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CDIO within the System of Continuous Education "From School to Higher Education Institution (HEI)": Stage "Conceive" at School

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The article describes the system of methods to reveal potential intellectual giftedness of pupils. The system is designed by the authors and based on TRIZ-pedagogy. Within this system the pupils, who are regarded as future university applicants, are related to innovative HEI (higher education institution) through innovative project activity. The authors have analyzed how appropriate the system is to introduce stage «Conceive» at school preparation for HEIs implementing CDIO system.

Key words: Conceive, TRIZ, applied dialectics, TRIZ-pedagogy, knowledge invention, innovative projects, CAI programs.

Making engineering education applicable to solving practical tasks is a topical problem for engineering institutions all over the world, so, many institutions have tested the technologies which may be effective to handle the problem. The task in common caused the similar results but different in terms of the stage of completion. CDIO initiative developed at Massachusetts Institute of Technology became the most complete and holistic system of standards. Many universities which applied similar approaches became the participants of CDIO world initiative. Many universities disseminated these approaches among the schools thus involving pupils into scientific and project activities under the supervision of both university and school teachers. Upon university education completion, these former school leavers got more opportunities to become promising specialists.

Classical example is the Russian scientific and social program for pupils and youth «Step into Future». The authors of the article participated in the program as scientific supervisors for many years, became prizewinners of national conferences and exhibitions, took part in international youth scientific forums. This is the program of leading Russian HEI: Bauman Moscow State Technical University, Lomonosov Moscow State University, Mendeleyev University of Chemical Technology of Russia, Moscow State University of Design and Technology – Kosygin Institute of Textiles and others. The idea of the program is to find gifted youth in all Federal districts of the Russian Federation.

To increase the educational level of applicants, the methods reveal potential giftedness (the term is introduced in the Concept of Giftedness [1]) were applied at leading regional universities, such as Krasnoyarsk State Technical University (KSTU), which in 2007 was included into Siberian Federal University (SFU). KSTU together with schools of Krasnoyarsk and Krasnoyarsky Kray, as well as the Institute of Continuing Professional Development of Educational Staff, began to use TRIZ-theory by G.S. Altshuller [2] (TRIZ is Russian abbreviation from «theory of inventive problem solving») and apply didactic technology of TRIZ-pedagogy [3]. The authors of the paper were supervisors of pupil's projects, organized continuing

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professional development courses on TRIZ-pedagogy for school teachers. As a result, the teachers, who were the most successful in doing the courses, ensured support for pupils to win the prizes of different categories at national conferences and exhibitions. During more than 15 years of TRIZ-pedagogy development and application at schools, it was amplified with some new methods. Along with the method of creative tasks [4], the authors of the paper contributed to development, testing, publication and introduction into the courses of continuing professional development the methods as follows: method of knowledge invention and method of innovative projects [5, 6]. These two allow applying TRIZ-pedagogy to all types of educational process, supplementary education, and scientific and technical creative activity of youth (STCAY).

TRIZ-pedagogy developed by the authors is relevant to modern standards of school education, including the systemic activity approach, and improves some essential meta-subject skills.

Over the past years the technology of substantial educational development (SED) [7] based on TRIZ-pedagogy has been introduced by the authors of the paper in collaboration with Scientific and Educational Centre of UNESCO (university department) «New materials and technologies», Siberian Federal University (SFU).

The method of innovative projects (which combines the project methods by J. Dewey and W.H. Kilpatrick with TRIZ by G.S. Altshuller) served as a basis to relate intellectually gifted applicants (i.e. those with revealed potential giftedness) to innovative HEI through innovative project activity. Under innovative project activity we mean the activity of pupils, whose results are innovative ideas on solutions to complicated problems and inventions. Doing an innovative project under the supervision of university scientists and teachers in collaboration with school teachers, the pupil, who is a future applicant, knows that to continue his or her project and reach success, he or she should enter the particular university and the particular department, where the project supervisors work.

The method of innovative projects has been tested many times at both creative studios of schools and youth intensive schools within the special sessions. The studios were established at Academician Ovchinnikov school № 10 and school № 82 in Krasnoyarsk, which are basic schools of UNESCO department «New materials and technologies», SFU. The studios work according to the schedule during the academic year. The innovative projects of pupils from studios were awarded with different prizes at regional and national conferences and STCAY exhibitions. Scince 1999 pupils worked out their projects within intensive schools: summer intensive schools in Krasnoyarsk, sessions of different profiles in national child centres «Orlyonok» and «Ocean», child health and education camp «Yunyj Neftyanik» of «Surgutneftegaz». In collaboration with «Orlyonok» book «Youth Intensive Schools of Innovative Era» was prepared and published [8].

In 2009, within the session of Zvorykin Project Forum «Seliger» a grant by National Fund «National Prospects» was awarded to project «Pupil's Creativity on the basis of TRIZ»; the money was spent on continuing professional development courses for teachers and publication of the book [6].

In 2013, the first patent «Protective system of the sportsman» was granted to school № 10 and SFU: the authors are scientific supervisors, pupils and students of SFU. There are other applications for patents being prepared at the moment.

CDIO being implemented and supported by Strategic Initiative Agency in Russia, it is reasonable to analyze the ways to provide «connecting link» of gifted applicants with universities, in particular, with those departments where CDIO is being implemented.

Within the system of such «link» new ideas are generated by applicants, which is relevant to the first stage of CDIO – «Concieve» (stage of reflection and planning, according to Standard 1), and primary elaboration of constructions, schemes and algorithms takes place, which is partially relevant to stage «Design» (stage of designing).

The particularities of «link» model suggested by the authors in comparison with classical ways to provide STCAY are content and methods of «Conceive» stage. The compliance of the model with CDIO and Syllabus standards is stated as follows:

CDIO Standards [10]:

Standard 4. Introduction to Engineering.

Working on innovative projects, future applicants get basic knowledge of TRIZ, which is considered to be the most effective technology of ideas generation all over the world. Today, TRIZ is taught at several leading universities, including Massachusetts Institute of Technology, where CDIO was developed, and there are researches on application of CDIO and TRIZ in common. Thus, future applicants study the important block of «Introduction to Engineering» in advance, being involved in engineering through solving problems.

Standard 6. Engineering Workspaces.

The space is broadened through employing facilities of schools, supplementary education centres, child centres (within intensive schools), computer classrooms, as well as centres of youth innovative activities and centers of prototyping established in several regions, where models and patterns may be designed. It is possible to provide the efficient use of the above-mentioned facilities applying CAI programs, such as «Innovation Workbench», «Invention Machine Goldfire», «Tech Optimizer».

Standard 7. Integrated Learning Experiences.

The methods of innovative projects and knowledge invention mentioned above are implemented: they incorporate TRIZ in disciplinary subjects, foster the learning of disciplinary knowledge simultaneously with personal and interpersonal skills, and product, process, and system building skills.

Standard 8. Active Learning.

The methods of innovative projects and knowledge invention are active learning methods engaging students directly in thinking and problem solving activities.

Standard 10. Enhancement of Faculty Teaching Competence.

The courses of continuing professional development for teachers of different types and education stages have been implemented and are being continuously enhanced.

Standard 11. Learning Assessment.

Assessment criteria measure innovativeness of solutions based on a five-level scale by G.S. Altshuller, the author of TRIZ. These criteria made it possible not only to compare innovative ideas form different fields and determine achievements within separate sections but also to provide overall ranking of participants at scientific competitions and conferences. The method of assessment was conducted at different final conferences within intensive schools, as well as multidisciplinary Olympiad «Young Innovators» hold by SFU.

CDIO Syllabus [11], Standard 2, CDIO learning outcomes:

1.2. Core Fundamental Knowledge of Engineering.

TRIZ methods being applied in transnational corporations and leading universities all over the world, prove the principle importance of fundamental knowledge of core engineering at the time of transition to the fifth and sixth technological modes.

2.1. Analytical Reasoning and Problem Solving.

TRIZ contains well-developed intellectual instruments of analysis and problem solving: laws of existence and system development, methods to overcome technical and physical contradictions, standards of contradiction elimination, algorithms of inventive tasks solving (today, that is ARIZ-85V, Russian abbreviation from «algorithm to solve inventive tasks», other algorithms are being intensively developed).

2.3. System Thinking.

TRIZ contains universal «intellectual instruments» of system analysis and synthesis, including «nine-screen scheme of talented thinking» – system operator (SO)).

2.4.3. Creative Thinking.

TRIZ is conceptually a method of creative thinking, based on fundamental dialectic laws of anthropogenic and non-anthropogenic worlds development: not only divergent thinking, which «steps aside» from stereotypes, but also convergent thinking, which «steps towards» innovative problem solutions.

2.5.3. Proactive Vision and Intention in Life.

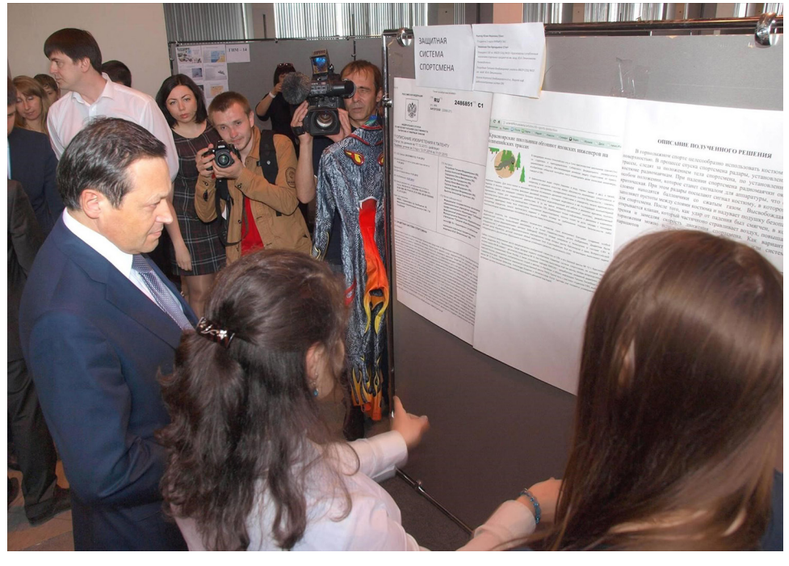
TRIZ makes it possible to provide more accurate foresight (medium-term foresight), which is admitted by the prominent foresighters (for example, S.B. Pereslegin uses the system operator), as soon as it helps to foresee quality changes in different anthropogenic systems on the grounds of fundamental development laws. Sometimes it is possible even to combine the forecast of a solution with the solution itself. Based on applied dialectics, i.e. TRIZ going beyond the scope of anthropogenic systems, the explorations on man's intention in life are being conducted, where man is considered as a subject of world development.

4.1.7. Sustainability and the Need for Sustainable Development.

Based on TRIZ-pedagogy in collaboration with UNESCO, research and development of didactic education system are provided to ensure sustainable development [7, 12].

4.2.6. New Technology Development and Assessment.

Fig. 1. Mayor of Krasnoyarsk E.Sh. Akbulatov at city STCAY exhibition is being declared about patent «Protective system of the sportsman» received by school № 10 and SFU



TRIZ is a new technology of development (laws, methods, standards) and assessment of innovative solutions (five-level scale).

4.7.1. Identifying the Problem or Paradox.

In TRIZ there are effective methods to determine contradictions and identify «operational conflict zone».

4.7.2. Thinking Creatively and Communicating Possibilities.

The methods of innovative projects and knowledge invention based on TRIZ contribute to development of creative thinking in accordance with algorithms correlated to world development laws.

4.7.3. Defining the Solution.

Defining the solution of a problem is based on the notions of «ideal system» (IS) and «ideal final solution» (IFS) with «intellectual instruments» of TRIZ being applied.

4.7.9. Inventions.

In the process of «link» system development, more and more patentable solutions are found (for example, [9]).

To conclude, the developed system of «link» of intellectually gifted applicants to innovative universities through innovative project activity based on TRIZ is in compliance with a number of CDIO standards and CDIO Syllabus expected learning outcomes, is considered to be hands-on and thus, might be suggested to CDIO community as a system of pre-university preparation.

Fig. 2. Winners of «Shustrik» competition organized by Association of Innovative Regions of Russia (AIRR): N. Bezrukikh and Ye. Ilyasova, pupils of the 7th grade of school № 10 of Krasnoyarsk, are presenting the project on utilization of «litter islands» in the ocean «Clear Island» at Baby Farm, Startup Village conference in «Hypercube», Skolkovo

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