

## Conference Paper

# Project-Based Learning at Nizhny Tagil Technological Institute of Ural Federal University

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## Abstract

This study describes the processes of projecting and implementation of project-based learning at Nizhniy Tagil Technological Institute of UrFU. We observe the adopted conception supposing cooperation of teachers, external and internal consultants and experts, customers and students; such cooperation is aimed at creating a unique product, service or technological advance and results (besides the product, service or technological advance) in planned and extra educational outcome. The principal goal of adoption of project-based learning at the institute is to adjust the academic departments of the institute according to the business-based model. The main idea is that "A specialists grows in a professional environment". Such an environment should be created through organization of project activities at the institute with professionals participating as experts, consultants or customers. Representatives of the professional community will benefit due to the opportunity to "see their future workers at work", test their adventurous ideas and implement projects with limited budget. By stimulating business activities, the institute becomes a center of much-in-demand competences, forms technological advances and favors emergence of research teams. The study presents methodical and organizational practices and the achieved results.

**Keywords:** education, project-based learning, training, competence, implementation, learning-by-doing, skills, practice

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## 1. Intention

What it looks like now:

- The student does not understand the reason to waste time in class while knowledge can be freely acquired via electronic media.
- The student's development is seriously limited by the sophistication of lectures and practical works. Therefore, we train "uneducated" specialists without discovering and developing the potential of talented students.

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- The student usually understands the significance of a certain competence only when in their workplace.

In general, this approach can be depicted as “pushing knowledge into the student”.

What it will look like:

- Being involved in project activities and imagining their final goal, the student is motivated to “mine” knowledge; they get a need for knowledge. The teacher rather assists the student in interpretation of the mined knowledge.
- Motivated students are not affected by the limitations of an educational program defined by the sophistication level of lectures and practical works.
- The flexibility of the educational trajectories comes from the student’s individual decision on their role and commitment to the project.
- Acceleration of business experience at the institute.

## 2. Goals

The principal goal of adoption of project-based learning at the institute is to adjust the academic departments of the institute according to the business-based model. Such a model supposes that the key performance indicators of a certain department are 1) the value of business income and financial return of research activities and 2) the value of business income and financial return of small innovative businesses, created with the institute’s participation and effecting the technological advantages created by the institute’s academic departments.

Having studied a number of works on the subject of project learning and modernization of engineering education [1-3, 6, 7, 12], CDIO approach [4, 5, 11] and Ural Federal University experience [8-10, 13] we will keep to the following description of project-based learning: it is cooperation of teachers, external and internal consultants and experts, customers and providers (students); such cooperation is aimed at creating a unique product, service or technological advance and results (besides the product, service or technological advance) in planned and extra educational outcome.

Uniqueness does not have to be defined in global terms; instead, it should 1) be viewed in accordance with the level of the community in which the project has been implemented and 2) reflect the need of the community for acquiring a certain new competence.

The definition supposes the following project criteria:



- The project should be aimed at creating a unique product, service or technological advantage.
- The project is participated by a teacher, external and internal consultants, and students.
- The project has a customer and an external inspection.
- Education outcome should be planned at project launch; planned and extra education outcome should be evaluated upon completion of the project.

### 3. Motives

The motives for introduction of project-based learning at the institute:

- To meet market demand for research activities.
- To create conditions for active professional networking.

### 4. Implementation

The mechanism for engaging students and teachers in project activities supposes organization of unsupervised work.

Engaging students and teachers in project activities is performed at the level of education programs (including cross-program level) by launching unsupervised work in a special form supposing access to the project engineer's advice. The interaction of students, project teams and project engineers is organized in project rooms: open spaces of 10-12 groups for 4-6 persons each.

Besides the traditional steps, the design of an education program includes:

- Analysis of the training outcome components to check whether they can be obtained through project learning (Fig. 1).
- Search for customers of work under relevant projects.
- Consideration of potential involvement of external consultants and experts.
- Formulated need for resourcing of project activities within the educating program and project.
- Developed criteria of evaluation of educational outcome.
- Definition of the labor required for the project.

If involving consultants/experts and necessary resourcing are possible, the program lead decides to supplement the education program modules with a project which is to become the integration point of the module training outcome. Formally, a module project is embedded in a module and implemented as an independent (project) work within the total hours of the module.

The core idea of the implemented practice of project learning implies a special form of organization of unsupervised (individual or group) work of students: they have an infrastructure necessary for project implementation (workplaces at the institute, equipment, computing capacities); project schedule is drawn up; one of the teachers is assigned project engineer.

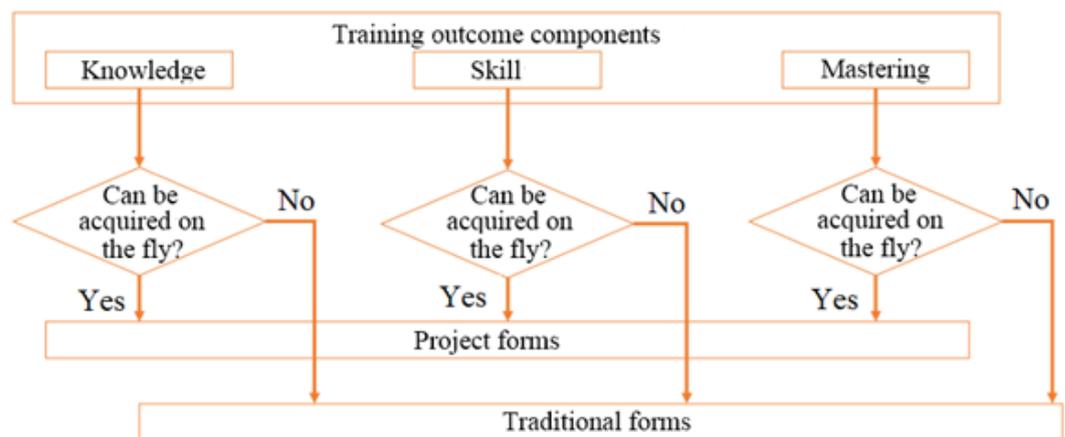


Figure 1: Analysis of the training outcome components

Goals:

- Activation of students’ cognitive activities.
- Creation of conditions for rapid development of talented students.
- Refocusing the attention of all the education process participants from knowledge reproduction to generation of new knowledge.

Project learning technologies are best integrated in the education process for the professions of Computer Science (UGSN 09.00.00) and Machine Building (15.00.00) at the university level.

Education levels: bachelor, master.

Specialties: 09.03.02 Information Systems and Technologies, 09.03.03 Applied Computer Science, 15.03.06 Mechatronics and Robotics.

## 5. Description of the Education Technology

The project engineer functions as a project manager (project lead) and internal expert; they assist students in interpreting knowledge and detect the team’s needs for additional competences.

When the semester begins the project engineer forms teams out of the students of adjacent specialties; then they issue statement of work and hold introductory seminars. During the whole semester, 2-3 times a week, 4-8 hours a day, students work on projects guided by the project engineer and with participation of external consultants and experts (fig. 2).

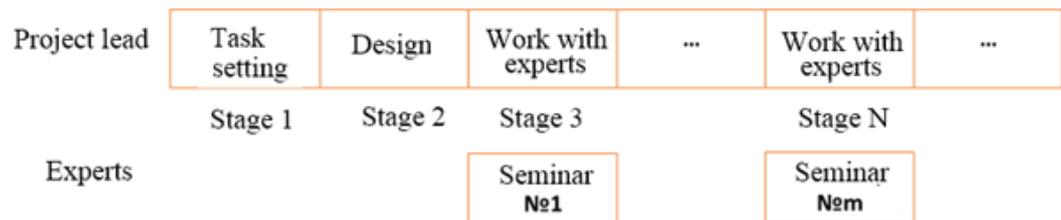


Figure 2: Workflow

The elements of the project learning forms are integrated in education process beginning from the second semester of the first bachelor year and from the first semester of the first master year.

## 6. Project Types

Projects are different in terms of labor input and final outcome. The minimal required input of a project is 4 hours. Such projects are usually implemented by students of the first and second years and a module project may include multiple implemented projects of this kind. The max labor input of a project is the labor input of a module, and it reaches 400 hours.

In terms of final outcome, projects are either 1) learning projects resulting in technological advances and new competences or 2) project tasks resulting in a product or service.

## 7. Implementation Process

At the first implementation stage, we changed curriculums: reduced classroom hours and added unsupervised project work (grouped in projects according to education program modules).

At the second stage, we prepared classrooms for project learning (ensured power supply to workplaces, provided Internet access and visualization tools).

Implementation of project learning caused teacher's higher labor input in the education process. Teacher accustomed to traditional teaching methods were not ready to such changes. Therefore, for the third stage, it was decided to forward the funds released after switching hours from classroom to unsupervised work to pay to the project engineers who work 8 hours a day, 5 days a week.

External experts and consultants are involved without financial compensation; they represent organizations really interested in the outcome of certain projects.

Challenges:

- Not enough room suitable for teamwork on projects.
- No common access to workshops and laboratories.
- Time-consuming procedures of buying materials for project execution.

Risks:

- Focus on business approach in prejudice of scientific and technological outlook.
- Failure to reach planned training results, if the project scenario is changed.

## 8. Management Model

General description. The main element of the management model is educational program lead responsible for maintenance of the educational program and, consequently, the content of the project learning forms. Educational program leads are reportable to the head of department governing general matters in adjacent fields of study, administrative support of education process, contacts with the institute management.

The educational program lead is responsible for organization of project learning within a certain educational program; they can organize projects and project tasks under the program as a Module Project discipline.

The educational program lead predicts adaptation and involvement of available rooms (laboratories, classrooms, computer classes, workshops etc.) for project jobs.

They also ensure work accessibility and safety for students and plan funds for expendable materials required for the projects.

Developed within a specific educational program, methodical guidelines include: implementation regulations; methodical support of the Module Project specialty; requirements for content, types and scope of projects/tasks; evaluation criteria.

The educational program lead involves external consultants and expert, creates an up-to-date list of educational projects and project tasks and selects responsible project engineers who will support the projects.

Current Problems of Management:

- Long-term prediction about expendable materials which is not always possible.
- Institute services buying foreign expendable materials too slowly.

## 9. Results

Questioning key employers about the quality of graduates' expertise has shown better satisfaction with the following points: readiness to practical work, formation of basic skills, teamwork, capacity to maintain professional communications.

Questioning has revealed that students prefer project learning forms rather than traditional forms and find them more interesting. Graduates state that now they understand perfectly well the nature of their future profession.

Teachers note that students get more interested in engineering activities and new technologies; they are motivated in studies and professional growth.

According to the first graduation in Mechatronics and Robotics at Nizhny Tagil Technological Institute of UrFU, it can be stated that efforts do yield results [14–16]. For most graduates, graduation thesis is only a first step in massive work on their project. Three projects have been supported by the Innovation Promotion Fund (UMNIK and START programs). This is about development of a mechanotherapy device for regeneration of limbs and treatment of cerebral infantile paralysis; development of an innovative machine for application of protective coating on electric contacts (way more efficient than manual method); a robotic machine designed to apply coating by electrosparking in out-of-reach spots like pipes. Other graduation theses in 2017 proposed laboratory benches for examination of positioning systems, machine-tool drive, electric heat control systems [14–16].

Over 2 years, there have been over 50 IT-related projects including those for augmented reality, web services, IoT devices, machine vision, smart power-consumption measurement. The projects have involved about 100 students.

We are going to introduce cross-disciplinary approach and form mixed teams of students in technology, mechatronics, IT, electrical engineering to work on projects.

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