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Engineering Modeling: Educational Practice Analysis

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The paper studies a wide variety of additional education programmes and courses in engineering modeling ranging from radio technical simulation and robotics to mathematical modeling. It provides a detailed analysis of the courses according to some particular criteria. It proves that the programme implementation at different education levels depends on specific features of the institute and target student audience.

Key words: engineering modeling, design, mathematical modeling, 3D-modeling, robotics, additional education.

Introduction

Training highly-qualified staff in the sphere of engineering modeling and design is a complicated and long process. Therefore, it is of great importance to lay down the firm theoretical foundation as soon as possible to improve engineering educational programmes, i.e. to train future professional staff as early as at school. However, based on the school curriculum it is impossible now to implement engineering components without updating the curriculum and introducing additional specific disciplines. As a result, development of engineering design programmes is possible on the basis of additional education. Hence, search for and analysis of most efficient educational techniques and practices of teaching engineering design disciplines is a topical task.

Analysis results and discussion

The performed analysis of existing engineering design curricula and programmes for senior schoolchildren has made possible to distinguish several categories of the given profile programmes implemented at various educational institutions. These are additional courses which are taught at school in the form of elective computer modeling courses as a means to increase efficiency of teaching math, physics, and biology. The courses are provided by the additional education centers and students' universities communities, such as "School of Young Physicist", "School of Young Technician" etc., to promote engineering professions, attract schoolchildren, and improve their awareness in career choice, increase the quality of professional engineering education thanks to earlier professional guidance. There are also courses offered by various commercial educational centers and those provided within the additional general educational development engineering programmes held at Centers of Children's and Youth's creativity.

The analyzed education programmes can be grouped into the following profile categories:

- sports and radio-engineering modeling [1–4];
- computer modeling and robotics [5–11];
- courses on specialized software products [12–15];
- mathematical modeling [16–17].

This classification allows covering all existing engineering design educational programmes on the open access and arranging them by "simple-to-complex" principle. To perform comprehensive analysis of programme and course data, the following criteria were used:

1. Novelty.
2. Distinguishing features of analogues programmes.
3. Time consumption (the number of hours).
4. Programme extension.
5. Conditions.
6. Target audience.
7. Programme content.
8. Forms and methods of programme outcomes.
9. Materials and equipment, technical means.
10. Availability of distance-learming programmes.
11. Expected outcomes of the programme.
12. A criterion defining a choice of this or that course is open access to programme content. It is impossible to estimate its relevance to our research without this factor.

The programmes included in the sports and radio-engineering modeling group are the first stage in learning engineering modeling and are usually implemented at Centers of Children's and Youth's creativity, Yong Technicians' Centers, Centers of Children's and Youth's Engineering and other similar organizations. The target audience of such courses covers a wide age range, from 7 to 18. The programmes of primary engineering modelling intended for young school age children have not been investigated within the given research, but they lay the foundation for further effective acquisition of educational engineering programmes.

In terms of time consumption of the given courses, they are the longest – from 1 year to 4 years, 72–216 hours each.

The analyzed programmes are focused on development of engineering thinking, inventive skills, visual and spatial thinking as well as design competencies. It should be underlined that due to the absence of drawing discipline in the school curriculum, these courses allow acquiring the necessary skills of individual drawing, developing combinatorial thinking and is a source of developing spatial images which is basic for not only future engineers but also specialist of any profile [18-19].

The next complexity level comprises the programmes of "computer modeling and robotics" group. The target audience of these courses includes also a wide age range of both pupils and students. These courses are implemented at the Centers of Children's and Youth's Creativity, open distant education platforms, and at colleges and universities, as they are of a wide range and now are in great demand. The extension of the given education programmes can also be long enough – from 14 days to 4 years.

The considered courses are aimed at pupils' acquiring basic knowledge in fundamental electrical engineering and robotics as well as developing 3D-models and their visualization. Pupils are taught to make radio-controlled and programmed robots independently, plot 3D-models for various fields of science and engineering. The creative skills and design competencies are efficiently developed. Some analyzed courses imply a transition from modeling (copying the suggested model) to design (creation of individual operational contraction using specified parameters). However, this approach requires serious methodical preparation, search for a balance between classes and independent work. One needs to take into account group diversity not to lose pupils' interest in the training outcomes, for example, at multiple playback of simple models or "bogging down" in individual project, for completion where the acquired skills are not enough to complete the task. Different kinds of competitions, which are a logic completion of such courses, are a basis for developing leadership, independent work, and teamwork skills.

The universities implement the given courses as a part of the main curriculum within profile engineering training and allow students to acquire design and research competencies. It should be noted that profile-related subjects are not included in the research scope, but they demonstrate the courses continuity at different education

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levels. Thus, it is obvious that effective training of qualified engineering staff is a rather long and multi-aspect process.

The category of "courses on specialized software products" is a subsequent stage in engineering training, which presents a higher and more complicated level of knowledge. The target audience of the given courses is diverse, but they are mostly experienced specialists in the sphere of engineering design and modeling who need to learn this or that specific software or sufficiently improve their skills. These programmes are mostly designed for senior schoolchildren [20–21], rarely for other groups. As a rule, the programmes are implemented at commercial educational centers or specialized additional vocational education centers of universities. It is necessary to note that this category includes the most number of engineering modeling programmes with distant learning. In terms of time consumption, these programmes are the shortest, from 1 to 5 days or from 16 to 40 academic hours.

The most complex programmes to learn are referred to the "mathematical modeling" group and implemented, as a rule, at universities only as a part of the main engineering curriculum [22]. In this case, even at the Bachelor level both theory and practical application are delivered as a part of the given disciplines [23–24]. More deep insight into these disciplines is given at Master and highly qualified staff training courses. Within the given group 2 programmes were analyzed. The target audience is Bachelor students. The time consumption is from 144 to 216 hours. This group of programmes is focused on development of students' theoretical fundamental knowledge in the sphere of mathematical and geometrical modeling as well as its application in mathematical model design in different sphere of science and technology [23].

Detailed analysis of engineering design curricula and courses has shown that in most cases the authors neither show application of new methods and techniques nor indicate the distinguishing features of the courses taught, i.e. their specificity in comparison with analogues. Hence, one can conclude that on the whole the course designers do not always possess sufficient competencies of methodical programme description.

As a result of engineering modeling programme popularity, the target audience is of wide age range from junior schoolchildren to university graduates and specialists working in this sphere. Therefore, it is necessary to consider engineering modeling programmes and courses for senior schoolchildren as a constituent of general engineering training system, since an engineer is learning all his/her career long. To present a holistic vision, the analysis additionally includes the programmes intended for different target groups, not only for senior schoolchildren.

One of the key criteria is classroom technical equipment. According to the analysis, the level of technical base in the institutes is very diverse. The content of curricula shows that some institutions use a sufficiently wide range of specialized equipment, materials, and software in specially equipped classrooms to develop engineering competencies. Whereas other institutions train students by means of improvised tools only (scissors, glue). It should be noted that Centers of Children's and Youth's Creativity and other institutions of similar profile with limited resources appear to be at a particular disadvantage. Training of highly qualified engineering staff should be performed from the childhood – a period when substantive knowledge, skills and abilities are formed for the further effective learning. For this purpose, the educational institutions need to be equipped with the most advanced technological and software base as it is senseless to train future specialists using out-of-date technology. It is of particular significance that such training courses would be available for any schoolchild. The skill to find the unconventional problem solutions, visual and spatial thinking, interest in knowledge acquiring in the sphere of natural-mathematic sciences – all these are developed when learning engineering modeling and can be practically used in any sphere and are in demand in any job. The competencies acquired contribute to a conscious choice of future profession [19].

Conclusion

It is shown that engineering design courses are implemented at different level of education taking into account specialization of institution. The practice-oriented approach promotes better understanding of theory; clear illustration of the theory knowledge acquired and is a foundation for developing competencies or further mastering the disciplines within the profile engineering training at universities.

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Integrated Laboratory System

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This paper presents an integrated laboratory system, which enables to conduct laboratory work in "Electrical Engineering with the Basics of Industrial Electronics", "Electronics", "Electrical Work" and others in the course of teaching complex electrical and electronic professions. The design of the system enables to perform physical simulation of laboratory work by intgrated plug-in units and also electronic simulation by a personal computer.

Key words: integrated laboratory system, laboratory work, physical simulation, electronic simulation.

Formulation of the problem

The age of technological advances, the intensive development of science, technology and their integration result in complication of nature and structure of professional work. The emergence of new technologies requires more serious training of engineers from specialists of technical institutions. This also concerns future teachers related to vocational education, who are being prepared at teacher training institutions.

Rapid implementation of scientific achievements in production, especially in electrical- and radioengineering, leads to the expansion of educational material in programmes and, as a consequence, to the increase in the period of study. Due to the rapid development of electronic production, i.e. the application of new materials, the implementation of new technologies, changes in hardware components of electrical and radio equipment, it can be said that the society sees a technological challenge, which affects training in educational institutions [3, p. 228].

Because the volume of knowledge, skills and abilities in these professions is so large and constantly growing, it is required to change the professional training content of engineers. On the one hand, there are inconsistencies between rapid technological progress, constantly changing range of electronic manufacture, and on the other hand, operational difficulties in displaying this amount of information in teaching- and programme documentation, textbooks, teaching aids and textbooks. This impacts the training quality of specialists of higher- and vocational education.

Analysis of current research activities and publications

Due to high rates of science and technology progress, the entire education system and professional education in particular, are faced with the efficiency improvement of learning process. The changes in question must be primarily reflected in the curricula, academic programmes, textbooks, manuals and other literature. This is particularly important for specialists in the sphere of complex electrical and electronic professions. Today, they account for approximately 30% of all professions. Workers and engineers associated with these activities have to perform much practical work on assembly, connection, disassembly and adjustment of various electrical and electronic circuits. Correct execution of these operations is achieved by long training during various practical and laboratory work.

It must be noted that currently there is a large range of equipment to perform laboratory work in electrical- and radio-

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