PROCEEDINGS OF SCIENCE

Work with motivated and gifted students in physics in RCT "Mihajlo Pupin" from Pančevo – a review of the last 15 years

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ABSTRACT: Since the very beginning, Regional Center for Talents "Mihajlo Pupin" in Pančevo had a physics group. Over time, the number of classes has grown, but so did the number of students and mentors. Consequently, the achievements on national and even international competitions in physics were growing steadily. After first few years spent in experimenting different possibilities in the field of work with talented students in physics, the standard of classes has been established. Such standard, with the help of motivated students and mentors has produced a successful mechanism for preparing students for various challenges in the field of physics and beyond. This paper presents a model of working in the physics group in Regional Center for Talents "Mihajlo Pupin" in Pančevo, as well as the results our students have achieved on national and international physics and science competitions in the last 15 years of work.

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„Experience shows that our high school graduates, even when they satisfactorily master the technique of solving problems in physics, have a gap in knowledge and understanding of the principles and laws that they should use in solving those problems.

Another shortcoming is the poor knowledge of phenomenology, but it is much more difficult to correct them. . . "

Ivan V. Aničin

1. INTRODUCTION

The Regional Center for Talents (RCT) "Mihajlo Pupin" was founded in December 1998. He started working in March 2000. The cofounders of the Center are the city of Pančevo and the Republic Center for Talents from Belgrade. The RCT "Mihajlo Pupin" from Pančevo is one of the eight RCTs of the Republic of Serbia: KOC Vranje, RCT Niš, RCT Bor, RCT Čačak, RCT Loznica, RCT Belgrade 1-Zemun, RCT Belgrade 2 and RCT "Mihajlo Pupin", Pančevo (Department of RCT "Dušan Vasiljev", Kikinda).

The Republic Center for Talents was founded with the idea of taking care of motivated students with special needs in an organized manner, who excel in intellectual quality and creativity, and whose pursuit of knowledge goes beyond the content offered in schools. Regional centers were established in cooperation with local selfgovernments and are distributed throughout Serbia. Working in the RCT, and their departments, enable work throughout the school year, in small groups made up of primary and secondary school (PSS) students with similar interests, eager for additional knowledge.

Interested PSS students are offered content that they cannot get in their matic schools. In RCTs, we work with the best and motivated PSS students. This implies that:

1) Create conditions for quality continuous work in the environment of (PSS) students with similar intellectual abilities and needs;

2) PSS students participate in research projects of scientific and professional institutions and development centers;

3) Facilitate meetings, consultations and conversations of students with wellknown and recognized scientific workers and artists, as well as visits to professional scientific institutions, cultural institutions and companies;

4) They organize courses that are significant methodological support for the areas represented in the programs.

The physics group started in the RCT "Mihajlo Pupin" from the very beginning, from the school year 2000/2001. years. In the beginning, we worked only with elementary school students.

It is important to point out that work at the RCT "Mihajlo Pupin" from Pančevo is free for students. About 80% of the funds, which are spent during the year, are provided by the local self-government, and the rest of the funds are provided by projects.

2. FORMS OF WORK IN RCT "MIHAJLO PUPIN", PANČEVO

Work with PSS students at the RCT "Mihajlo Pupin" is based on several different methodological methods:

1. Work of the permanent school of the Center, which lasts throughout the school year (preparations for the competition and laboratory work);

2. Mentoring work with selected PSS students and preparing PSS students for the Regional and Republic competition in research papers, and all other affirmative competitions and reviews (creating scientific and artistic youth);

3. Organization of colonies (camps) during the school year and holidays;

4. Organization of seminars for students, lecturers and professional services;

5. Professional excursions that take place during the school year, as well as visits for students to attractive events (exhibitions, festivals)

The way of working in RCT "Mihajlo Pupin" is subordinated to the development of the motivation of PSS students who participate in the work of physics groups. It is completely built so that students love physics, that they consider it important, and that they feel important in their environment because they know physics well, that their selfconfidence is developed and that they have confirmation of their achievements.

2.1 The permanent school of the Center

The work of the permanent school of physics starts in November and is held every Saturday. About 60 classes are held in total. After the municipal competition (the surest way to define PSS students who are interested in practicing physics at a higher level), PSS students who have qualified for the next level of the competition are also invited. In this way, students prepare for the competition organized by the Society of Physicists of Serbia (SPS).

It is worked with PSS students who are interested in physics includes groups from the 6th grade of elementary school to the 4th grade of secondary school. Groups range in size from 5 to 15 PSS students. In addition to tasks from competitions organized by SPS, experimental exercises are also done with elementary school students and, if necessary, with secondary school students. In addition to professors who have extensive experience in preparing for competitions organized by SPS, students who have won awards at national and international competitions, such as secondary school students, work with secondary school students: Stefan Šušnjar, Stefan Stojku, Željko Arsić, Milica Žeželj, Marko Šušnjar, Aleksandar Milošević, Dušan Cvijetić, Danilo Zećević, Aleksandar Djordjević, Aleksandar Cucić. In addition to preprepared assignments for classes and homework, students can always, and at any moment, point out to their lecturers assignments and theoretical topics that they have problems solving or understanding. We must mention that these are experienced students competitors who in the 6th grade decide to compete in physics, and who have been competing in mathematics since the 3rd grade of elementary school. This form of work with students is not applied by any institution in Serbia except RCT "Mihajlo Pupin".

PSS students of the 7th and 8th grades of primary school, as well as students of secondary schools, also participate in a competition organized by the Republic Center Talents of the Republic of Serbia, in which, PSS students work the knowledge test and defend the paper that the students wrote during the school year.

Since 2016, students of RCT "Mihajlo Pupin" regularly participate in the Mathematical Gymnasium Cup, organized by the Mathematical Gymnasium. In this way, the spirit of the competition is fostered, which differs from the competition organized by the SPS and RCTs of the Republic of Serbia. Special preparations are being made for this form of competition, which is held every year

at the end of June, in Belgrade. On February 12, 2021, the RCT "Mihajlo Pupin" team participated in the online physics competition fyziklani 2021, in the B category, where they won 22nd place among 121 teams, and the overall result is 80th place out of 442 teams in the A, B and C categories. A member of our RCT participated in the same competition in the "Grandmother's Grandchildren" team, and his team won 4th place in the A category, i.e. 8th overall. In the period from June 4 to 6, 2021, the World Team Online Physics Olympiad was held. One of the teams from Serbia consisted of students from the RCT "Mihajlo Pupin". 620 teams participated in the competition. The RCT "Mihajlo Pupin" team won 244th place. The result is excellent, especially considering that the team included second-grade PSS students, and the competition included tasks from all areas of secondary school physics.

2.2 Mentoring work

Mentor work implies that the student writes a research paper and that he has a mentor who "guides" him so that both the paper and the poster (or presentation, the PSS students can choose how they will defend the paper) are original and meaningful and are the result of months of work on a clearly defined themes. The topics are determined in agreement with the PSS students. After many years of participation in competitions in research papers, PSS students later at the faculties have a significant advantage over their fellow students when writing seminar papers or reports of various forms.

Considering the large number of works done with the students at RCT "Mihajlo Pupin", we will mention only a few: Galvani's experiment and the invention of Galvanic currents, Invention and application of radio waves - FM transmitter, Surface tension and Deny's paradox, Determining the direction of the meridian.

The seriousness of the competition is also indicated by the fact of who was in the commission for the defense of work at state competitions. We will give an example of only the last two commissions at the secondary school competitions held in 2021 and 2022: 2021: Dr. Milorad Kuraica, Dr. Jasna Crnjanski, associate professor at University of Belgrade, Jelena Marković, professor in secondary school in Pančevo and 2022: Dr. Duško Borka, scientific advisor at Institute for Nuclear Sciences Vinča, Jelena Marković and Vladimir Marić. Beside research papers that have mentor support in the academic year 2017/18. students who expressed their desire to compete in a correspondence competition in physics organized by SPS were also mentored. The group of 5 participants with whom we worked achieved outstanding results, three of them entered the selection for the international competition.

2.3 Colonies and camps of science

The first colony of the physics group in Divčibare was organized in 2008. The colony consists of: lectures and preparation for the competition, lectures by guest lecturers, fun competitive activities (prizes, quizzes, surveys and writing essays, watching movies and series), exhibitions and recreation.

The lecturers who worked with the PSS students in the colonies are: Ljiljana Janković, Vera Stanoevski, Dr. Dragoljub Cucić, Irinel Tapalaga (softmanger of Bank of Serbia), Vladimir Marić (professor in Gimansium "Uroš Predić"), Dr. Nenad Lazarov and Milivoje Vidić (professor in primary school in peace).

FIGURE 1. Students of the 8th grade of primary school during task exercises, preparation for the competition organized by SPS (2017)

Vera Stanoevska: "The paper fully describes our efforts as mentors and the exceptional work of our PSS students through their constant top achievements, at national and international competitions. I have been working as a mentor at the Center since 2015, at first with a competitive group, and for the third year I have been leading a mixed group of elementary school students for physical experiments. What differentiates the work at the Center and a regular elementary school is that children who are particularly interested in physics, independent in their work and with a special gift to look at the problem from completely different angles are gathered in one place, which leads to unexpected, sometimes surprising and witty solutions. That child's talent, ie. future man is crucial for the world to move forward. And precisely nurturing that talent is the aspiration of all of us at the RCT."

Guest lecturers at Divčibare were University professors: Dr. Ivan Aničin, Dr. Mirjana Popović-Božić, Dr. Ilija Savić,Dr. Jovan Dojčinović, Dr. Jovan Puzović, Dr. Milorad Kuraica, Dr. Bratislav Obradović and M.Sc Jovan Jović (Director of Electronetwork of Republic of Serbia), Bratislav Stojiljković (curator of Museums of Science and Technology "Nikola Tesla")

The colony at Divčibare is only for elementary school students. There, motivated and interested students work all day long: in the morning, in the afternoon, and often in the evening. Free time for students is used for skiing and sledding, we lead a professional recreationist - a physical education pedagogue. The time period of maintaining the colony is January to March and lasts 7 days. This is also why RCT "Mihajlo Pupin" is unique in Serbia, for 15 years all costs have been borne by the city of Pančevo.

The scientific-educational camp in Idvor is based on multidisciplinary work, combining: physics, informatics, programming, mathematics, astronomy, history and philosophy of physics and science. The camp is organized by invitation, whereby PSS students who had significant achievements in the previous school year in physics, programming or mathematics are invited. The camp is a reward for participants, and it is free, like all other activities organized by RCT "Mihajlo Pupin". Mentors at the camp are: Dr. Dragoljub Cucić, Milan Surla (independent researcher) and Slobodan Tršek (independent researcher). During the 12 years of the camp, the participants had the opportunity to listen to the lectures of University professors: Dr. Darko Kapor, Dr. Dragoljub Martinović, Dr. Mirjane Popović Božić, Dr. Ivan Aničin, Dr. Jovan Puzović, Dr. Sava Ćebić, Dr. Dusan Vudragović, Dr. Nenad Simonović, Dr. Milorad Kuraica, Dr. Bratislava Obradović and M.Sc. Jovan Jović. The camp consists of a group from 12 to 20 students. Beside of regular and guest lectures, the following activities were organized: quizzes, sports competitions, trips to the swimming pool and a tour of the museum in Kovačica, a visit to the memorial house of Mihajlo Pupin, visits to the Institute of Physics in Belgrade etc.

2.4 Excursions

The excursions of the physics group were initially related to the Institute of Physics at Belgrade. They visited it for the first time in 2006, when they were presented with the Paradox computer. The low-frequency laboratory for nuclear physics was visited in 2008, when the host was Dr. Ivan Aničin, and the lectures were given to the students by doctoral student Zoran Grujić and Dr. Dragan Markušev. Visits and tours of HPP Bajina Bašta were supported by the lectures of Jovan Jović, M.Sc. In 2009, the physics group visited the Institute for Nuclear Sciences "Vinča". The students visited the atomic physics laboratory, the Center for Nuclear Technologies and Research, and listened to lectures on dark matter and experiments at CERN. In 2010, students of the physics group visited the "Incentive Physics" exhibition, and also visited the "Morava" thermal power plant near Svilajnec. For the first 4 years, visits to the Science Festival in Belgrade were also organized.

The tour of HPP "Đerdap" was organized in 2011. The following year, the participants visited the "Gamzigrad" hydropower plant. A group of PSS physicists visited the "Dositej Obradović" primary school in Požarevac with their mentor Milivoj Vidić, where they attended an experimental class organized by the SPS. The following year, in 2015, the older students of the physics group were TE Kostolac, and the younger PSS students went to the Institute of Nuclear Sciences "Vinča". In 2016, the combined scientific group was on a group visit to Petnica, the older physicists were on a tour of the wind generator in Kula, and the younger group of physicists was on a one-day excursion to the Institute of Nuclear Sciences in Vinča. In 2017, we only went to the Institute of Nuclear Physics "Vinča".

3. THE SIGHTING OF LJILJANE JANKOVIĆ

I have been working at the RCT "Mihajlo Pupin" in Pančevo for more than 15 years, and for all these years we have had several models of work with PSS students who are interested in physics. Mentoring for research paper writing and preparation for competitions starting from Municipal to State, then to Olympiad, Balkaniad, International and World competitions in senior/secondary school classes. Additional work at the RCT with PSS students who are interested in physics is

FIGURE 2. Excursion of participants of the 11th scientific and educational camp Mihajlo Idvorski Pupin, Idvor 2021 at the Institute of Physics in Belgrade (Zemun), July 2021

FIGURE 3. Students of the physics group, 8th and 7th grade (a few years later winners of many international awards in physics) with their mentor, Milivoje Vidić, on a professional one-day excursion to the in Đerdap Hydroelectric Power Station (2011) .

different from working at school. The works at RCT in groups of five to fifteen PSS students (which depends on the interest of the PSS students, from year to year). PSS students come to the RCT from several schools and from different social environments (urban and rural). Such work requires additional preparation, both for a smaller and a larger group of PSS students. Introductory tasks that include basic physical expressions and formulas are done first, followed by more complex ones that require more activity. PSS students are encouraged to investigate through experiments and research papers, to solve problems, to express their ideas in their own way, and therefore to compete in every class. Accordingly, PSS students can express all their creativity, but also strengthen themselves for further research and advancement, because they are in a group where everyone is approximately equal. At school, they are often not motivated to do such work because such PSS students are often lonely in the class. The difference between working with PSS students in primary school and working in the RCT is reflected in the fact that at school we can more easily monitor the work of PSS students because we are in daily contact and there are only a few of them in a generation, while we monitor PSS students in the RCT only from November to April , while they are writing papers and while the competitions are going on. However, working in the RCT provides PSS students with greater opportunities for advancement and encouragement, such as, for example, mutual competitions, then trips to colonies that are free (seven-day camp in Divčibare, ten-day camp in Idvor), one-day thematic excursions, visits to cultural and historical places the memorial house of Mihajlo Pupin in Idvor and Museums of Science and Technology "Nikola Tesla", visits to scientific institutions (Institute of Physics - Beograd, Institute of Nuclear Science - Vinča, Faculty of Physics, Research Station Petnica), visits to companies closely connected with contents that are done in classes (Bajna Bašta, Hydropower Plants "Đerdap", Obrenovac thermal power plant) and the Science Festival (until 2019). PSS Students attending the RCT are more communicative, progress more easily in further education, and overcome social differences, which unfortunately are increasing, more easily.

4. ACHIEVEMENTS OF STUDENTS OF RCT "MIHAJLO PUPIN", PANČEVO IN THE LAST 15 YEARS

The physics group at RCT ”Mihajlo Pupin“ has existed since the RCT was founded in 2000, and the results at state competitions were achieved even then. It is worth mentioning PSS students Aleksandar Nikolić, Bojana Milošević, Jelena Marković who continued their education at the Mathematical Gymnasium, but there were also, in different generations: Srđan Keča, Ljubiša Milošević, Dijana Sredić, Ana Stanojević, Darko Fabijan who regularly won prizes at state competitions in physics.

Previously, participants of RCT "Mihajlo Pupin" won awards at state competitions, but there was no continuity, which was established in 2007, when the city of Pančevo took over to finance two salaries of employees and work with PSS students. Then work begins in colonies and camps with students, as well as regular one-day educational excursions. Then a well-designed continuity in work with gifted and motivated students was established. The participants of the Center achieved results at the IJSO (International Junior Science Olympiad) and IPHO (International Physical Olympiad): 2022 - Anja Šušnjar, student of the 3rd grade of the Mathematical Gymnasium (MG), commendation at the IPHO;

TABLE 1. Results of participants of RCT "Mihajlo Pupin" at national and international competitions organized and supported by the Society of Serbian Physicist

School year	**Number of awards at Serbian Physical Olypiades 1,2,3**	**Number of awards on IPhOs (1,2,3)**
2007/08	1+0+0	
2008/09	1+0+1 (0+0+1)	
2009/10	1+0+1	
2010/11	3+4+4 (0+0+1)	
2011/12	3+4+3 (0+1+0)	
2012/13	6+1+2 (1+2+3)	0+0+1 (1)
2013/14	3+5+4	-
2014/15	4+3+7 (0+1+0)	0+0+1
2015/16	2+2+8 (0+0+1)	-
2016/17	4+12+5 (1+1+1)	0+1+0
2017/18	5+2+5	-
2018/19	4+3+9 (1+0+0)	0+0+1
2019/20	Covid	-
2020/21	3+1+3	-
2021/22	1+1+7 (1+0+0)	Commendation at the 52nd IPHO

2019 - Anja Šušnjar, student of the 8th grade of the MG, bronze at IJSO,
2017 - Marko Šušnjar, student of the 4th grade of the MG, silver at the IPHO;
2015 - Željko Arsić, 4th-grade student of ETŠ "Nikola Tesla", Pančevo, bronze at IPHO;
2013 - Marko Šušnjar, student of the 8th grade of the MG, bronze at the IJSO;
2013 - Ognjen Tošić, student of the 8th grade of the MG, participation in the IJSO.

5. CONCLUSIONS

For good work with students, it is important: continuity in work and constant maintenance of students' motivation. A permanent school in an environment of peers with similar interests, colonies where work is done in a motivating environment, the selection of mentors who have a motivating influence on students, one-day excursions to institutions, power plants, exhibitions. All of the above contributes to improving knowledge, as shown by the results of the students in the physics group at RCT "Mihajlo Pupin". We believe that it is very important that all the listed activities are free of charge for participants of RCT "Mihajlo Pupin". Many parents are unable to provide the means for their children to develop giftedness. It is important that giftedness and desire for advancement should not be claimed only by those who can pay for it. That way we will all be deprived.

6. PICTURES

Photographs of participants who are now of legal age were selected.

FIGURE 4. In memoriam of University professor Dr. Ivan Aničin (1944-2016) gave a two-day lecture on the theory of errors, for the later experiments that the participants of the camp in Divčibare will work (2012).

FIGURE 5. Experimental exercises. The photo shows the participants of the colony on Divčibare (2012). In 2023 they are physicist in PSS schools or Ph.D. students.

FIGURE 6. In memoriam of University professor Dr. Jovan Puzović (1960-2023) gave a lecture to the students of the Colony of Physicists in Divčibare (2012).

FIGURE 7. Mentors Ljiljana Janković and Vera Stanoevska do experimental exercises with participants of the colony in Divčibare (2015).

FIGURE 8. During the winter vacation, the Gymnasium "Borislav Petrov Braca" in Vršac held a Physics Winter School for primary school students 2016.

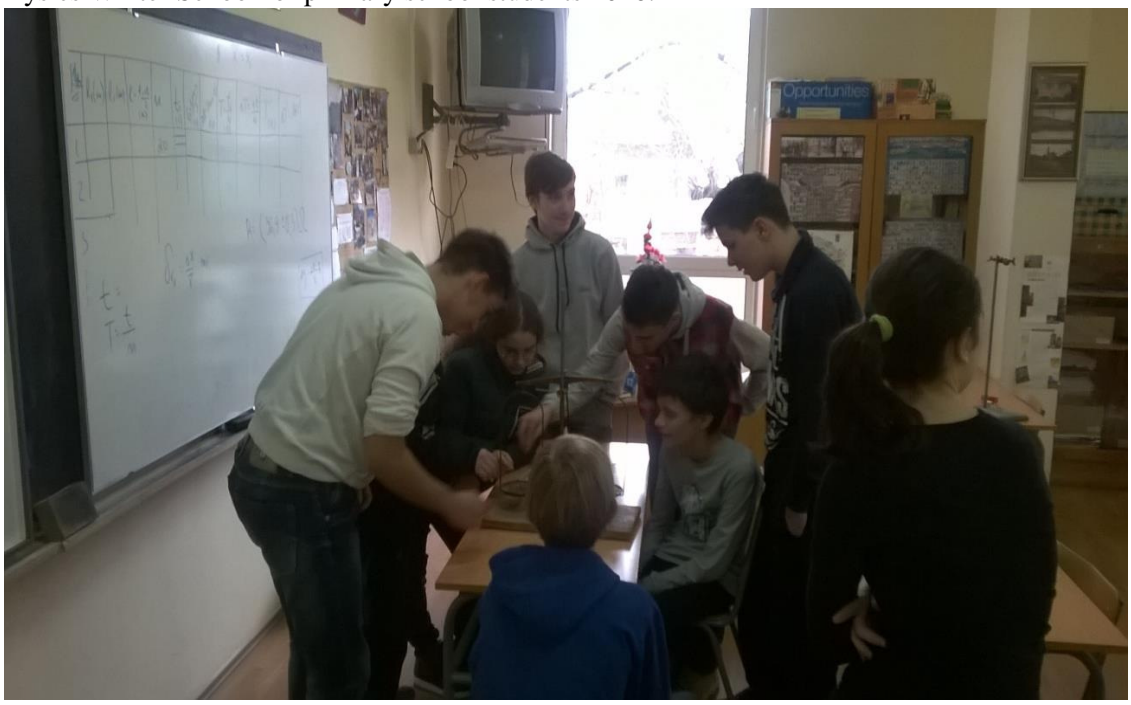

FIGURE 9. In 2016, in cooperation with the Association of Physicists of Pancevo, RCT "Mihajlo Pupin" held a science festival at the primary school "Mlada pokolenja" in Kovačica.

Also the pictures can be seen from the following websites:
https://www.facebook.com/RCTMIHAJLOPUPIN
https://www.facebook.com/profile.php?id=100054420282481
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