Modernization of Teaching Materials for the Curriculum “Electric Circuit” National Research Nuclear University (NRNU), Moscow Engineering Physics Institute (MEPHi)

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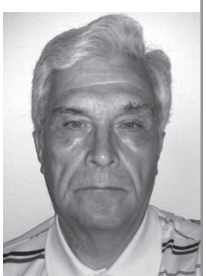

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Due to the introduction of IT a new situation has emerged in the sphere of electric engineering, which, in its turn, defined the demand in re-designing the core curriculum “Electric Circuit”. The following factors are discussed in this article: modernization (up-dating) paradigm, definition of forms and methods under new conditions, development of technical and material resources, including IT, and filling up the Education Gap.

Key words: *electrical engineering, teaching activities, educational space.*

The advanced achievements in electronics, once a branch of electric engineering, resulted in the development of a new situation- its (electronics) fusion with electric power engineering. Due to a rather sophisticated intellectual management of the electromagnetic (EM) energy flux, there was the possibility of a wide-range non-linear load connection and expansion of old application spheres. For example, the synthesis of electric (power) semiconductor switches with MPU (microcontrollers) supported the induction motor flexibility, which according to many textbooks was considered to be uncontrollable. The introduction of multiwatt pulse technology made it possible to work at a power level of 1015W, and thus, electronics could register stop-actions. Figuratively speaking, modern electric engineering is experiencing a reversible transition from Nikola Tesla AC current to Alexandro Volta DC current.

At the same time, computerization and electronic communication development introduced new elements into project activities and close-related academic activities. Modern program systems completely computerized such processes as design engineering, simulation (modeling), and, in some cases, production of electrical appliances. Designers of electric appliances only see what is before them- computer display or ready-made products.

Critically, considering the teaching process in different electric engineering courses in this context, it has become obvious that this process must be up-dated. First and foremost, it was necessary to select the teaching process paradigm as a quality “Ariadne’s thread”.

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Modern pedagogical approaches in teaching process organization in higher education institutions include the competence concept, i.e. "competence is implemented knowledge"[1]. However, if we state "electric current is implemented voltage", then how could the Ohm Law have been comprised. In both cases there are two different understandings for one and the same notion "medium": the first one that through which the current flows, and second one that where competence is formed and implemented. L.S.Vigotski suggested the notion "environment". He considered the social situation development as "particular and specific for a given age, an exceptional, exclusive and unique relationship between a child and his\her reality, i.e. social reality" [2]. This trend in pedagogy and psychology developed into the so-called pragmatic which was furthered by G.P. Schedrovitski and his colleagues [3].

Thus, in our case, the paradigm can be considered to be the notion "education activities", based on the trainee-engineering environment interaction. An excellent example could be the teaching process organization and development in A.S. Makarenko communities, i. e. from carpenter workshop to the modern optomechanical enterprise [4].

In other words, the student education activities should be organized in the same way as those of the production activities. But there is one distinct difference – the results of student education activities may not have any commercial value and must be maximally disburdened of production routine. Therefore, the basis for the teaching process organization should be independent quasi-production problem-solving by applying sophisticated production tools and facilities. The volume and content of such problems should be maximally versatile and subdivided into minimum, average and successful progress results. But, it is only in the army that the company's test time is determined by the last run-in soldier.

The above-mentioned paradigm deemphasizes the traditional forms of the teaching process: lectures, seminars, labs and autonomous tasks. The first and outmost form is autonomous tasks in modeling (project engineering) and analysis (testing) of electric engineering facilities. Its execution location- at home or lab- is determined only by the technique operation complexity. The workplace for a student or engineer can be organized out-of university through Internet and WEB-devices. Lectures and seminars function as comprehensive tutorials in search of primary information (problem statement, know-how analysis, etc) and secondary information (service instructions, technical regulations and specifications, etc.).

The overwhelming amount of information in electric engineering furthered the development of new electronic slide review lectures with Internet access. As they say in Oxford "please read around the subject and find the explanation \ description that is best for you. Go to the Library!" [5].

The problem discrepancy involves the difference in content volume to given curriculum hours and is easily solved by dividing the topics into basic and secondary ones. If these lectures are review ones then this problem will not exist, because the number of lecture curriculum hours determines whether the lecturer is present or not, but does not affect the lecture content itself. Now the curriculum defines the education activities. The initial 16-hour student course was redesigned into a 40-hour advanced training course. However, in both cases, there was\is no student autonomous module, which, in its turn, has become a challenging task.

First of all, a precise organization mechanism for the education activities was developed involving such characteristics as continuous process and feedback. The 150-student stream is a serious working community and providing relevant tasks is not a simple thing to do. The solution to this problem was the existing university system MEPhIST, widely known as "moodle" (ru.wikipedia.org\wiki\Moodle).

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Student autonomous tasks were approximately divided into a 2-week period, involving one single topic and concluding test. The credit is a successfully completed series of tests. The above-mentioned system makes it possible to put these tests in the Internet as learning and controlling ones [6].The following fact should be highlighted that although the computer is the go-between the student and instructor, at the same time, it only ensures the forwarding of well-defined tasks. This is a serious disadvantage which could be solved in the near future; however, one should remember such a factor as personal human communication. In this case, seminars and after-tutorials are planned where non-traditional problems are discussed and analyzed.

Content of each topic (segment) involves a differential approach, providing minimum, average and successful progress results. This does not hamper successful students, but allows every student to determine his\her own progress trajectory.

The structure of every topic includes a package of tasks- homework (mathematical problem textbook), calculation lab task (mathematical modeling), lab diagnostic tester for analog modeling and description, workbook for recording modeling and analog modeling results, tests for programmed survey.

The first structure element is homework, including the following four chapters: (1) easy-type tasks: for those "who can't, but want to"; (2) university-level tasks: "Erudite and eruditress"; (3) advanced-type tasks (designed by the university department): "Talented and gifted" [7], and (4) preliminary-test-tasks: for test-based tasks. These tests include task-problems which have been developed for programmed survey and involve elementary mathematical tasks with easy answers. In the learning regime most students spend from 10-60 minutes for 5 test tasks

The second structure element is calculation lab task in mathematical modeling of electric circuits, which are further studied on the lab diagnostic tester. This task is based on the element values described on this unit which includes both compulsory and supplementary tasks. One calculation task result is an approximate oscillograph which a student obtains during analog modeling. This is based on the fact that a signal in modern electric engineering is an impulse and it's this impulse mode that determines the task solution. For example, the first topic devoted to elementary circuit with sine-waves includes the study of its phase deviation.

Complex signal form and non-linearity of applied elements results in the necessity of modeling computer programs. For above-mentioned tasks the MicroCAP program was selected (www.spectrum-soft.com) because the producer markets a free-load student version with a calculated grid volume of up to 50 nodes. This is sufficient. The Multisim program (www.ni.com\multisim) can be used as an alternative as it includes a distinct graphic interface and is in-built into a large program system LabView, used in many departments of NRNU. As the license cost (45US$-student version) is rather high for a student, it has a limited home application. Basically, all these programs are similar and are based on the basic electric circuit calculation program Spice. Students easily cope with these programs, and, besides this, there is a vast amount of references devoted to these programs. The application of these programs furthered the introduction of supplementary tasks, which are rather difficult to implement into the learning labs, for example, induction (eddy-current) heating.

Technically, the most complex element is the lab diagnostic tester, designed for scheme analysis (analog modeling) where perfect elements are substituted by factual elements. The principle of the diagnostic tester "ELUS" (which has been used for over 30 years) was used in this case. Its operation is simple- it is practically an automated workplace for an electronic engineer. This tester includes a computer plus program package and Internet, sophisticated digital oscillographTDS-2002B, involving not only the study of analog signals but also their transformation into a digital form; further processing as well as DC current source and generator for specific signals (harmonic and impulse). There is a digital multimeter to measure these values. Later this tester can be changed for an ordinary tester. This device is widely used and a student should be able to operate it.

The basic diagnostic tester element is a base-plate (card board) with elements and leads. In the course of time, a circuit of 3-4 basic elements was used. Although, in this case, there were some difficulties in the calculation of mathematical models, this did not hinder the possibility of using it for many years and considering it to be more than enough for the students. With respect to different views, the most appropriate basic circuit is 3 rows of separate elements, R, L, C, the ratings, of which is selected in accordance to the rows E24, E12, and E6, respectively. Thus, there are 24 element series RLC or 24 task variants. Adding one variable resistor and in-phase filter made it possible to design elements for four basic topics on a 150x100mm base-plate (cardboard): "Linear electric circuits with harmonic signals", "Resonance in linear electric circuits", "Magnetic-coupled coils", "Transient processes in linear electric circuits". To increase the performance reliability simple 2.8mm knife switches were used, as circular plug-in connection proved to be unreliable during their application in the long-performance of the tester base-plate "ELUS". The cost of one base-plate ranges within 1000 roubles.

We turned down the proposal of buying the teaching material package of Multisim due to one rather important reason. Let's examine the structure of the program package in the design of the electronic base-plate PCAD. So, it is developed in accordance to the following principle: introduction of elements which further tracing of tracks. In the real-life production, the element is primary, while the track is secondary. However, in the teaching material package of Multisim, visa versa: track is primary and the element is inserted. This stands in stark contrast to the previous stated paradigm of education activities and can be compared to kindergarten blocks rather than to work in an enterprise.

The remaining topics, such as "Three-phase circuit", "Transformers", "Long-distance transmission lines", "Non-linear elements" are similarly designed as the previous ones on separate base-plates. In the future it is planned to arrange the major training tasks of the course "Power semiconductor technology" on such base-plates.

Above-mentioned principles in the organization of the teaching process in an electric engineering lab can be easily implemented into the system of professional education in accordance with each individual instructor and his\her methodology.

However, in the higher education system, all lab tasks are integrated into the student timetable. Based on this fact, 13 diagnostic testing lab tasks were designed in accordance with one lab task for two students at standard number per student group. A projector can be used during seminar discussions, and, in the near future, an interactive board will also be installed.

It is obvious that the student timetable itself cannot regulate the execution of student autonomous tasks (as well as library attendance and homework). In this case five additional diagnostic testing were designed in a free access regime. If there comes the time when university "people" would understand all the absurdity of class-labs, then it would be easy to shift them into the "library-lab" regime. In this case we would only benefit from it, i.e. changing to new teaching technology- tutorials.

Such an organization approach of the student autonomous could make it possible to shift it (student autonomous) out of the teaching laboratory. In this case, analog modeling could include WEB-oscillographs and WEB-generators. The student would receive a set of base-plates with conductors, tester and WEB-device AKIP-4107 PV65 as well as a task package. Whereas, lectures, tasks, workbook with a record of completed tasks, test tasks can be found in Internet through the MEPhIST system. Naturally, one can agree that there is no personal communication in this case; however, it can exist in a more free way as tutorials or seminars.

The first experimental results showed the basic disadvantage of today's education –low student task orientation, resulting in no professional motivation. According to data results, only 1\3 of students are somehow interested in the teaching process. The remaining students are "ballast" who would need further training at the enterprise itself. The statement that "a student is not a vessel which must be filled in, but a flare that must be kindled" is not only still the issue of the day in our education system but also requires a new versatile approach in its implementation. However, this question is beyond the scope of this article.

The major problem in our case is to provide a balanced teaching process for the students. The absence of any professional motivation resulted in the internal quality control of the student's everyday work, while external monitoring is governed by the term – quality control principle of the teaching process itself. Earlier there was no free information access which today's IT provides, and in those days, the professor was the "pivotal figure" who posed only eternities. Everyday control was based on the professor's assertions, but not on the student activities. This fact still exists and has become an administrative regulation, including rudiments from past-century massive training of engineers, i.e. engineers of the 30's.

Excluding all above-mentioned factors, it can be stated that the introduction of sophisticated IT into the teaching process contradicts existing organization principles.

In conclusion, the selected approach in modernizing the teaching materials for the curriculum "Electric Circuit" not only updates the requirements to student autonomous activity but also opens up new vistas for further teaching and studies. As A.S. Makarenko said:" forty "40-rouble" teachers could completely degrade not only a homeless community , but also any community".

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