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On the "Phystech System", Its Implementation at the Bauman Moscow State University, and One Pedagogical Method

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***Abstract*-The purpose of the article is a brief presentation of the "Phystech System", features of its implementation at the Bauman Moscow State Technical University, the work of one of the "basic enterprises" of the Faculty of Instrument Engineering of the University - the Scientific Research Institute for Applied Mechanics named after Academician V.I. Kuznetsov in the field of innovative development of gyroscopic technology with the involvement of students to participate in the implementation of the state contract using the original pedagogical method. An example of the creation at the institute creative group of three students selected according to the criteria of the "Phystech System", including a "personal interview" with the team leader (mentor of the "group X"), which worked effectively for five semesters, successfully completed four stages of the contract and the contract as a whole. A record result was achieved - each of three students, in parallel with their studies at the university and with the fulfillment of the state contract at the institute, published more than 50 works. The essence of the pedagogical method was the complete trust in the students - the "chief designers" of three new gyroscopic directions: gyros on de Broglie waves, Bose-Einstein condensate and helium superfluidity with continuous mentor support.**

Keywords-education science, "Phystech System", classical Russian school of engineering polytechnic education

I. INTRODUCTION

Moscow Institute of Physics and Technology (MIPT), known informally as PhysTech, is a Russian university, originally established in Soviet Union [1]. It prepares specialists in theoretical and applied physics, applied mathematics and related disciplines. MIPT is known for specifics of the MIPT educational process ("Phystech System") [1]. With its emphasis on embedding research in the educational process, MIPT "outsources" education and research beyond the first two or three years of study to institutions of the Russian Academy of Sciences or leading industrial enterprises [1].

The following is a summary of the key principles of the Phystech System, as outlined by Kapitsa in his 1946 letter to Stalin arguing for the founding of MIPT [1]: "1) Rigorous selection of gifted and creative young individuals; 2) Involving leading scientists in student education, in close contact with them in their creative environment; 3) An individualized approach to encourage the cultivation of students' creative drive and to avoid overloading them with unnecessary subjects and rote learning common in other schools and necessitated by mass education; 4) Conducting their education in an atmosphere of research and creative engineering, using the best existing laboratories in the country".

In its implementation, the Phystech System combines highly competitive admissions, extensive fundamental education in mathematics, as well as theoretical and experimental physics in the undergraduate years and immersion in research work at research institutions of the Russian Academy of Sciences or leading industrial enterprises starting as early as the second or third year [1].

The word "phystech" is used to refer to Phystech students and graduates [1].

One of the authors of this article (Nikolay I. Krobka) is "phystech" of 1979 release.

Nowadays, many Russian universities use the Phystech System, in particular, the Bauman Moscow State Technical University (BMSTU). The BMSTU is a public technical university located in Moscow [2]. The BMSTU is the oldest and largest Russian technical university offering B.S., M.S. and PhD degrees in various engineering fields and applied sciences [2]. The BMSTU is the second oldest educational institution in Russia after Lomonosov Moscow State University (1755) [2].

The article [3] reveals the basic principle of the classical Russian school of engineering polytechnic education based on the integration of education, science and industry,

effective interaction and cooperation with industry and research organizations.

The example of organization and operation of the BMSTU based on the integrated system of education and continuous research and production practice of students has been represented.

One of the authors of this article (Aleksander S. Fadeev) is a graduate of the BMSTU 1974 release.

The Scientific Research Institute for Applied Mechanics (SRIAM) was founded in 1955 [4]. The SRIAM was the first enterprise in Russia whose task was to create gyroscopic command instruments for rocket and space technology [4]. Since 2006, the SRIAM has been a part of the Federal State Unitary Enterprise “Center for Operation of Space Ground Based Infrastructure” (TsENKI) [5]. The SRIAM is the leading enterprise in Russia for the creation of precision command tools for rockets and space vehicles. Until 1985, only mechanical gyroscopes were developed at SRIAM. Since 1985, the development of quantum-optical gyros: ring laser gyros (RLG) and fiber-optic gyros (FOG) began at SRIAM because of the trend in their application in rocket and space technology. Research works on a new generation of inertial sensors based on cold atoms were initiated at SRIAM in 2008 [6].

II. THE WORK OF GROUP X, CREATED AT THE SRIAM FOR THE IMPLEMENTATION OF THE STATE CONTRACT

Taking into account the publication [6] about the new generation of gyros on cold atoms, Director of the SRIAM Valery P. Krehtunov instructed the author of the work [6] to prepare an application for a competition to receive a state contract. The application was prepared and won the competition, taking first place. March 15, 2010, General Director of TsENKI Aleksander S. Fadeev signed a state contract [7] with Federal Agency for Science and Innovations in the framework of the federal program "Scientific and scientific-pedagogical personnel of innovative Russia 2009-2013".

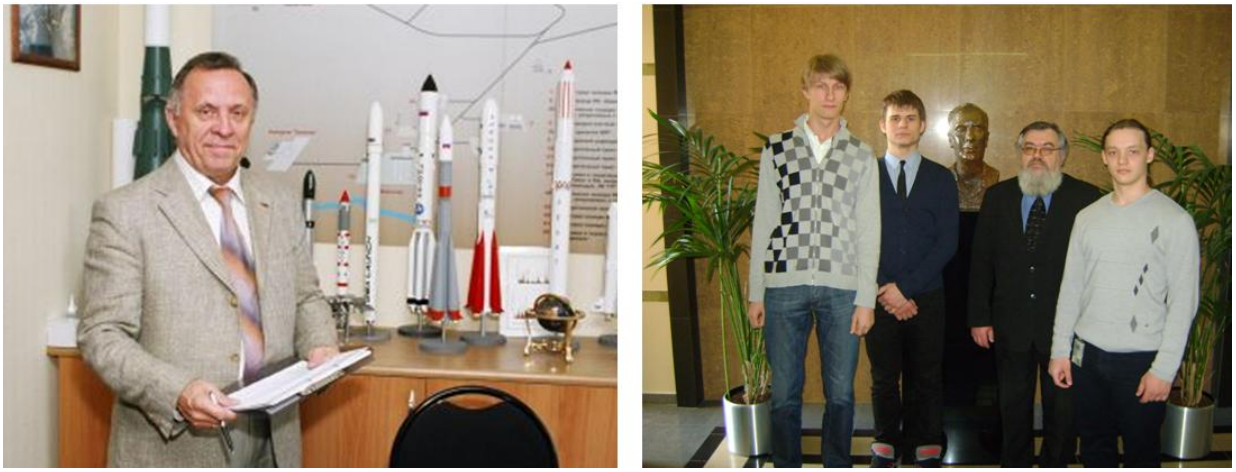

Figure 1. Start of experimental group X

In Fig. 1, left is General Director Aleksander S. Fadeev; right is group X, established in the SRIAM to fulfill the contract [7] in part of a new generation of gyros based on cold atoms (from left to right: student Nikita Tribulev, student Alexander Bidenko, bust of Academician V.I. Kuznetsov, group leader, mentor of the group X Nikolay I. Krobka, student Vladislav Chernichenko).

On the basis of a three-stage competitive selection of students of the Faculty of Instrument Engineering (FIE) of BMSTU, mainly students who completed the second year, in June 2010 a group of three students was formed (Fig. 1). After the summer holidays, group X has gathered to practice at the SRIAM from September 15, 2010. The instructor had the opportunity to work “on two fronts”: prepare the groundwork [8] for carrying out the first stage of the contract and, in parallel, introduce students of group X, practically “from scratch”, to the topics of quantum physics, quantum optics and quantum interferometry [9], conducting weekly 2-3 seminars of group X.

As a result, students of group X made a worthy contribution to the interim reports on the four stages of the contract [7]: I: Analytical studies of ways to use the generalized Sagnac effect to create new generation gyroscopes — gyroscopes on the generalized Sagnac effect; II: Elaboration of the technical appearance of gyroscopes on the generalized Sagnac effect; III: Elaboration of requirements for the elements of gyroscopes on the generalized Sagnac effect; IV: Selection and justification of basic technologies for creating gyroscopes on the generalized Sagnac effect; and in the final report on the contract [10]. In essence, in one semester, we managed to prepare students of group X for independent creative work.

In Fig. 2, student Nikita Tribulev (group X) presents the very first poster “Innovative space technology: precision cold-atom gyroscopes for space applications”.

Figure 2. The very first poster of the group X at the All-Russian Space Innovation Convention (Uglegorsk, Russia, March 30, 2011)

In Fig. 3, the very first posters of the group X at the international conference are presented.

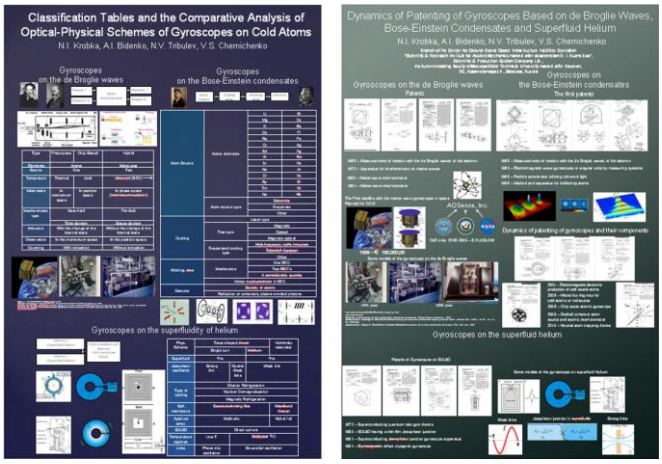

Figure 3. Two posters of the group X at 18th Saint Petersburg International Conference on Integrated Navigation Systems (30 May – 01 June 2011, Saint Petersburg, Russia)

In Fig. 4, Vladislav Chernichenko (group X) is preparing for a report at 26th International Conference on Low Temperature Physics, Institute of Physics, Academy of Sciences of China.

Figure 4. The very first poster of the group X abroad (August 10-17, 2011, Beijing, China)

In Fig. 5, Alexander Bidenko (group X) gives an introductory lecture for employees of the SRIAM.

Figure 5. The lectures of group X for employees of the SRIAM (March 30, 2012)

III. SUMMARY

We gave a practical example of combining the experience of the MIPT (the Phystech System) and the BMSTU (Education through Science) and the two mottos: “Dare to Know!” (MIPT) and “Courage, Will, Labor, Perseverance!” (BMSTU). A record result was achieved - each of three students of group X, in parallel with their studies at the University and with the fulfillment of the state contract at the Institute, published more than 50 works, including in English [11-16].

In Fig. 6, the final report in seven volumes [10] on the contract No. 02.740.11.0528 [7] is presented.

Figure 6. Group X result for 5 semesters

The experience of group X was noticed by the management of TsENKI and SRIAM. Over the past years, more responsible areas of work have begun to trust young people. The average age of SRIAM employees has decreased from 57 years to 42 years. The average age of today's heads of departments, divisions and deputy directors at SRIAM is significantly lower than the average age of institute staff.

ACKNOWLEDGEMENT

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