Environment. Technology. Resources, Rezekne, Latvia
Proceedings of the 10th International Scientific and Practical Conference. Volume III, 159-163

Structuration of courses at studying disciplines of programming

Natalya Prokofyeva, Marina Uhanova, Oksana Zavyalova, Sabina Katalnikova
Riga Technical University, Faculty of Computer Science and Information Technology.
Address: ¼ Meza str., Riga, LV-1048, Latvia

Abstract. **The article describes the methodology of learning programming for students of various engineering disciplines (chemists, electricians, programmers, and mechatronicians). The courses "Computer Training" and "Programming Languages" taught at the Faculty of Computer-Science and Information Technology of Riga Technical University are used as examples. The purpose of these courses is to prepare specialists able to use computers effectively and without error in their future careers. The course structure depends on the particular specialty area. The course structure consists of three parts: the main (theoretical) part, the laboratory part and the practical test. In this paper we show that for better development of course material it is necessary to consider the solution of specific practical problems that may be encountered by engineers of particular profile, as well as to provide current and final control of students.**

Keywords: **methodology of course structuration, computer training, programming language.**

I INTRODUCTION

Many international scientific conferences (such as IEEE ICALT, IADIS e-Learning, IASTED CATE, etc.) and e-journals [1][2][3] are dedicated to research in the field of computer-based learning and knowledge assessment.

The current stage of educational development in Latvia is connected with the transition of higher education to the educational standards of the third generation based on the methodology of competence approach [4][5].

With the transition to the new standards, university teachers face a predictable range of questions - “Why do I have to teach?”, “What to teach?”, “How should I do the teaching?” and “How to evaluate student performance?” [6][7][8][9]. The answers have universal bearing, because they give the guidance for constructing and mastering each study discipline.

The Authors of this article would like to dwell on the methodology of structuring educational course content. The importance of the discussion is determined by the fact that functional and conscious acquisition of learning material mainly depends on its structure, in which the structure and character of the activities aimed at mastering the material is already implied.

Firstly, we want to focus your attention on the important principle of contemporary methodology – the principle of complementarity. It is connected with the introduction of innovations as an addition to the existing traditional components of study content and strengthening the links between them in the context of modelling a new system of educational course content. In this way it defines the priority of systemic and integrative approaches to selection and construction of content, which ensure that created courses focus on integration, systematization and structuring of a plurality of content elements into a rational system of educational content.

The rationality of educational content can be reached by founding “the core” of the content, which also defines the subsequent filling of courses. It is important to proceed from submission of content in any educational discipline, which is admitted in pedagogy – that is scientific knowledge, practical skills and also experience and professional skills in a specific area of knowledge. Moreover, we should consider general pedagogical principles of optimizing the amount and difficulty of educational material (theoretical and practical significance; matching the material to the age and individual characteristics of students, etc.)

Considering the above, “the core” can be presented through the unity of the following invariant parts of educational course content: informational and scientific part; laboratory and practical part; examination and verification part. Obviously, the filling of identified invariant parts with concrete elements will depend on requirements of educational standards, goals and objectives of learning in concrete disciplines, its peculiarities and other factors.

Courses in programming for chemists, electricians, programmers and mechatronicians are taught at the Faculty of Computer-Science and Information

ISSN 1691-5402
© Rezekne Higher Education Institution (Rēzeknes Augstskola), Rezekne 2015
DOI: http://dx.doi.org/10.17770/etr2015vol3.179

Technology of Riga Technical University. The following article describes the methodology of structuring of the courses "Computer Training" and "Programming Languages" for students in these fields.

II THE CONTENT OF "COMPUTER TRAINING" AND "PROGRAMMING LANGUAGES" COURSES

The "Computer training" and "Programming languages" courses form the basis for the implantation of information technology into the educational system. The courses have an important place in the multilevel system of preparation of experts in different fields. They not only presuppose the organization of practical work using a computer, but also introduce students to the principles of algorithmic computational processes and to the technology of creating application programs.

The course "Computer Training" in RTU is taught to the first-year students of two faculties – the Faculty of Material Science and Applied Chemistry and the Faculty of Power and Electrical Engineering.

In the first theoretical part students learn techniques for algorithm development and programming, get acquainted with the syntax of high-level programming languages by the example of VBA (Visual Basic for Applications). It includes the following topics: elaborating branching algorithms and programs; writing cyclic programs and the use of nested loops; working with strings of characters and text files; using Microsoft Excel object model.

In addition, examples of tasks are selected for students, some of which are cited as the examples during lectures, some of which the students have to carry out on their own during the laboratory works and some of which are offered as optional tasks of high complexity for enthusiastic students.

In the laboratory and practical part a number of practical works are offered. For example, a part of laboratory work devoted to branching programs and algorithms is the development of macro for calculating stationary sedimentation rate of the particles by using the Reynolds number. Practical application of the cyclic program is illustrated by using numerical methods for calculating definite integrals. The estimation of the value of the definite integral is necessary in solving many engineering tasks, e. g. for calculating the parameters of the chemical process such as heat transfer.

The use of nested loop is shown not only on the example of matrix problems and the examples of processing of array elements, but also on the example of calculating the composition of the mixture obtained by mixing various substances.

The tasks associated with the calculation of the mixture usually are reduced to the calculation of the product vectors and matrices and are encountered quite often in chemistry. Other more common tasks include the opposite to given task nd require from chemical technologists the calculation of proportions of initial materials in order to obtain the mixture of a given composition. Given tasks are reduced to solving a system of linear equations. The development of macros in VBA for solving systems of linear equations is offered to students for independent work as an optional task of high complexity. One example of the development of programs for working with character strings is the task of finding a relative molecular mass of a substance. The students are offered to write in VBA the program that introduces the chemical formula of the substance (for example H_2SO_4) and calculates the molecular weight. It is proposed to try to implement the error handling in case when the user enters the name of a nonexistent element or enters the name of the element using the wrong case of letters. The programs written during laboratory work are performed in Microsoft Excel environment that facilitates the creation of user-friendly interface and allows using the advantage of Excel in the automation of calculations.

It is known that the pledge of quality training of students is to ensure the feedback, that is, the organization of knowledge and skills control acquired in the learning process. That is why examinations are held regularly on this study course after completing each topic.

The course "Programming Languages" is taught to the students of the Faculty of Computer Science and Information Technology and of the Faculty of Transport and Mechanical Engineering. The aim of this course is to introduce students to new software in the area of information technology. Thus, the main goal of the discipline is to provide theoretical knowledge about programming languages and their use in solving applied tasks. As a result of the program, students are expected to master the principles of organization of computing processes as well as programming techniques for high level programming languages.

The course content includes the following topics: classification of programming languages and their use; development of algorithms of and programs in C (work in the editor DEV C ++); work with dynamic variables; work with records and text files. In addition to traditional topics teachers give students the task – independently prepare abstracts on contemporary topics in the field of computer and information technologies and read a report in front of their classmates.

Laboratory practical part of the course consists of classical traditional tasks in studying any programming language: implementation of branched and cyclic algorithms; basis of modular programming, learning functions and procedures; working with text and text files.

For several years, in conducting classes on "Programming Languages", teachers have been using the ORTUS educational environment [10] for knowledge evaluation. With the help of this environment different types of examinations, tests and independent work checks can be incorporated into the learning process. The teacher can create a test by setting the number of times of passing the test, time and place of delivery (such as in class or remotely). It is possible to envisage the formation of random questions, as well as the rotation of answer options in question. All types provide comments, answers, as well as the ability to use pictures, tables, etc. It is possible to create tests from different categories of questions, to take into account the difficulty of questions accord more points to complicated questions [6].

The teachers successfully implement the ORTUS environment in the traditional model of the educational process as it allows to make learning more interactive and increases the importance of independent student work. This course develops the basic skills of programming and it is important not only for professional training but also for the formation of information culture of future engineers.

Thus, in the courses "Computer Training" and "Programming Languages" a whole range of skills are acquired by future specialists (chemists, electricians, programmers mechatronicians), which are necessary for the widespread use of information and computer technologies as well as the appropriate software in the future professional activity.

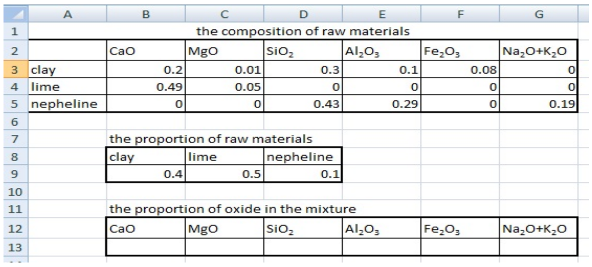
III METHOD OF STRUCTURING AND ITS RESULTS

As is known, every learning course comprises three components: the main (theoretical) part (ideas and knowledge); the laboratory-practical part (skills, experience); the evaluation part (evaluation of skills). All these parts are obligatory and traditionally are taught by all teachers in higher education.

It has been proved that the use of computer systems in laboratory and practical part increases students' academic performance and motivation [11].

The authors suggest improving the structure of the course content, supplementing it with new elements that are directly related to the solution of applied tasks of relevant specialties – chemists, electricians, etc.

For example, during the learning process of nested loops theme on the subject "Computer Training", in one of the tasks students are encouraged to develop a program for calculating the proportions of the oxides in the cement charge. The cement charge is prepared by mixing clay marl (composition: CaO 12-25%, MgO 0-2%, SiO_2 25-40%, Al_2O_3 5-15%, Fe_2O_3 about 8%), lime (composition: CaO 48-55%, MgO 4-8%), nepheline (composition: $Na_2O + K_2O$ 19-20%, Al_2O_3 29-30%, SiO_2 43-44%). In the composition of raw materials volatile substances are not typically included. Students are encouraged to create an Excel spreadsheet, similar to that shown in Fig. 1.



	A	B	C	D	E	F	G
1				the composition of raw materials			
2		CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	Na_2O+K_2O
3	clay	0.2	0.01	0.3	0.1	0.08	0
4	lime	0.49	0.05	0	0	0	0
5	nepheline	0	0	0.43	0.29	0	0.19
6							
7		the proportion of raw materials					
8		clay	lime	nepheline			
9		0.4	0.5	0.1			
10							
11		the proportion of oxide in the mixture					
12		CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	Na_2O+K_2O
13							

Fig. 1. Example of Excel spreadsheet

To find the proportion of oxides in the mixture it is necessary to multiply the vector containing the proportions of raw material by the matrix of raw material composition. As a result, the vector will be obtained 1x6 containing a proportion of oxides in the mixture. Macro that performs multiplication of this vector by a matrix and displays the results in Table Excel (in cells B13: G13) can look like this:

```
Public Sub Sostav()
For j = 2 To 7
  For i = 1 To 3
    Cells(13, j) = Cells(13, j) + _
      Cells(9, i + 1)*Cells(i + 2, j)
  Next
Next
End Sub
```

To solve this task, students need to know, firstly, how to work in the Microsoft Excel environment, secondly, to be able to describe the cyclic algorithm in the language of VBA (Visual Basic for Applications) and to use macros for solving a specific task. In such a way the laboratory and practical part is complemented by a new element (module), which allows students of chemical faculty to acquire knowledge in the area of information technology, as well as in their professional area.

So the subjects "Computer Training" and "programming languages" include not only the main components ("core") of training courses, but are supplemented with new content elements Mi (modules). The general scheme of structuring training courses is presented in Figure 2.

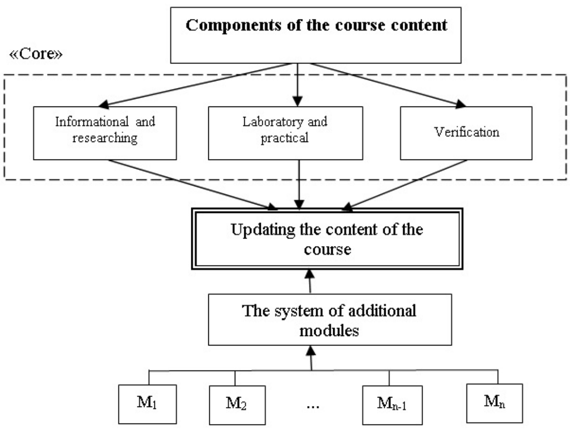


Fig. 2. The components of the course content

The modules can consist of applied tasks for chemists, electricians and mechatronicians. Those may also be the tasks for independent work, e. g., to write and defend an essay on one of the topics in the area of information technology, etc.

Thus, the authors hypothesize that a balanced complement of courses with new content must significantly improve student performance, as well as the quality of education in these disciplines.

In order to prove or disprove the hypothesis, an experiment was conducted and statistical data collected for five academic years at the Faculty (Table. 1). Students are divided into two main groups: the students who were trained under the traditional method (year 1, 2) and the students trained and evaluated under the proposed method (year 3, 4, 5).

TABLE 1.
THE NUMBER OF STUDENTS PARTICIPATING IN THE EXPERIMENT

Subject	Academic years					Students in total
	1	2	3	4	5	
Computer training	95	80	93	79	115	462
Programming languages	282	266	242	287	280	1357

The general formula for determining the coefficient of assessing the quality of student groups in the discipline of the training period (semester) has the form [12]:

$$K = \frac{1}{3}\left[\frac{1}{2}(A_{val} + A_{exam}) + \frac{1}{2}(O_{val} + O_{exam}) + \frac{1}{40}(Q_{val} + Q_{exam})\right]$$

Where

K - the evaluation of the quality coefficient;

A_{vol} - the average score of a group of students according to the results of current knowledge control during the semester;

A_{exam} - the average score of student groups according to exam results;

O_{val} - the overall assessment of student groups per semester, determined as follows: "5" - 90% of students have a positive assessment, with 50% of students having an assessment of "10" and "9"; "4" - 90% of students are evaluated positively, with 50% of students having a rating of "10", "9", "8" and "7"; "3" - 80% of students have a positive evaluation; "2" - not satisfying conditions for assessing the "3";

O_{exam} - the overall assessment of student groups for the exam, defined as O_{val};

Q_{val} - the percentage of good and excellent ratings in the group of students according to the results of the current knowledge control during the semester;

Q_{exam} - the percentage of good and excellent ratings in a group of students according to examination results.

The results of the experiment are shown in Tables 2 and 3.

As can be seen from the tables, in teaching students under the traditional scheme the coefficient of assessing the quality of training of students K is significantly lower than when applying advanced methods in teaching these subjects.

Thus, the balanced addition of courses with new content elements not only improves student performance, but also greatly improves the quality of education and knowledge control.

TABLE 2.
COEFFICIENT OF ASSESSING THE QUALITY OF STUDENT TRAINING ON THE SUBJECT "COMPUTER TRAINING"

YEARS	A_{VOL}	A_{EXAM}	O_{VAL}	O_{EXAM}	Q_{VAL}	Q_{EXAM}	K
1	5,57	6,56	3	3	42,22	49,00	3,78
2	5,71	6,52	3	3	40,51	48,15	3,78
3	5,97	7,20	3	4	45,83	64,04	4,28
4	6,28	7,20	4	4	58,05	67,45	4,63
5	6,79	7,37	4	4	52,43	73,45	4,74

TABLE 3.
COEFFICIENT OF ASSESSING THE QUALITY OF STUDENT TRAINING ON THE SUBJECT «PROGRAMMING LANGUAGES»

YEARS	A_{VOL}	A_{EXAM}	O_{VAL}	O_{EXAM}	Q_{VAL}	Q_{EXAM}	K
1	5,34	5,79	3	3	38,15	42,10	3,53
2	5,71	6,12	3	3	41,08	43,13	3,68
3	5,97	6,80	3	4	46,78	53,26	4,13
4	6,12	7,15	3	4	56,78	62,18	4,37
5	6,07	7,09	3	4	49,38	60,23	4,27

That is the actual task in the formation of the skills engineers will use in their future professional activities.

IV CONCLUSION

This technique of structuring training courses (Fig. 1) can be used for all courses taught in higher education institutions, as the quality control of training students encourages systematic, independent and creative learning activity, self-control of achieved results and their regular and objective evaluation, as well as the cultivation of responsibility for the results of one's academic work.

V REFERENCES

[1] The Electronic Journal of e-Learning (EJEL) [Online]. Available: http://www.ejel.org/main.html [Accessed: March, 2015].

[2] Journal of Educational Technology & Society [Online]. Available: English version: http://www.ifets.info/, Russian version: http://ifets.ieee.org/russian/periodical/journal.html [Accessed: March, 2015].

[3] International Academy, Research, and Industry Association (IARIA) [Online]. Available: http://www.iariajournals.org/ [Accessed: March, 2015].

[4] United Nations Educational, Scientific and Cultural Organization [Online] / – http://en.unesco.org/ [Accessed: March, 2015].

[5] Joint Council of Europe/UNESCO (Lisbon) Convention [Online]. http://conventions.coe.int/Treaty/en/Treaties/Html/165.htm [Accessed: March, 2015].

[6] L. Rastrigin, M. Erenshtein, *Adaptive teaching with a model*. Riga, Zinatne: 1986.

[7] L. Nicetsky, *Requirements specification for development of the RPI computer-based teaching system first version*. Riga, Riga Polytechnic Institute (RTU): 1977.

[8] L. Zaitseva, L. Novitsky, V. Gribkova, *Computer-aided teaching systems development and using*. Riga, Zinatne: 1989.

[9] N. Prokofjeva, *The Methodical and Technical Aspects of Students Knowledge Control*, Proceedings of the 13th Education and Virtuality International Conference, VIRT - 2011, Ukraine – Yalta, 2011, pp. 263 – 272.

[10] N. Prokofjeva, A. Anohina-Naumeca, O. Lebedeva, *Administration of Knowledge Assessment at Riga Technical University*. Proceedings of the 8th International Multi-Conference on Computing in the Global Information Technology (ICCGI 2013), July 21-26, 2013, Nice, France, IARIA, pp.34-39, ISBN: 978-1-61208-283-7. (indexed in ThinkMind Digital Library).

[11] N. Prokofjeva, D. Zagulova, S. Katalnikova, “Possibilities of Use of Computer Systems in Educational Process by Preparation of IT of Experts,” Educational Technology & Society, 2013, Vol.16, No.4, pp.511-520. ISSN 1436-4522. [Electronic resource] / – http://ifets.ieee.org/russian/depository/v16_i4/pdf/18.pdf [Accessed: March, 2015].

[12] O. Grigorash, A. Trubilin, “Methods for estimating the quality of training of students and effectiveness of the training activity of teachers and department,” Polythematic network electronic journal of the Kuban State of Agrarian University (The science journal KubGAU). Krasnodar: KubGAU, 2013. - №92 (08).