INTERDISCIPLINARY PROJECT FOR BACHELOR ENGINEERING PROGRAM

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ABSTRACT

One of the main tasks of modern technical education in Russia is to make learning and teaching process less fragmentary. It can be achieved by introducing project-based education within the framework of practice-oriented Bachelor's program. In General Engineering Modules students make an interdisciplinary project based on teamwork throughout 5 semesters (starting from the fourth one). A project is defended in front of peer students, staff and representatives of the Ural Mining and Metallurgical Company. The best projects are presented in students' research conferences. Engineering and technical staff of the Ural Mining and Metallurgical Company act as consultants in designing projects, tutors in monitoring and commissioners in defending them.

KEY WORDS

Innovative education programmes, design of education programmes, learning outcomes, module structure, project-based learning and teaching, integrated curriculum, interdisciplinarity,
CDIO Standards 1, 2, 3, 5, 7, 8, 11.

INTRODUCTION

Internalization of education is one of the major strategic concerns of the top-ranked universities of the world. The principles of creating the Common Education Space declared in international conventions (transparency of educational systems, correspondence of degrees and qualifications, academic mobility, etc.) result in developing education curriculum that formalizes various educational activities in specific learning events involving students, teaching and administrative staff.

This raises new understanding of the content of education programmes. Formalization of goals and learning outcomes has become of utmost importance. Teaching scientific disciplines go by the wayside.

Addressing the best practices for engineering training allowed identifying significant methodological and technological aspects in design and implementation of curricula. They resulted in the framework of standards of the Higher Engineering School of UrFU.

The article presents the experience of the Higher Engineering School in designing the programme in the context of current international projects and initiatives: AHELO, LOLA and CDIO. CDIO Standards and project-based learning allowed us to design efficient curricula, comprehensible for graduates and employers, and demanded on the labour market.

DEVELOPMENT AND ASSESSMENT OF LEARNING OUTCOMES IN EDUCATION ENGINEERING PROGRAMMES

In developing education programmes we clearly distinguish between LO of the Programme and LO of the Module. Programme LO can be assessed to the full in a graduate qualification work (diploma project). In this article we focus our attention on the ways of assessing LO of the Module. Judging by our experience, they can be best assessed in implementing a Module project. We show it by an example of General Engineering Module project.

The aim of the project is to assess LO acquired in «General engineering» module and undergo real stages of project development using basic knowledge.

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The project includes the following stages:

Execution of working and assembly drawings and development of design documentation in accordance with USED demands.

3-D modelling, visualization of behavioural model of an object detailing and assembling.

Statistic, kinematic and dynamic analysis of object details.

Analysis of strength, reliability, life duration and wear fatigue of an object.

Design of object joints according to technical requirements. Selection and calculation of transfer mechanism.

Selection and calculation of electric motor, the simplest operating system.

Development of engineering working documentation in the field of measurement science, engineering legislation, standardization and conformation of compliance.

Selection and rational for choosing materials according to specific conditions of operation, with account of performance specifications, cost efficiency, reliability and product life.

LO can be assessed in progress reports on laboratory works and interdisciplinary exams (in Engineering mechanics, Theory of strength of materials, Machine components and elements of mechanical design, Mechanical drawing). They can also be assessed through the results obtained in each stage of the project (in the following disciplines: Mathematics, Engineering graphics, Mechanical drawing, Engineering mechanics, Theory of strength of materials, Machine components and elements of mechanical design, Electrical engineering, Material science, Standardization, metrology and certification).

Special emphases must be put on ways of implementation of an interdisciplinary project where students strengthen acquired integrated skills and attributes, demonstrate their knowledge of terminology, methods, information technologies and fields of application of LO. The project intends to assess Module LO and implement different stages of a real project based on basic knowledge. Stepping implementation of conceptual design, static, dynamic, kinematic and strength analysis, as well as, assembly drawing of simple mechanism in the package of AUTOCAD, KOMPAS or Autodesk Inventor, for example, winch or electric pulley block can be offered as an interdisciplinary project.

The project is developed for 4-5 semesters. It includes conceptual design based on functional requirements containing design of package and product data sheet; static, kinematic, dynamic and strength analysis involving design of relevant computational models, selection of solution methods, record of mathematical models and making researches based on solution of simple optimization problems.

After considering the results of decision analysis in accordance with technical requirements specifications students detail geometrical dimensions of a designed project, choose materials and standard hardware components set (engine, bearing, rope). In the course of making computation and accurate specifications students make drawings of separate components and assembly drawing in one of the packages (AutoCAD, KOMPAS, etc).

They prepare a set of design documents in accordance with the Unified system for designed documentation and working documents in the field of metrology, engineering legislation, standardization and conformation of compliance. They select materials in accordance with specified conditions taking into account performance specifications, economical efficiency, reliability and life of the product.

High level of students' competence can be exercised in making 3-D modelling, visualizing a dynamic model of detailing and assembling of the design object. It's essential that learning material is studied throughout the increasing number of practices and self-directed work.

Most part of the learning process should be given to creating those computational (design) models and methods that are necessary for implementing an interdisciplinary project. The time necessary for introducing new information technologies and software products are not taught as a separate discipline but included into certain discipline modules. For example, studying computer detail drawing technique and making an assembly drawing is taught within a concrete design task of an interdisciplinary project.

Results of computation are planned to be checked with the help of production programs provided for educational purposes (calculation of rope capacity, engine power and other technical characteristics). In order to realize real-world approach we requested the enterprises producing winches to provide us with real projects for educational purposes. Learning outcomes are assessed according to a coefficient of value for each part of the project.

Distinctive features

Provide the development and assessment of all LO stated in other programs;
Design object is a mechanism (electric hoist, pulley block), that is used in all kinds of metals practices;
The knowledge, understanding and skills required for project implementation are integrated into all the disciplines of the Module (its' theoretical and practical aspects);
The LO of the project are assessed by the staff involved in teaching other Modules as well as experts from enterprises;

Expected Learning Outcomes

- To identify the matter points of emerging professional issues;
- To identify the fields of engineering knowledge;
- To apply relevant physical representation and body of mathematics (mathematical tools) for solution of problems;
- To work out models for general engineering tasks;
- To plan, do theoretical, computational and experimental researches and analyze obtained data;
- To use cloud computing and mathematical packages in computation;
- To work out technical documentation in accordance with standards, technical regulations and other regulatory documents.

Assessment of LO

Coefficients of value for each part of an interdisciplinary project are summed up.

0,1 M-Mathematics (implementation of mathematical model)

0,1 EG-Engineering graphics (accompanying documentation, drawings)

0,1 IT-Information technology (effective usage of application program packages for engineering analysis)

0,1EM-Engineering mechanics (design of mathematical model, definition of kinematic characteristic analysis)

0,1 SM-Strength of materials (mechanical characteristics and limit state analysis)

0,1 MCSPD-machine components and principles of design (evaluation of reliability, life duration and safety)

0,1 ЭЭ-electricity and electronics (electric motor selection)
0,1 SMC-standardization, metrology and certification
0,1 MS – Material Science (selection of required materials)
0,1 CG- Computer graphics (rendering)

DESCRIPTION OF THE MODULE AND DISCIPLINE

General Engineering Module

Module code	ПТБ03
Title	General engineering
Module workload	21 credits
Period of study	2 nd- 4 th semesters
Authors	BerestovaS. A., GribovV. V., SobolevS. V., RizhkovaI. V., MityushovE. A., PonetaievaN. H.
Courses .	Engineering graphics Mechanical engineering Electrical and electronics engineering Materials science Metrology, standardization and certification

Goal of the module

To form scientific world view, the abilities to apply basic knowledge in engineering disciplines for solving scientific and technical tasks in the professional field.

Learning outcomes

On completion of the module a student will be able to:

- find out general engineering matter points of the emerging professional issues;
- identify the field of professional knowledge;
- apply relevant physical representation and body of mathematics (mathematical tools);
- work out models for general engineering tasks;
- plan, make theoretical, computational and experimental researches and analyze obtained data;
- use cloud computing and mathematical packages in computation;
- work out documentation as required

Teaching methods

Lectures, discussions, workshops, teamwork, lab classes and lab-based work (in-class learning on specialized tests, on-line lab work, independent work with methodological guidelines followed by video presentation of lab-based work). Usage of up-to-date equipment, multimedia presentation materials for in-class learning. Analysis of contextual (practice-oriented) tasks, professional cases.

Independent work (coursework, computation work as a part of multidisciplinary project, structural abstracts actively presented in students' conferences of different kinds). For example, conferences followed by forum discussions.

Independent work in personal account.

Monitoring of students' learning achievements.

Allocation of methodological resources in learning system (e-textbook, problem book, methodical guidelines for different kinds of classes, on-line lab works, test academic issues, tests). Use of networking technologies.

Counselling in independent work.

Methods of assessment

LO on the Module are assessed by systematic testing, lab works, interdisciplinary exam (theory of Engineering mechanics, strength of materials, machine components and elements of mechanical design), by doing computation in interdisciplinary project (mathematics, engineering graphics, mechanical engineering, electrical and electronics engineering, materials science, metrology, standardization and certification).

Course "Engineering graphics"
Workload 4 credits

Includes 4 hours of in-classwork per week, 2 hours of independent work per week, 2 hours of work on an interdisciplinary project per week. It doesn't require concurrent study of modules and disciplines. It is based on knowledge and skills of school programmes in Geometry and Drawing. It is the basis for General engineering and specialized disciplines. Skills achieved in studying the Course are used in course and diploma works.

LO in the Course

On completion of the Course a student will be able to:

- make product drawings according to operating standards
- visualize by the drawing the shape of the details and their interaction as assembled parts of the product
- use computer graphics in developing engineering documentation.

«Mechanical engineering» Course
Workload 6 credits

Includes 6 hours of in-classwork per week, 3 hours of independent work per week, 3 hours of work on an interdisciplinary project per week. It is based on the knowledge and skills acquired in studying «Mathematical» and «Science» Modules.

It's the basis for all the rest courses of "General Engineering" Module and engineering disciplines.

LO in the Course

On completion of the Course a student will be able to:

- formulate the basic concepts, hyposesis, laws and theorems in Mechanical engineering describing equillibrium of a single body under the action of forces.

- draw up 2D-analytical models and choose appropriate mathematical models for defining static, kinematic and dynamic characteristics while investigating equilibrium and simple motion of a single body.
- use mathematical algorithms for composition and solution of equations describing equilibrium and motion of a single body under the action of forces.
- plan, carry out theoretical and experimental researches in mechanical characteristics of materials and analyze obtained data.
- use application packages and conduct cloud computing for static, kinematic and dynamic analysis.

«Electrical and Electronics engineering» Course
Workload 6 credits

Includes 6 hours of in-classwork per week, 3 hours of independent work per week, 3 hours of work on an interdisciplinary project per week. It is based on the knowledge and skills acquired in studying «Mathematical» and «Science» Modules.

It's the basis for engineering disciplines.

LO in the Course

On completion of the Course a student will be able to:

- select, prove and apply methods of computation and analyses of electrical and magnetic circuits, electrical facilities. Know and be able to apply the methods of making lab researches and working out report documents on the results of experiments, measuring operations, computation and analysis.
- classify the types of electrical machines. Identify the sphere of their characteristics and application.
- prove the choice of type and characteristic quantities of electrical facilities. Calculate characteristics according to rated values in order to provide effective and economical running.

«Materials Science» Course
Workload 2 credits

Includes 1 hour of in-classwork work per week, 1 hour of independent work and work on an interdisciplinary project per week. It is based on the knowledge and skills acquired in studying

«Science» Module.

It's the basis for engineering disciplines.

LO in the Course

On completion of the Course a student will be able to:

- classify traditional and modern materials, differentiate their components, characteristics and structure.
- define the area of application of certain types of materials.
- carry out experiments on defining qualitative and quantitative characteristics of materials.
- to prove the choice of material under specific conditions of operation, with account of performance specifications, cost efficiency, reliability and product life.

«Metrology, standardization and certification » Course

Workload 3 credits

Includes 1,5 hour of in-classwork per week, 1,5 hour of independent work and work on an interdisciplinary project per week. It is based on the knowledge and skills acquired in studying

«Mathematical Module» and «Engineering Graphics» course. It's the basis for engineering disciplines.

LO in the Course

On completion of the Course a student will be able to:

- conduct multiple determinations, process, record and analyze the results.
- apply fundamental principles of metrology for providing uniformity of measurements by means of verification of calibration of measuring apparatus.
- find, draw up and use documents in the field of metrology, engineering legislation, standardization and certification of conformance.

CONCLUSION

The project provides an opportunity to assess the achievement of Module LO:

- to strengthen integrated competences;
- to demonstrate the knowledge of terminology, methods, information technologies and fields of LO application;
- to work through real project stages based on simple examples applying basic knowledge;
- to make dynamic assessment of students' learning activity;
- to make up an essential part of students' portfolio.

In order to save time at all the design stages there is an opportunity to make computation of individual elements of the product, use actively the so-called "brigade method" wherein different assembly units (connecting joints) are calculated by different students. In this case, students are taught very important skills and attributes of team work.

A group of metallurgical engineers consists of 25 students, 19 of which work effectively. They are divided into 5 teams with different number of students in each team, from 6 to 2. Their roles clearly depend on students' knowledge and skills. Some of them are good at accurate computations, others at finding and analyzing information materials or making reports and presentations. Students are not willing to choose a person responsible for managing a project, it's not an easy role for them.

Project materials are exchanged by e-mail. Counselling and supervision over the project work is done by one teacher, at the stage of making drawings one more teacher is involved.

At this stage the students were offered to write an abstract "Electric hoist" and make a presentation. Making presentation is one more competence we had to spend a lot of time on.

In the third semester the concept of performance specification was introduced. Meanwhile the students were not limited by any standards of its introduction. One of the teams chose the format of sales and purchase agreement, another addressed specialists in this field. The students were given a task to choose an enterprise for which they were going to develop an electric hoist and work out performance specification by themselves. Guided by it the teams selected and calculated the main elements. By that time, most part of the materials required for these calculations had been studied. The electric motor was selected according to its required developing power and technical characteristics. At this stage the students selected a rope, hook, gear reducer and calculated gear ratio of the mechanism, rope capacity and chose the dimensions of the drum. They calculated the size of the beam where electric hoist would be disposed, selected its' section and analyzed different kinds of assembly. It's important to emphasize different approaches to solving the problem.

The experience showed that there is no need to limit students by concrete design ratio. You should set a problem and supervise the process of searching for information, structuring and analyzing it. While selecting calculating formula students should be guided by the thesis "I understand all the values in it and can explain the way this formula was arranged".

The problems solved in classes were included in all the projects. Students were given more freedom in solving them for achieving better results.

Team works made in the course "Engineering graphics" were also included in the project. Classical drawings, 3D-modelling, video assembly of the details of a compensating roller, support for the drum, gear box cover, etc. were introduced in the project.

Skills obtained in the framework of the course "Information technologies" were also demonstrated. One of the teams made a presentation with the help of prezi- resource. Another team demonstrated the skills of making b-roll montage.

The projects were defended at the presence of a group curator, representatives of an administrative sub-department and UMMC company. The students demonstrated their works, answered the questions and got the appropriate marks for the projects. Members of the Committee honored some works and named the leaders. The students were offered a feedback request form where they assessed their own work in the project, input of each member of the team and presentations made by other teams. The final grade was a sum of experts' grades.

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