Continuous project study within the Russian system of higher engineering education

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ABSTRACT: The concept of continuous project-organised study for future engineers and the main features of relevant technology are described in this article. The concept is described using the educational programme for specialty *Radio Electronic Systems and Complexes* at the Tomsk State University of Control Systems and Radio Electronics, Tomsk, Russia, as an example.

INTRODUCTION

The teaching of future engineers using modern techniques in the fields of electronics in particular, is becoming more and more difficult because of the insufficient level of school training and a decline of engineering activity prestige compared with the activity in the field of service.

There are two conditions that must be addressed to ensure the solving of the contemporary problem of specialisations within higher education. First, it is necessary to provide a professional orientation for young people, to create and have them keep their motivation to acquire more and more knowledge while at university and after graduation. Second, the process of education itself should be organised in such a way that could help young people to acquire the creative ability needed to design new and modern techniques. The second problem can be solved only by students' involvement into the process of designing real technical devices, and the process should start as early as possible and continue up until graduation.

Among the requirements for entering the profession should be elements of design at all steps of study. The difficulty of the design process does not allow students to get quick results and shows the necessity of introducing continuous design in the process of education. This makes the process more complicated, but it needs to go in parallel and as close as possible to the study curriculum.

CONCEPT OF CONTINUOUS PROJECT TRAINING

At the University of Control Systems and Radio Electronics it was suggested that a programme of continuous project training be introduced for the specialisation in *Radio Electronic Systems And Complexes*, taking 5.5 years of study [1]. The programme is based on the following features:

- Mathematics, physics and subjects of general engineering should be taught in parallel with the subjects of the specialty starting from the beginning and making the content more substantial and full of meaning. The goal of the parallel study is to keep and develop the students' professional orientation and their interest in study and the future profession. However, the programme must not overload the students with abstract physics and mathematics showing how these subjects are used by their future specialties.
- A linear curriculum structure in which subjects overlap and have been adapted to the content of the special subjects studied. There are several lines: humanities, mathematical, general physics, statistics, circuits and signals, systems engineering, electrodynamics and microwave communications, information, design, and so on (see Figure 1).

- Sections needing individual activity should be introduced into the curriculum with the same particular problems. Such sections could be research, laboratory practice at the laboratories and testing grounds, seminars and project design in groups.
- The course paper should be continuous when next term's project is a continuation (but from the other side) of the previous one with an individual problem for each student within the frames of the same subject.
- Study some special subjects of the student's choosing during their training in industry with lectures presented by specialists from the industry.
- External assessment of the students' knowledge and ability should be carried out; the assessment being in the form of reports at seminars, conferences, and so on.
- Use of reports at seminars and conferences to assess students' knowledge competence.
- Tutorials for the students from the first day at university should be instituted.
- Structure and content of the curriculum should encourage students to work hard in class and at home during the whole period of their university study.
- Structure and content of the curriculum should support and encourage students' activity in using library resources and services, and in the laboratories.

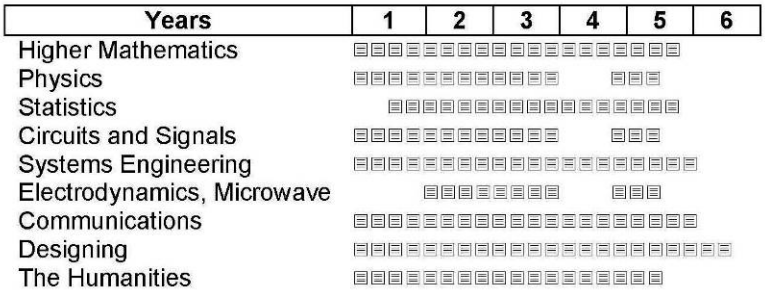

Figure 1: List of subject groups in the curriculum.

CURRICULUM

The curriculum includes:

- Term design papers and projects every term, starting from the second term, and with a particular focus to increase students' knowledge and help them to become competent in particular fields. Term design and solving real problems can help students in their study;
- Continuous design for six terms within the framework of research or working in groups;
- A diploma paper as the final project.

The time table of the project organised curriculum is shown in Table 1, with the number of hours of students' activity indicated.

Table 1: Continuous project organised training.

Designing form and substance		Terms										
		1	2	3	4	5	6	7	8	9	10	11
Yearly essay subject matter	Engineering graphics		36									
	Circuits			36								
	Signals				36							
	Programming					36						
	Antennas						72					
	Analogs							72				
	Microprocessors								72			
	Radio channels									72		
	Systems										72	
Training in design group	Review					72						
	Idea						72					
	Draft design							144				
	Simulation, experiment								108			
	Prototype									144		
	Checkout										108	
Graduation project												1080

The whole time devoted to term projects design in this scheme is 504 hours, 345 hours of which are unsupervised; work in groups takes 648 hours, 213 hours of which are unsupervised; and 1,080 hours are required for the diploma paper.

The complexity of the term papers is built up from a methodical and theoretical base of project-organised study and helps to make it active. The term papers go along the continuous design path and provide the opportunity to take part in a particular project at its different stages. The important part of the course design is acquiring the ability to undertake research, of working with the literature and of drawing conclusions. The main section of the term papers is based on individual tasks.

The term design teaches students to formulate problems without assistance, to find the questions to ask, and to demonstrate and apply the results of their research.

Training in industry during summer also can be treated as a project study.

The project design takes 3,312 hours (92 credit points), which means 27.9% of the whole time at university. In order to use this time rationally, it is necessary to do two things - to provide skilled individual tutorials and continuous assessment.

THE GOALS OF THE COURSE DESIGN

The course design addresses the following concepts and ideas:

- Giving life to the theoretical knowledge obtain during some particular subject study;
- Giving life to the ability to solve standard problems;
- Forming the ability to apply accumulated knowledge to solve non-standard problems;
- Forming the ability to work with software;
- Getting experience in analytical work, calculations and design;
- Getting experience in work with special literature and other sources of information;
- Forming the ability to formulate conclusions and recommendations using the results of the project;
- Getting experience on how to present the result of research;
- Getting experience in public presentation - reports; how to answer questions and take part in discussion; how to make people understand the ideas under discussion.

The term design should help the students to be more assertive of their creative and communicative ability, self-dependency and responsibility for the decisions taken; it also teaches them to work regularly.

Course design helps to develop students' imagination, ability to think and make decisions, as well as to present the results of their work verbally and in the written form.

DESIGN SUBJECTS

Continuous project training means gradually making the problem under design more and more complex and demanding, while students are getting more mature and experienced. The specialty *Radio Electronic Systems and Complexes* determines the system direction of the design process.

Course papers during the first three years are connected with calculations about electronic devices and circuits (amplifiers, oscillators, antennas, digital blocks, and so on) and their characteristics. But even at the very beginning, students have to do modelling, comparison and optimisation.

During the last years, the course design includes principles of design of electronic systems for different applications. The last project in the 5th year, just before the diploma, deals with circuits and is, usually, the final part of the research performed by the student.

The project aims to provide students with a systematic approach to some particular system design.

Examples of the course papers of the 5th year are as follows:

- Radar station - remote sensing.
- Radar station - aiming and target recognition.
- Synthetic-aperture radar.
- Two-position radar.
- Radio navigation system of a space device.
- Differential radio navigation system of a GLONASS user.
- Correlation extreme system of navigation.
- System of space monitoring of the Earth surface.
- Navigation system for aircrafts landing.
- Aircraft radar with active array.

- Phase radio direction-finder.
- Mono-pulse amplitude direction-finder.
- Pulse aircraft observation radar.
- Radar of the airfield observation.
- Radar with continuous transmission and frequency modulation.
- Radio altimeter.
- Satellite repeater.

Design work includes a general system description and its surroundings, design of the system mathematics model, planning and carrying out experiments (including computer simulation), design of the functional and structure circuits and calculation of the main characteristics.

GROUP PROJECT TRAINING

The goal of the group project study is to learn from research and the administration of research by designing devices or software meant for future applications, in parallel with the theoretical learning [2]. The subject of the design can be parts of radio electronic systems or other independent devices. The main particularity of this training is working in groups.

The beginning of group project training is the competition for innovation ideas and offers that can be realised in the form of new science-intensive devices and technologies needed by the market and industry. The competition is organised by chair professors and the university research departments. Teachers, engineers and students who report on their ideas take part in the competition. Representatives of industry and firms are also present.

The organisers of the competition choose the ideas for further development and form students into groups of 3-5 people. Students can be from different years of study, from different specialties, different faculties and even different universities. Each group has a tutor appointed for consultation with the students of the group. Each group has a student leader.

Each member of the group has his/her own problem to solve. The design is done under the supervision of the department that organised the competition and formed the groups. The same department provides materials, looks for sponsors and organises interaction between the groups and companies. If the project is performed for some particular organisation the contract is signed. The group owns the copyright of their work. The results of the project can be utilised by the firm or by the university for the academic and research application.

Students have one research day a week free from other study. Members of the design groups have workplaces in laboratories (see Figure 2). The academic chair provides all needed components and equipment.

Figure 2: Design group at the acousto-optic laboratory.

Within the framework of the project, each group has to undertake:

- Analysis of the problem, draft of requirements specification;
- Modelling of the objects and processes of the device (system);
- Experimental research;

- Design of the circuits and their technical and economic calculations;
- Prototyping or testing model fabrication;
- Writing all necessary papers including service instructions and test programs;
- Tuning, testing, including production testing;
- Making-up of reviews and reports with the results of the job done;
- Market research and business plan preparation;
- Organisation of the group activity, discussion within the group, decision-making;
- Searches of optimal decisions concerning the quality of the designed object, price, ecological security and labour protection (safety).

The overall project and its individual steps are finalised by production of concrete practical results: programmes or methods, modelling or experiments, making a device and testing it.

In the process of the project or upon its completion, the project group can take part in the competition to fill a vacant place in the students' business-incubator (see Figure 3). As a rule, students work in groups in their last year at the University, while preparing their diploma papers.

Figure 3: Project groups of the TUCSR Student Business Incubator.

Groups formed in the process of the project design are *staff troops* ready to join a profile firm or to start their own business. The University helps such groups after graduation.

In 2013, there were 33 laboratories of project design at TUSCR, where 256 design groups with 890 students worked. The projects were performed for 44 science intensive firms where TUCSR graduates are the leaders. The members of the design groups defended 159 diploma papers and Master theses, presented 386 papers to scholarly journals and at a range of conferences. Four design groups started their own businesses.

CONCLUSIONS

Continuous project-oriented training guarantees a higher quality outcome of teaching of future engineers, reduces student attrition, improves the image of the university among firms' managers and community, and attracts able young people to the University. Besides this, the technology leads to more intensive research within the departments and improves the qualifications of the teaching staff.

The prerequisites to reforming study technology at technical universities are quite real: students are ready to become competent in their specialties as quickly as possible; industry needs well trained engineers and is ready for co-operation

with universities. The new technology and methodologies used widen the scope of universities' research activity and help to combine research with academic study.

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