematic of *Arduino* and ultrasonic sensor SR04

At the beginning of the code, the labels for the pins are defined and variables are declared. Within the void setup() function that is executed only once, when the microcontroller receives power, the TRIG and the ECHO pin are set as output and input, respectively. This is where the serial communication between the microcontroller and the PC is initialized, using the function Serial.begin(9600), where the number indicates the bit rate. Within the infinite loop, ie. void loop() function, which is executed while the microcontroller has power, first sets the TRIG pin to a logic zero state, then to a logic one state for 10 µs, and again to a logic zero state. In this way, the trigger impulse was generated. After that, the result returned by the pulseIn function, which measures time, is written into the variable *vreme*. The arguments of this function are the pin and the parameter to be measured. In this case, the function measures how long the ECHO pin was in the logical one state, ie. HIGH. The measured time is expressed in µs. After that, the distance is calculated and written into a certain variable. The obtained value is sent to the PC via serial communication, using the print and println functions from the Serial class.

```
#define trigPin 2
#define echoPin 3
long vreme;
int rastojanje;
void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  Serial.begin(9600);
}
void loop() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  vreme = pulseIn(echoPin, HIGH);
  rastojanje = vreme*0.034/2;
  Serial.print("Rastojanje do prepreke je: ");
  Serial.println(rastojanje);
}
```

After compiling and flashing the program into the microcontroller, the students read the measured distance on the PC's serial monitor. The displayed code is provided for educational purposes and, together with the schematic shown in Fig. 3, allows those who are interested to implement the detailed exercise.

The students showed the initiative to improve the project by adding an LCD and printing the measured value on it, and by adding a piezo-buzzer that is activated when the distance is less than expected. They got the inspiration for these modifications based on the previous exercises (Fig. 4) realized during the *Arduino* course (Table 3).

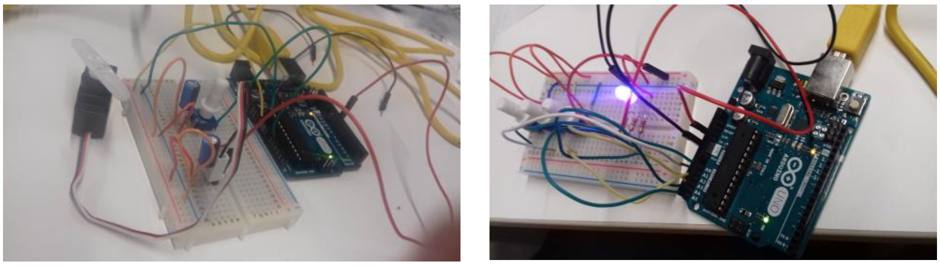

Fig. 4 Examples of practically realized Arduino projects

3.2. Assessment of the course

At the end of each term, the students took a quiz to check the knowledge gained during that exercise. At the last session, a survey was conducted, 13 students participated. The results of the survey are shown in Fig. 5. The average rating on a scale of 1-5 was 4.9. Although the students thought that the course was useful and they would participate in a similar course again, not all of them saw, at the time of the survey, how to apply the knowledge they had acquired in practice. Also, the students presented their impressions after the Arduino course. Some of the answers are:

"*The course is excellent; I would like it to be continued.*"

"*Very useful time spent, I don't regret signing up, the workshops were inspiring*."

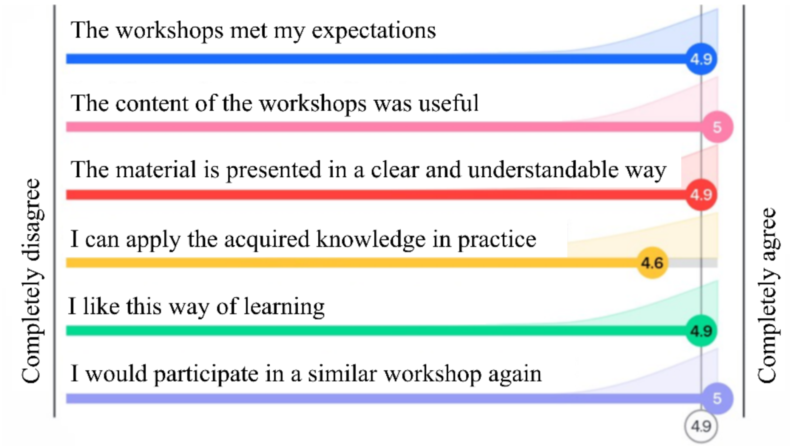

Fig. 5 Survey results after the *Arduino* course

Figure 6 shows two word clouds. By surveying the participants of the course and giving them the opportunity to write five words each that they associate with the course, before and after its holding, the following results were obtained. It is interesting to note that of the general

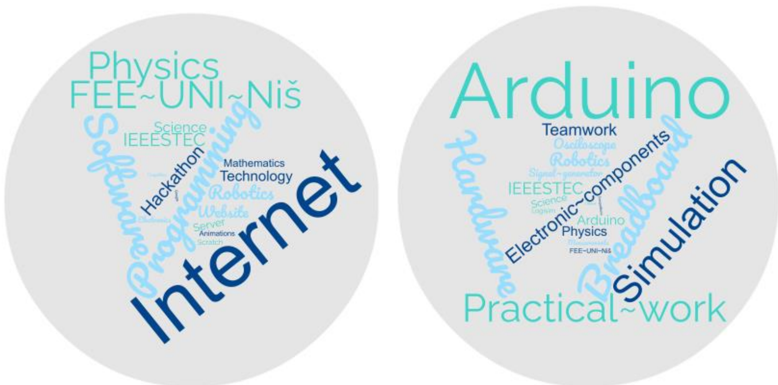

Fig. 6 Words those students associated with the course (left-before, right-after course)

words that they pointed out before attending the course, after the workshops, those words were much more concretely related to the terms they learned about during the course, for example *Arduino, Breadboard, Simulation, Electronic Components* and *Practical Work.*

Students who participated in the course "Let's put knowledge into practical work" in addition to knowledge and practical skills gained many other skills and abilities like as: leadership, open and flexible communication, managing fear especially in asking the questions, logical and critical thinking in problem solving, efficacy and effectiveness in doing home works, independence, team-work and collaboration.

The very important impact of the course could also be seen through an example that illustrates it well. It is worth pointing out some valuable effects that resulted from this work. For example, some participants who were in both courses, further developed their interests and obtained skills like as continuing working with Arduino microcontroller, transfer of acquired knowledge into scientific papers, consultative and practical work with young, non-experienced students, motivating students to create ideas and publish then by using the knowledge and skills developed within Arduino and related courses.

The concept of the *Arduino* course was liked by the high school professors. They launched an initiative to organize a course for their students in the laboratories of the Faculty of Electronic Engineering Niš. Also, at the request of many high school professors, *Arduino* courses were organized for them as well. Although this course was not accredited by any competent institutions, professors were motivated to complete this course and pass the knowledge on to their students.

4. Conclusion

The author's many years of experience have shown that when students enroll in the Faculty of Electronic Engineering Niš, they lack practical knowledge, which also affects the loss of students' self-confidence. The authors carried out a series of described activities to eliminate the shortcomings. After completing the course "Let's put knowledge into practical work", students pointed out that they learned a lot because they practically realized electric circuits, that they are interested in more similar courses and would recommend this course to future generations. The course influenced the raising of self-confidence of grammar school students, which can be seen through their high school graduate theses in which they used the acquired practical knowledge but also improved it. Later at Faculty, some of these students attended a facultative *Arduino* course, also based on the practical application of knowledge, where they also showed self-confidence in solving problems compared to the other course participants. Namely, in addition to the students who passed the course "Let's put knowledge into practical work", there were also the other students on the *Arduino* course who had no prior practical knowledge. The research showed that grammar school students who attended a special course achieved better results in regular education compared to the other students from their generation, did not study "for grade" but to deepen practical knowledge.

In many activities, the authors were ahead of the time of activities carried out by state institutions. Based on all the above, the authors recommend organizing special courses and workshops, conferences of practically realized projects to overcome the problem of the lack of practical work in high school and to increase students' self-confidence in further education.

After two years of holding the course in the premises of the Student Creative Center at the Faculty of Electronic Engineering in Niš, the course had to be held online in accordance with the regulations during 2020-2022. Despite everything, the continuity of this course has been preserved. So, we will organize an extracurricular activity in 2023 as well, in the hope that students will continue to show interest. For this purpose, a special space was set aside this year in the new the Faculty annex. Students will work with state-of-the-art equipment and devices provided by the Ministry of Education, Science and Technological Development's teaching improvement projects, as well as projects of the Center for the Promotion of Science and international STEM projects within the IEEE TryEngineering initiatives and the Engineers Demonstrating Science: An Engineer Teacher Connection program.

One of the goals of the authors of this paper is to create a student team from the Electronic Components and Microsystems module, two students from each year of study, who will undergo training to hold this type of workshop. In this way, students would gain a new experience that will be useful to them later when they start working in some companies or schools, and in addition, this concept of workshops and *Arduino* courses would be sustainable.

As a special task that the authors will carry out in the coming period, is the writing of a booklet, as well as the preparation of online material, which would contain all the exercises that are covered during the course, as well as homework that the course participants could do independently.

The main goal of these mentioned projects, *IEEESTEC Student's Project Conference*, workshops, professional trainings as well as special course for grammar school students, was an evolutionary shift in the way of teaching the subject with the aim of improving the perception of high school students. The goal was that the high school students did not experience the material they were working on as unrelated items, but as parts of a functional entirety. This was achieved by intensive introduction of practical examples, thus increasing the motivation of high school students to look deeper into the principles on which their realization is based. In this way, they are enabled not only to just passively go through the subject matter, but also to essentially learn it. In support of this project and the raising of the level of practical work among high school students, the newly introduced subjects that promote practical work also go.

The development of such projects and courses are motivated by the fact that the Faculty of Electronic Engineering Niš is a higher education institution involved in the implementation of the Action Plan for the Implementation of Strategy of Development of the Information Technology Industry for the period from 2017 to 2020 (APISDITI, 2016) and the Action Plan for the Strategy for Development of the Education in the Republic of Serbia in 2020 (APSDE, 2012). The Faculty of Electronic Engineering Niš provided the appropriate space, and the professors and associates prepared appropriate literature and provided the necessary equipment for the realization of one-day and multi-day workshops.

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VANNASTAVNE AKTIVNOSTI U FUNKCIJI UNAPREĐIVANJA PRAKTIČNIH VEŠTINA BUDUĆIH STUDENATA U OBLASTI ELEKTROTEHNIKE I RAČUNARSTVA

Ovaj rad se zasniva na višegodišnjem iskustvu autora u nastavi, organizovanju specijalnih kurseva i jednodnevnih radionica za različite grupe studenata, kao i IEEESTEC konferencije studentskih projekata. Rukopis sadrži kratak opis i rezultate realizacije i evaluacije specijalnog kursa „Pretočimo znanje u praktičan rad"za učenike gimnazije. Kako bi nastavili učenje i pružili studentima dodatna znanja, osmišljen je i Arduino kurs. Od 2018. godine pohađanjem kursa kao vannastavne aktivnosti studenti stiču nova znanja iz oblasti elektronskih komponenata i programiranja mikrokontrolera. Na osnovu sprovedenih analiza i evaluacija, kao i aktuelnih pedagoških trendova, autori daju preporuke kako da se prevaziđu problemi koji mogu nastati usled nedostatka praktičnih znanja i kako povećati samopouzdanje učenika, te ukazuju na značaj osmišljenog kursa na ovaj način za one brucoše koji žele da steknu neke nove veštine i znanja.

Ključne reči: *praktičan rad, Arduino, radionice, IEEESTEC*