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"Formula-Student" Project as a Platform for Practice-Oriented Training of Enginnering Graduates

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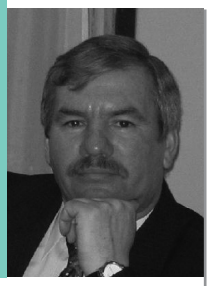
Practice-oriented training, an innovative teaching technology, is one of the conditions for quality assurance in Higher Education. Such innovative international "Formula-Student" project, combining education, science and sport, is being implemented at Togliatti State University.

Key words: *educational program, "Formula-Student" project, curricular module, learning outcomes, engineering activity, employer.*



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One of the criteria of innovative approach to managing education process at universities is particular attention to developing engineering thinking by incorporating peculiar methods and engineering issues into various programs. In accordance with this criterion, university should strive to train such engineers who will be able to work in any sphere of human activity – engineering, humanitarian, scientific, and pedagogical. Besides, an "engineer" is defined as one who is capable of identifying and solving complex problems, knowledgeable of existing constructions, is capable of designing new products and technologies, managing processes and creating self-improvement strategies.

Training such engineers who can be qualified as a "born and bred engineer", a creative specialist, can only be achieved through the application of innovative practice-oriented teaching technology instead of traditional teaching and learning techniques. Practice-oriented education implies that students have opportunities to be engaged in a diversity of practice-related experiences within their discipline areas. The basic principle of such education is "Docendo discimus" (Latin) - the idea that "We learn from teaching". In other words, teachers and students work together producing a real product which can be of practical and commercial value both for university and a potential employer.

Practice-oriented training ensures the quality and relevance of education and stimulates the interest of different participants in the process itself:

- university benefits from image improvement, employers' investments and the expansion of existing partnerships;
- graduating departments gain advantages of new internship and job placement opportunities, strengthening relationships with professional communities, making commercial contracts;
- faculty members have not only financial benefits, but also gain advantages of developing new methodological guidance and expanding the scope of professional activity;
- students are encouraged by a better opportunity for well-paid jobs, including executive positions, financial benefits and cooperation with analogue student teams from other universities.

International "Formula-student" project which combines learning objectives, scientific work and sport, is one of the most innovative and promising projects implemented at Togliatti State University.

Today, International "Formula-student" is the best project of its kind in Europe, the United States, and Australia. Also, it is becoming more and more popular in Russia. Initiated by the Society of Automotive Engineers (SAE) in 1998, it stimulates student engineering work and inspires them to conceive, design and fabricate a small single-seat racing car with further participation in racing competitions. The idea is that students with different education background must not only design, build and develop a product as a team, but also solve problems concerning marketing, advertising, logistics, economy and other issues related to the project implementation. Thus, it can be stated that the project contributes not only to growing talented engineers, but also developing other professional skills related to various spheres of human activity. The project provides students with a real practice in design, manufacture and business issues of automotive engineering. It helps them to gain experience and develop corresponding skills to become "handy" engineers who have deep understanding of different factors affecting the final product – qualitative characteristics, cost, safety, reliability and etc. – and are able to apply this knowledge in competitive tournament in order to achieve best results. It teaches them all about team work, under pressure and to tight timescales. Participation in "Formula-student" project demands total commitment, lots of work even at late nights and weekends. Besides, students are not free from many frustrations and challenges along the way and sometimes they have to do again what has been already done but it is this fact that contributes to the development of highly talented young engineers.

Another advantage of this project is that being implemented at university level it also stimulates the interest of pupils in various engineering disciplines. It is not a secret that engineering jobs are not so popular in Russia. That's why for most engineering programs, enrolment competition for state-funded places is not very high. The "Formula-student" project, particularly single-seat racing car designed and fabricated by students themselves to participate in a real racing competition makes an effective striking picture (Fig.1) and can encourage school-leavers to pursue engineering courses and careers.

The concept of the project is the following: during an academic year, students must organize a team themselves, share their responsibilities, find sponsors and draw up a business plan, design and, finally, fabricate a racing car which is presented to a panel of leading engineers and PR-managers. The cars are judged in a series of static and dynamic tests, as well as during final racing competition.

Understanding how International "Formula-student" project is incorporated into education framework at TSU

The first three stages of the project are incorporated into educational process itself while the fourth one is made as a sport team completion, i.e. extra-class activity.

First stage – the objective of the first stage is to provide students with contemporary engineering knowledge and develop corresponding professional competences by incorporating new teaching and learning technologies, among which are practice-oriented training, stimulation of student scientific work, project-based training and team work. Students are taught the fundamentals of the different educational programs in accordance with specially developed modules incorporated into course curricula.

A module is a part of a course or discipline which is aimed at developing a definite competence or particular ability important to student future career prospects. The achievement of the module learning outcomes, including acquisition of theoretical knowledge and practical skills is always controlled at the end of the module.

Each module has a definite load (in credits or hours), as well as the list of "entry" requirements a student must meet before enrolling in this module and the list of learning outcomes a students must achieve at the end of the module. "Entry" requirements specify students' level of knowledge, abilities and skills required for

Fig.1. Racing Car Fabricated by TSU Students within International "Formula-student" Project

successful module completion. Module learning outcomes include detailed description of the competences a student must acquire at the end of the module. Modules are not strictly sequenced and are not always referred to a definite discipline within an educational program. In this respect, each module represents an independent unit. At the same time, any module can be easily incorporated in program curriculum if it corresponds to program objectives and learning outcomes.

In addition, module includes the requirements to teaching resources, teaching faculty and facilities, which ensures quality of education. Modules are developed as separate units which are not connected with the existing educational programs. Thus, each module can be incorporated into several educational programs.

As a rule, module consists of following components:

- clearly defined objective;
- clearly defined module learning outcomes (set of competences, knowledge and skills);
- resource section – structured theoretical material, study guides and training simulators, training software, and various databases;
- practice section – a set of typical, complex problems, cases and exercises with solution algorithms;
- assessment section – set of assignments developed in accordance with module objectives, which include placement and final tests, special problems of different difficulty levels and assessment guidelines.

The example of "Formula-Student" modules with regard to the objectives and engineering problems to be solved during the project is given in Table 1.

"Formula-Student" project modules (FS module) incorporated into educational programs comprise a special teaching technology which falls within the purview of copyright law. This teaching technology is characterized by a number of peculiarities and principles to be considered when being incorporated into education process. As these modules are parts of common Bachelor's and Master's Degrees programs, most students pursuing engineering degrees should have a possibility to take them. However, it does not mean that lecturing is the only teaching method to be used.

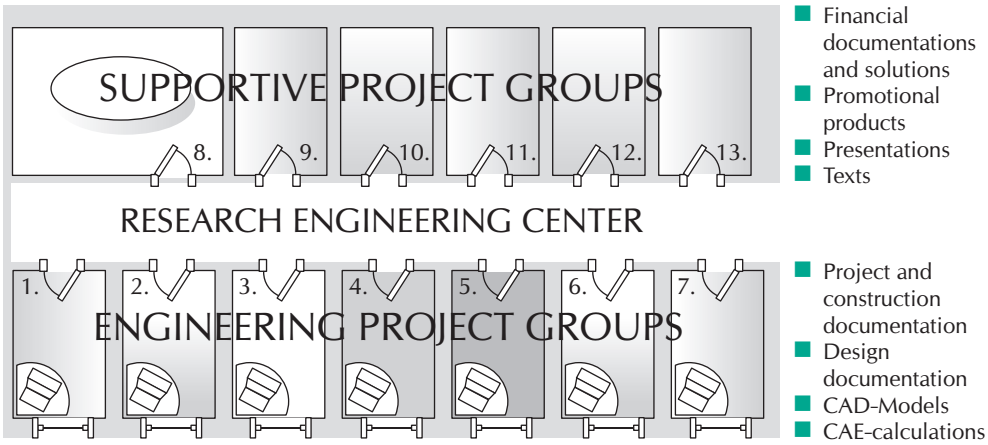
The structure and content of a FS module is defined by the characteristics of teaching technology which contains maximum amount of student independent work and minimum number of class hours. To ensure effective use of the technology, TSU has launched a special education portal which provides students with resources for independent work, access to teaching materials and study flowchart.

Thus, these modules can also be applied within distance learning programs (e-learning technology when interaction

Table 1.

Project Group Objectives	FS Modules	Degree Programs Relevant to FS Modules	Courses Relevant to FS Modules
Analogue examination and selection of internal-combustion engine design	Collect and interpret data on internal-combustion engines	141100.62 Power plant engineering 141100.68 Reciprocating and combined engines	- Protection of intellectual property - Configuration and operation mode of internal-combustion engines
Collect and interpret data on internal-combustion engines			
3D-modeling of internal-combustion engines (CAD)	3D CAD-modeling of internal-combustion engines		- Building of internal-combustion engines - Engine systems - Computer graphics - CAD fundamentals
		150700.62 Machine Building. Specializations Mechanical Engineering Technology", "Machines and Fabricating Technology"	- CAD fundamentals
Engine assembling	Internal-combustion engine assembling	141100.68 Reciprocating and combined engines	- Internship - Process-layout preparation
Collect and interpret data, analogue examination and selection of principle unit construction	Collect and interpret data on transmission	190109.65 Land Transport Vehicles and Tractors 190100.62 Land Transport Technological Complexes	- Patenting - Configuration of vehicles and tractors
			- Vehicle design - Process-layout preparation - Self-organization fundamentals
Component and final transmission assembling	Transmission assembling		- Internship - Configuration of vehicles and tractors
3D-modeling of transmission (CAD)	3D CAD-modeling of transmission		- CAD principles in building vehicles and tractors; - vehicle engineering design - computer graphics
		150700.62 Machine Building. Specializations "Mechanical Engineering Technology", "Machines and Fabricating Technology"	- CAD Fundamentals

Fig. 2. Layout and Results of «Research Engineering Center» within "Formula-student" Project



of a student with the author of a module is computer mediated).

As FS modules are designed to enable learners to acquire necessary professional experience, they involve maximum number of active teaching technologies, i.e. simulators, imitation games, role games, seminars, case studies, master-classes, individual and group work.

Second stage implies application of the theoretical knowledge obtained at the first stage including computer-aided structural design of automobiles, technology development, market research of value engineering and feasibility studies, application of PR-technologies, and etc. Students work under the supervision of a skillful engineer or faculty member who has experience in design work as a member of "Research Engineering Center" initiated by "Formula-student" teams. The role and responsibilities for team members, including team supervisor, are clearly set and involve drawing up plans and graphics of all current and further works. A student team is divided into the separate groups based on functional responsibilities (Fig.2).

The groups of «Formula-student» project team.

1 Internal-combustion engines.
2 Transmission and running gear.
3 Carroserries, basic structures, interior.
4 Electric accessoires.
5 Configuration and design.
6 Process-layout preparation.
7 Engineering calculations (CAD,CAM,CAE).
8 Full-scale tests.
9 PR-management.
10 Economics and Finance.
11 Art and design.
12 Journalism.
13 Foreign language.

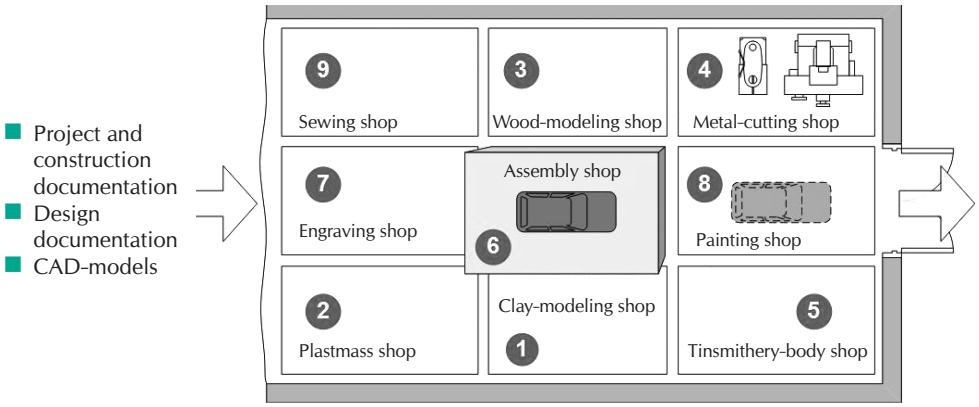
Third stage involves students working on manufacturing a racing car according to their design, drawings and technologies developed in a special work room which is equipped with all necessary instruments and tools. Here students work together with professional engineers and technicians under supervision of both the team leader (student) and the project supervisor. Production area (Fig.3) is divided into several different sites based on the kind of work.

All stages are supervised by a project supervisor who must hold a position of department head or be a member of research-and-development center.

The final stage involves such extra-curricular activities as static and dynamic tests of the fabricated car and final racing competition. Static tests include "Project Presentation and Defense", "Presentation", "Cost Event".

The purpose of "Project Presentation and Defense" is outlined in SAE rules and regulations as: "The objective of the presentation event is to evaluate the team's ability to develop and deliver a compre-

Fig. 3. Producaion Area Layout



hensive business case that will convince the executives of a corporation that the team's design best meets the demands of the market".

The presentation must logically cover all factors which can influence the competitive capability and viability of a business model. Teams should make presentation with a view to obtaining a business deal to manufacture the team's car. To intensify the effect, it is essential to demonstrate technical features of the proposed car.

The main objective of «Cost Event» is to prepare cost report including accurate vehicle cost estimates at low sales volume, which is to be sent to the Cost Judges prior to the competition.

Dynamic tests involve "Acceleration Test", "Figure of 8", "Sprint", "Endurance Test", "Fuel Economy Test". All dynamic tests are carried out at a special site with witness of judges and great amount of spectators. This very fact emphasizes one of the objectives of the project – to stimulate the interest of young people in various engineering degree programs offered by TSU.

Conclusion

Management of international "Formula-Student" project presents a great number of challenges to students, faculty members and university administration. One of the basic peculiarities of the project is that it stimulates motivation to improve education quality not only of students but of faculty members, as well. It is explained by the fact that students, being motivated to achieve the best results, strive to gain deep practical knowledge in engineering problem solving, as well as to understand innovative methods and technologies applied in engineering work and management. Thus, the project helps both students and faculty members to enhance their professional attributes, which in its turn significantly contributes to improving education in general.

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