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PEDAGOGICAL CONDITIONS OF PROFESSIONAL TRAINING FOR FUTURE PROGRAMMER ENGINEERS

Abstract: The problem of professional training of future engineers-engineers in the technical university is studied. It is considered the implementation of pedagogical conditions that contribute to the improvement of this training. The ways of introduction of the offered pedagogical conditions in the process of professional training of students are offered.
Key words: pedagogical conditions, vocational training, engineers-programmers, activation of students, dual approach.

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ПЕДАГОГІЧНІ УМОВИ ПРОФЕСІЙНОЇ ПІДГОТОВКИ МАЙБУТНІХ ІНЖЕНЕРІВ-ПРОГРАМІСТІВ

Анотація: Досліджується проблема професійної підготовки майбутніх інженерів-програмістів в технічному університеті. Розглядається реалізація педагогічних умов, що сприяють удосконаленню цієї підготовки. Пропонуються шляхи

впровадження запропонованих педагогічних умов у процес професійної підготовки студентів.

Ключові слова: педагогічні умови, професійна підготовка, інженери-програмісти, активізація студентів, дуальний підхід.

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ПЕДАГОГИЧЕСКИЕ УСЛОВИЯ ПРОФЕССИОНАЛЬНОЙ ПОДГОТОВКИ БУДУЩИХ ИНЖЕНЕРОВ-ПРОГРАММИСТОВ

Аннотация: Исследуется проблема профессиональной подготовки будущих инженеров-программистов в техническом университете. Рассматривается реализация педагогических условий, которые способствуют усовершенствованию этой подготовки. Предлагаются пути внедрения предложенных педагогических условий в процесс профессиональной подготовки студентов.

Ключевые слова: педагогические условия, профессиональная подготовка, инженеры-программисты, активизация студентов, дуальный подход.

Problem statement. The specialty of a programmer engineer today is in great demand in the labor market. According to the results of the European Business Association IT Committee, the IT industry took the third place in the export structure of Ukraine for the first half of 2017 [25]. A number of educational institutions in Ukraine train future programmer engineers, but how ready future professionals are to fulfill their professional duties in real life, what is missing in the academic process at universities to prepare professionals who are able to solve any professional problem while working in real IT projects.

Analysis of recent research and publications. In the pedagogical research on the improvement of professional training of future programmer engineers, the approaches to mathematics teaching (O. M. Dubinina, O.Ya. Kucheruk, N.Y. Padalko, S.O. Semerikov, D.E. Schedrolosiev) [7,10,14,20,24] and foreign-language training, especially English (M.V. Bernavskaya, Ya.V. Bulakhova, V.V. Strilets, I.V. Chirva) [1,2,21,22] are discussed in more detail. Some other aspects of future programmer engineers' training were studied by M.O. Vinnik, M.M. Gladysheva, L.V. Grishko, F.S. Ilyasova, O.M. Ishakova, D.A. Mustafina, V.V. Osadchy, O.O. Rychkova, V.E. Sedov, Z.S. Seidametova, T.M. Shalkin et al. [3,4,5,6,8,9, 12,13,16,18,19,17,23].

To the best of our knowledge, there is no integral study on the professional training of students in the direction of "Software Engineering" in the technical university, namely the development and implementation of pedagogical conditions that facilitate the professional training of future programmer engineers. The purpose of the article is to describe the process of implementation of the pedagogical conditions into future programmers engineers' professional training in a technical university.

Presentation of the main research material. To develop the pedagogical conditions for the training of future programmer engineers, we used the methodology of collective expertise (MCE) [11]. The analysis showed that MCE is used to solve important and complex problems and found wide recognition in the world. When organizing collective expertise it is necessary to observe certain stages. First, it is the preparation of a collective expertise, secondly, the formation of an expert panel: the determination of the expert number and personal membership. The third stage, which is the expert information for concept formation, consisted of sub-stages, namely – experts' orientation on the development of the pedagogical

conditions for the professional training of future programmer engineers; the generation of ideas and ideas analysis as to the variant-richness of pedagogical conditions. The next, the fourth stage was a direct expertise: it consisted of the generation of expert commentaries, assessment of the dimension of agreement and determination of the sufficiency of the dimension of agreement of experts' opinions. At the fifth stage, the ranking of pedagogical conditions proposed by experts was perfomed, which included the calculation of an aggregated expert panel assessment and the determination of the most significant pedagogical conditions for their implementation into the educational process for professional training of future programmer engineers [11] .

The selection of experts was carried out among well-known competent specialists working in the field of students' training - future programmer engineers, namely among the heads of the departments, professors, and teachers of the leading higher educational institutions of Ukraine. In addition, when training future professionals in this direction, great attention is paid to the requirements of employers, who after students' graduation are ready to hire them. Therefore, when developing the pedagogical conditions for the training of future programmer engineers, it was highly desirable to include also potential employers into expert panel - heads of large computer firms and leading specialists in IT industry.

According to the results of the expert evaluation, the following pedagogical conditions were developed:

- integration of the content of mathematical, foreign language, social and humanitarian, professional components of the professional training of future programmer engineers;

- intensification of students' activity in the acquisition of knowledge, skills and experience as well as the development of soft skills which are important for the professional activity of the programmer engineer;

- using a dual approach aimed at quality improvement of future programmer engineers' professional training based on the interaction between universities and IT companies.

The integration of the content implies a holistic perception of the material being studied by the students, their better comprehension of material significance, the teachers' selection of the disciplines content done on the principles of professional importance and consistency, providing a comprehensive and integrated information analysis.

The curriculum of students' training in the field of "Software Engineering" includes, in addition to the basic training in mathematics, foreign languages, social and humanitarian disciplines, the disciplines with the integrative content such as "Computer Discrete Mathematics", "Empirical Methods in Software Engineering", "English for Specific Purposes","Group Dynamics and Communication"," Professional Internship in Software Engineering". The study of these disciplines involves mastering Mathematics, the English language and humanities from the perspective of the programmer engineer's professional activity, in accordance with the future students' specialty.The integration of the content for the future programmer engineers' training includes:

- a general basic mathematical, foreign language, social-humanitarian training with the elements of professionally oriented content;

- an in-depth reflection of professional activity within the course of study of mathematical, English, social and humanitarian disciplines;

- mastering professional disciplines using the basis of mathematical, the English language and humanitarian training.

Substantial mathematical training is an essential foundation for future programmer engineers. In many areas of human activity, the development of software involves the creation of a mathematical model and the application of mathematical methods for finding the optimal solution. In general, the choice of optimal solution, modelling, analysis and algorithmization of the model, the choice of software require mathematical preparation. The mathematical thinking of a programmer engineer is the basis for successful professional activities. At the same time, while conducting an expert survey within our study, consulting with the faculty and analysing the training of future programmer engineers, the problem of teaching computer mathematics to students (a cycle of mathematical disciplines with a clear bias on professional problem solving) became rather evident. At one point, it became clear that the general department of higher mathematics, which had been teaching mathematics to future programmer engineers, did not meet all the needs, and in this regard, the National technical university "KhPI" raised a question of formation a special department that would be focused on students' training in the field of applied computer mathematics. And in 2002 the department of computer mathematics and mathematical modeling was organized. This department formation and introduction of special courses in mathematics for future programmer engineers became an important factor in their high quality professional training.

Integration of the content of mathematical and professional training allows a student to master the fundamental knowledge, to realize its importance and to develop the ability to use mathematical tool for professional problem- solving.

In the system of professional training of a future programmer engineer an important role is played by a foreign language focused training. In foreign language classes special attention was paid to the importance of English for students' future professional activitiy. IT technologies are being developed most of all in the English-speaking countries and almost all software product manuals are published in English. During the English classes students discussed the importance of English for:

- searching and processing information from foreign sources (reference literature, articles, books, electronic resources, etc.);

- handling out specifications, instructions and other technical documents, as well as writing their own ones;

- oral and written communication with foreign partners and customers;

- public presentations and presentations in English at scrum meetings, business meetings and negotiations;

- personal professional growth: getting acquainted with new achievements in the IT sphere;

- adaptation in the English-speaking professional environment.

Foreign language classes included: individual tasks in accordance with the level of knowledge of each student; monologues on a certain topic; work in pairs for communication in dialogues; work in microgroups and in groups for general discussions and debates. Certain professional topics were role-played within discussions, and the simulation of real professional situations was performed during English classes. Reading, listening, and writing were also professionally-oriented. The content of a foreign language teaching provided language immersion into professional subjects and the ability to perform professional tasks using English.

While learning a foreign language the content integration stipulated the incorporation of professionally-oriented tasks in the process of acquisition speech skills, whereas in contrast the content of disciplines on professional training was integrated through teaching these disciplines in English and using the language in the accomplishment of professional tasks.

Teaching professional disciplines in English allowed achieving simultaneously two goals: the formation of students' professional competence, and a significant improvement in the quality of their mastering a foreign language and a culture. Such teaching stipulated the solution of several problems related to:

1) students' readiness to study in English;

2) teachers' readiness to teach in English;

3) organizational issues of the English-speaking environment formation (teaching and methodological support of the educational process, additional courses for teachers and students, etc.).

Teaching professional disciplines in English meant to have good abilities for listening, reading, writing, speaking English at all stages of the training process within curriculum and extra-curriculum activities as well.

But besides a foreign language and professional training content integration it was stipulated that while studying a professional component in training, students use foreign language skills when:

- working with educational materials and professional literature (educational and methodological support for teaching professional subjects in English and foreign-language library of technical literature was compiled);

- accomplishing tasks for obtaining additional information from the Internet resources;

- listening to lectures and communicating with foreign teachers and specialists who are invited to the national universities;

- participating in foreign conferences, seminars and other events of the department;

- writing a scientific papers in English under the supervision of a teacher;

- doing internships in foreign universities.

Integration of a foreign language and professional training content included not only learning English for Specific Purposes, but also the use of language as a means of professional knowledge, skills, experience, qualities and values for students.

The results obtained in experimental studies showed that students underestimate the significance of social and humanitarian training. The content analysis of the socio-humanitarian curriculum for future programmer engineers and consultations with teachers made it possible to determine that the cause of this is the disconnect between the training material and programmer engineers professional activity. The consultations with teachers of social and humanitarian disciplines allowed structuring their content in accordance with the principles of combination theory with practice and professional orientation of the studied information. Social and humanitarian disciplines raise the issue of the social significance of a programmer engineer, the impact of information technology on modern people and society as a whole. Teaching these disciplines should be based on discussions on socially important topics in the age of informatization.

It is philosophy that considers the most general issues of being, spiritual significance, and morality. Discussions with students whether information technologies (computers, gadgets, software) are a boon or a bane for a man, aroused much interest among the students and their class participation.

Special attention in psychology teaching was given to the issues of organizational psychology and communication psychology. The specialist activity in software engineering is a special type of activity aimed at the collaborative development and maintenance of complex software systems.

Integrating the content of socio-humanitarian and professional training involved the use of humanitarian training basis when accomplishing learning goals and objectives on

professional disciplines: the use and further development of communication skills and students' ability to team work in the classroom and in exra class activities, in laboratory studies, project implementation, role-played situations, and discussions. The need for effective group communication skills of the future programmer engineer in further professional activities after graduation is especially emphasized. When presenting the results of software development tasks students were provided with feedback on the quality of the presentation and their report accompanying the presentation. Such issues as psychological principles of human-machine interactions; character and a role of professional societies; social, legal, historical and professional problems and interests; a system of ethics and professional behaviour, an ethics code for a software engineer; concept of quality and software culture were also considered within the content of professional disciplines.

The implementation of the second pedagogical condition - *intensification of students' activity in the acquisition of knowledge, skills and experience as well as the development of soft skills which are important for the professional activity of the programmer engineers* is based on the activity and person-centered approaches which involve the implementation of a number of principles: the student's personality is developing in the process of a specially organized activity, under certain conditions that are necessary for the development of student's individual characteristics, for his self-determination and personal fulfillment. Intensification of students' activity means:

- stimulation of their cognitive activity;
- active mental activity;
- personal fulfillment;
- increasing interpersonal interaction in the student group;
- strengthening practical component of the educational process for skill-building;
- awareness of the importance of the learning material studied by the students; positive motivation for professional training in university.

The following methods of learning were used for intensification of the students' activity: discussions, brainstorming, project method, project chain, inverted learning method, problem learning method, role and business games, modeling of professionally oriented situations. The forms of training included lectures, practical classes, laboratory classes; individual, pair, microgroup, group work.

The technical and software learning tools are of great importance in the training of future programmer engineers. Training tools included: 11 Pentium 4, 12 Pentium Core 2 Duo, 6 Pentium D, 6 Pentium 4. Training tools included Eclipse_java 3.5, Eclipse_modelling, Intellij IDEA, JDK 1.6, NetBeans Java EE, Vissim 3.0, Visual Studio 2012, Microsoft SQL Server Express Edition, Visual Paradigm 5.1, Scilab, Microsoft office: Access 2003.

Motivation has immediate influence on students' activity, because the direction and intensity of human actions directly depend on his desire to implement these actions. The activity, the efforts that students make in the training process, the power and depth of knowledge depend on the students' motivation. Our studies confirm that students who choose the direction of professional training "Software Engineering" are rather strongly motivated, they want to get exactly this profession and continue to work just for this profession. On the one hand, it is a good ground for organizing a quality training process, for teachers who have to assimilate the relevant knowledge and skills. However, some students demonstrate mainly external motivation, that is, factors such as future material rewards, high demand for IT workers, which means good enough employment opportunities, etc., are of primary importance to such students. And, on the other hand, a special work should be done in order to get future programmer engineers to study, to have interest in the content of professional

training, to exhibit internal motivation that has a greater impact on the outcome, on the depth of the material learning**.**

Learning the first year's discipline "Professional internship in software engineering" allowed students to take a closer look at the general issues of a programmer engineer's professional work, its requirements, features of such activity. The disciplines of the social and humanitarian courses provided better understanding of programmer engineer's role in modern society, his capabilities, responsibilities and duties. When learning the subjects on professional training the students were explained the relationship between the material being studied and the tasks of future professional activity. The students were motivated by special types of work: discussions, brainstorming, individual reflexive exercises. The discussions were organized on the following topics: "The profession of a programmer engineer in the modern world", "Creativity in the activity of a programmer engineer", " Programmer engineer as an innovator", "Career opportunities of a programmer engineer", "The success of a programmer engineer». The discussions allowed students to analyze the features of the profession, consider the profession of a programmer engineer from different facets, reflect on and express their point of view, listen to the other students' ideas. The important areas of work for intensification of students' activity were also: providing a deep understanding of the teaching material and developing practical skills, creating an evolutionary environment. Various active teaching methods (the method of discussions and brainstorming, the method of "inverted learning", the method of projects, the "project chain" method and others) contributed to the comprehension of the material and the development of abilities.

Different training activities allowed to simulate the situations of interaction that students will have in their future professional life. Programmer engineers will perform individual tasks, will work in teams of developers, and will update the software products made by other people. The work of future programmer enginners on a joint project allows them to develop such personal qualities as teamwork, responsibility for the decision-making, ability to analyze the results of their activities, the ability to succeed, independence and other qualities needed for a future programmer engineer.

Based on the results of the 5-6 year students' research projects they were able to write scientific articles in English under the guidance of a teacher. The subject of the articles could be in two directions: a) analytical (the development of models and algorithms); b) on information technologies (the development of software architecture, coding, testing). Writing a scientific article involved the ability to formulate the problem, to summarize the results, to make critical analysis, to highlight the main point, to prove the point of view, to pose arguments consistently, to give intelligible explanation, to use academic style, to solve the problem. Business and role games stipulated the possibility of role-playing, having both a game and educational goals (learning through games), aroused a considerable students' interest. Some games included simulation of a professionally oriented situation: "Project Manager", "Project Team", "Communication with a Customer". Each game included a reflexive analysis after it was completed: whether the tasks were successfully done, how students behaved in situations that were played in accordance with a certain role, how effective communication was, what students did after the game, what was positive, what mistakes were made, what was possible to do otherwise, and so on.

Intensification of students' activity was also facilitated by the developmental environment of a higher educational institution, which included teachers who upgraded their qualifications, working in real IT company projects and used active teaching methods; technical equipment: the availability of several computer classrooms, a training classroom with microprocessor simulators, more than 150 personal computers, integrated into the local

network of the department with an access to the university network and the Internet connection, foundation of a modern Information Technology Center; educational and methodological support, which included a library with educational and technical literature; wide opportunities for students to get individual consultations both from lecturers, and teachers who conducted laboratory classes; visiting foreign professors and IT professionals for presentations, lectures, and experience sharing.

The simulation of quasi-professional situations was also due to the strict teachers' requirements to students' learning outcomes. It was important not only to perform work before deadline, which met the requirements of the real-life situation when a developer interacts with a customer: a failure to perform the work within the specified time period leads to problems and negative consequences. A failure to comply educational tasks within a certain time resulted in lower assessment grade - the student received a "satisfactory".

The implementation of the third pedagogical condition - *using a dual approach aimed at quality improvement of future programmer engineers' professional training based on the interaction between universities and IT companies* was associated with a very special aspect of future programmer engineers' training, namely its practical orientation. You can master to develop software only by developing software. And if at the first years of study these are relatively simple training tasks, with the gradual modeling of more complex production conditions, but for undegraduate students it is preferrable to have real, practical work experience in IT company. According to the recommendations on teaching curriculum for engineering and computer science at universities: "the curriculum must necessarily include the implementation of at least one serious enough activity that requires the development of a solution for a specific customer. Software engineers should be aware of the necessity to develop software first and utmost relevant"[15, p.31].

A dual approach allows students to understand better the employers' requirements, to make aware of the importance of their competencies, to deepen and consolidate their knowledge, skills and abilities, to realise the professional functions and responsibilities that a programmer engineer is to perform, to develop responsibility, discipline, perseverance and other professionally important features. A dual approach is not only interesting to students and is useful in terms of improving the quality of professional training, but also important for further employment after graduation. The graduates with practical experience have significant advantages when looking for a job.

The implementation of the dual approach was carried out in the following ways:
- stimulating students to practical work;
- providing professional internship within the curriculum;
- working undergraduates as freelancers or in IT companies in their extra-curriculum time;
- accomplishing internal projects for firms and companies of the IT sphere;
- working in educational-scientific and production complex;
- accomplishing informatization tasks on the educational process for universities where these students study.

To make the implementation of the dual approach possible, it was necessary to establish active cooperation between the department of the higher educational institution and the IT companies, which included the coordination of the peculiarities of students' professional internship and work in these companies, the improvement of curriculum, the introduction of additional courses of disciplines, the adaptation of graduates to the requirements of firm-employers and other. Thus, the Department of Program Engineering and Information Technology Management (PEITM) of the National Technical University "Kharkiv Polytechnic Institute" established partnerships with the largest, prestigious Ukrainian and

foreign (with Ukrainian representative offices, affiliates) companies. For example, such companies as EPAM Systems, NixSolutions, Global Logic, Sigma, Telesens are known for high salaries and company benefits for their employees. Thanks to this partnerships 1-2 year students get acquainted with the work of IT companies through presentations and excursions to their offices. Training at higher educational institutions, presentations and excursions, special professionally-oriented lectures allow 2-3 year students to choose a direction in the IT field which would be interesting for them. After the third year of studies, tests and interviews with students, conducted by company employees, together with the teachers of the department are being conducted. As a result of testing, students take a preparatory external training courses in IT companies and / or internal extra-training at the department. External training courses in IT companies or extra-training at the department are directed to mastering a specific programming language or software testing, etc., and are aimed at adapting students to the specific professional requirements of the companies. After the courses, one more interview takes place, as a result of which a student has an opportunity to start a career in an IT company and perform specific practical work (starting from the second half of the 4-th year, as well as in the 5-th and 6-th years).

Realising the neccessity to introduce a dual approach for the training of future programmer engineers, since 2015, the management of the Department of Program Engineering and Information Technology Management (PEITM) NTU "KhPI" introduced a special training schedule that allowed students to combine successfully training and professional activities in IT- companies. The idea was that during two years of the master's degree (5-6 years of study) a student worked one part of week, and the second part - only studied at the university. To achieve this became possible only after previous negotiations with the management of IT companies. The department of PEITM offered a university scheduling with a concept of dual approach. The outcome of negotiations with IT companies resulted in the introduction of this form of training for future programmer engineers in NTU "KhPI".

Thus, the approach offered to students solved the main problem of distinct time division for studying at the university and practical work in IT companies. This, on the one hand, allows a student to get professional experience, skills in real project work and to be financially independent, which is very important in modern facts of life, and, on the other hand, have free time to attend classes, which undoubtedly affects the quality university training. The arrangements for a dual approach introduction is developing curriculum on the basis of a dual approach, changing the university scheduling, implementing Graduate and Course projects on the basis of practical developments, introducing innovative learning technologies, and providing conditions for the successful combination of education and work.

Conclusions. Thus, the implementation of the first pedagogical condition - *integration of the content of mathematical, foreign language, social and humanitarian, professional components of the professional training of future programmer engineers* involved a general basic mathematical, foreign language, social-humanitarian training with the elements of professionally oriented content; an in-depth reflection of professional activity within the course of study of mathematical, English, social and humanitarian disciplines (within the course of disciplines "Computer Discrete Mathematics", "Empirical Methods in Software Engineering", "English for Specific Purposes","Group Dynamics and Communication"," Professional Internship in Software Engineering"); mastering professional disciplines using the basis of mathematical, the English language and humanitarian training. The implementation of the second pedagogical condition - *intensification of students' activity in the acquisition of knowledge, skills and experience as well as the development of soft skills which are important for the professional activity of the programmer engineer* - stipulated the

method of discussions and brainstorming, the method of "inverted learning", the method of projects, the "project chain" method and others. The following methods of learning were used for intensification of the students' activity: discussions, brainstorming, project method, project chain, inverted learning method, problem learning method, role and business games, modeling of professionally oriented situations. The forms of training included lectures, practical classes, laboratory classes; individual, pair, microgroup, group work. The important areas of work for intensification of students' activity were: motivation, providing a deep comprehension of educational material, working out practical skills, creating a developmental environment. The implementation of the third pedagogical condition - *using a dual approach aimed at quality improvement of future programmer engineers' professional training based on the interaction between universities and IT companies* - provided the encouragement of students to practical work; professional internship according to the curriculum; undergraduates' work as freelancers or in IT companies in extra-curriculum time; implementation of internal projects for firms and organizations of the IT sphere; work in educational-scientific and production complex; accomplishment of informatization tasks on the educational process for universities where these students study.

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