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APPLICATION OF DIFFERENT EDUCATIONAL STRATEGIES TO ENHANCE THE EFFECTIVENESS OF WORK-BASED LEARNING FOR STUDENTS IN ENGINEERING AND SCIENCE EDUCATION PROGRAMMES

Annotation

In the context of modern social and technological transformations, universities must ensure the continuous development of students' skills necessary for employment through their involvement in professional communication, individual and continuous learning, in the implementation of projects, research, analysis and problem solving. At the same time, universities should ensure regular monitoring, updating and adjustment of educational programs, learning strategies, learning outcomes, the use of student-oriented approaches in teaching, create a comfortable and trusting learning environment, provide timely and constructive feedback. In accordance with this, the aim of the work was to determine the most effective strategies for practical training of students of engineering and natural science educational programs at the workplace in the company. To achieve the purpose of the research, practical training programs for students in the workplace were developed and tested in companies of the Karaganda and Akmola regions, an analysis of the progress of students and the results of self-assessment in the development of key skills within the framework of practical training programs at the workplace was carried out. During the research, assessment protocols, online questionnaires and self-assessment methods were developed and used in the work. Based on the results of the approbation of practical training programs for students in the workplace according to the bachelor's degree programs “6B06201 – Radio engineering, electronics and Telecommunications” and “6B05304 – Physics”, their effectiveness in the development of professional and technical skills, teamwork and teamwork skills, critical thinking, important personal qualities necessary for graduates of educational programs of engineering has been established and natural science profiles for successful integration into the professional environment and career development. Based on the analysis of the effectiveness of applied workplace learning strategies, it is shown that when teaching students of engineering and natural science educational programs, universities need to involve students more in problem-solving, project-oriented and practice-oriented tasks and cases, which will allow them to acquire the necessary practical experience in identifying and analyzing problems, making adequate decisions, and improving their assessment self-efficacy, improve social and professional communication and interaction skills.

Key words: experiential learning, workplace learning, engineering education, science education, learning situations, case technologies, project-based learning, learning strategies.

Introduction. In the context of rapid changes in technologies and working methods, employers are increasingly demanding practical experience and skills from graduates of engineering and natural science educational programs of universities that cannot be fully mastered only in classrooms [1, 2]. These skills should be continuously developed by students throughout the entire period of study through their professional communication, individual and continuous learning, teamwork, participation in projects, research, analysis and problem solving. At the same time, students should know and understand the environmental and social aspects related to their future professional activities [3 - 7]. For the effective development of the listed knowledge and skills among students, universities must ensure regular monitoring, updating and adjustment of educational programs, learning strategies, learning outcomes, and the use of student-oriented approaches in teaching. Teachers should create a comfortable and trusting learning environment that will support and encourage students to develop the necessary skills, unlock their potential through finding solutions to problematic problems, understanding the practical significance of their knowledge, and overcoming difficulties. Starting from the first courses of study at the university, it is necessary to prepare students for the realities of professional activity, cooperation and interaction in a real professional environment, bridging the gap between theoretical knowledge acquired at the university

and the real tasks they will face in the profession [3, c.71-74; 4, c.1064-1066; 8-11]. Also, the effectiveness of learning is influenced by timely and constructive feedback, which helps students understand their strengths and weaknesses, conduct self-analysis, and motivate them to self-development and self-improvement. Practice-oriented approaches to learning, including practical on-the-job training, can greatly contribute to the successful solution of these tasks. The relevance of such approaches in the preparation of students of engineering and natural science educational programs is due to a number of key factors that are associated with 1) modern requirements for the qualification of specialists and changes in the labor market, 2) the gap between the student's theoretical knowledge and skills of their practical application in real situations, 3) technological innovations and their impact on the process 4) the importance of involving students in the implementation of real projects and solving problematic tasks, 5) the need to expand the forms and methods of interaction between universities and the professional community, 6) the importance of developing students' relevant and in-demand competencies necessary for successful employment and adaptation in a real professional environment.

In accordance with this, the purpose of this work is to determine the most effective strategies for practical training of students of engineering and natural science educational programs at the workplace in the company. To achieve the purpose of the study, the following tasks were set in the work: 1) development of practical training programs for students at the workplace in the company for bachelor's degree programs “6B06201 – Radio engineering, electronics and telecommunications”, “6B05304 – Physics” and their approbation using various learning strategies, 2) analysis of the results of the approbation of practical training programs for students in the workplace and the progress of students in developing key skills, 3) self-assessment by students participating in the approbation of practical training programs in the workplace, communication skills, leadership, creativity, self-organization, stress tolerance, emotional intelligence 4) conducting self-assessment by students participating in the testing of practical training programs in the workplace, self-analysis skills and self-efficacy.

Methods and Materials. When conducting research in the work, protocols were developed and used for evaluating the actions performed by students by course teachers and mentors from the company within the framework of various strategies for practical training in the workplace. To analyze the progress of students in on-the-job training, an assessment of the development of key skills such as teamwork and teamwork, critical thinking, professional and technical skills was carried out before and after program testing. The assessment of the results of practical training of students in the workplace and the progress of students was carried out using a 10-point scale, where 1 point corresponded to the lowest grade, 10 points corresponded to the highest grade. The work also developed online questionnaires for self-assessment by students participating in the testing of practical training programs in the workplace, such parameters as independence, the ability to take responsibility and risks for solving problematic and practical tasks, the ability to track all situations affecting the development of professional skills and competencies, to identify successful and unsuccessful manifested initiatives and actions in the performance of practical tasks and their consequences, the ability to analyze the causes of failure and their strengths, They allow you to successfully complete practical tasks, the ability to build effective communication with a mentor, students, company employees, and a teacher. The questionnaires were developed using GoogleForms software and sent to respondents by e-mail with information about the purpose and objectives of the survey. For a detailed selection of answers to the questionnaire questions, the Likert scale was used, which allows measuring the opinions of respondents, their attitude, motivation and other parameters. Parameters such as averages and standard deviation were used in the analysis of the survey results.

Results and discussion. 47 students took part in the testing of practical training programs for students at the workplace according to the educational programs “6B06201 – Radio engineering, electronics and telecommunications” and “6B05304 – Physics”. The testing of the programs was carried out on the basis of three companies of the Karaganda and Akmola regions specializing in the field of television and radio communications, information technology and digital service systems, the development of innovative technologies for processing ores, non-ferrous metals, waste from

processing and metallurgical production. When conducting practical training in companies, contextual learning, experience-based learning, case technologies, project training, and learning situations were used. When testing practical training programs for students in the workplace, seven basic learning strategies were used, shown in Figure 1.

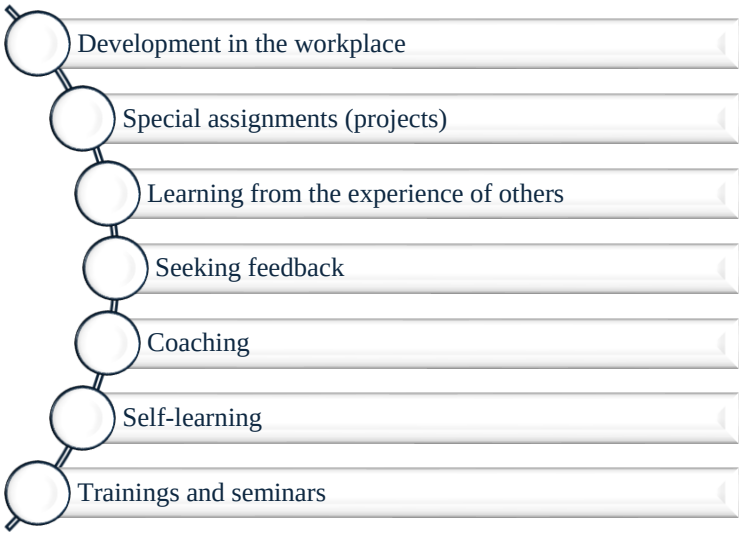

Figure 1. Learning strategies used in the testing of practical training programmes for students in the workplace
Source: compiled by the author

Within the framework of the training strategy “Development in the workplace”, 12 practical sessions were held, during which students performed tasks that allowed the instructor and mentor to assess their independence, ability to monitor situations affecting the development of professional skills, skills to analyse the reasons for failure and their strengths, and others (Table 1). The results of the evaluation by the instructors and mentors from the company of the students' actions are presented in Table 1.

Table 1. Evaluation of students' actions in work-based learning using the Workplace Development strategy

Actions of students when performing practical tasks at the workplace	**Average score on a 10-point scale**
During training, students demonstrate autonomy, take responsibility and risks for solving problematic and practical tasks	7
During practical assignments, students monitor all situations affecting the development of professional skills and competences	6,25
Students identify successful and unsuccessful initiatives and actions taken in carrying out practical tasks in the workplace and their consequences	6,8
Students analyse the reasons for failure and their strengths that allowed them to successfully complete the practical tasks	7,25
Students build effective communication with mentor, trainees, company employees, and instructor	8,25

Source: compiled by the author

As follows from the data in table 1, the highest assessment by the course teacher and the mentor of the company was given to such actions of the student as building effective communication with the mentor, students, employees of the company, with the teacher. The lowest rating was given to such actions of the student as tracking all situations affecting the development of professional skills and competencies when performing practical tasks. The average assessment of the actions performed by students within the framework of the “Workplace Development” strategy was 7.11 points.

As part of the on-the-job training strategy “Special assignments (projects)”, students performed tasks such as forming a plan for the installation of satellite television reception and distribution by districts and dealers; checking the readiness of the main and backup equipment of receiving and transmitting equipment for television and radio broadcasting (TV and RV); developing and applying an algorithm for checking the readiness of funds communications, alarms and communications for the transmission; development of a structural, functional and schematic diagram of power supplies with increased protection against electrostatic discharges (ESR) and with a high level of electromagnetic compatibility (EMC); assembly of a device for collecting and transmitting data wirelessly based on the RAK3272 module; development of a network architecture for IoT devices based on the MQTT protocol using ESP32 modules; development of a calibration methodology spectrometer; working with databases of spectra for various materials; designing and performing experimental work to study the interaction of light with matter. According to the results of special assignments, the average student performance score on a 10-point scale was 5.85.

As part of the “Learning from the experience of others” strategy, students observed the work of mentors, performed various types of work that contributed to the development of their independence in assessing situations, decision-making skills, engineering thinking and technical abilities, leadership and professionalism in work, creativity, professional communication, self-organization, stress resistance, emotional intelligence. These types of work included monitoring the sequence of actions followed by recording the operations performed by the mentor, participating in the search for the necessary component base, participating in the preparation of orders, and others. The average assessment of students' work on a 10-point scale within the framework of the strategy “Learning from the experience of others” was 8.67. At the same time, based on the experience gained during on-the-job training, students noted that they would like to develop such personal and professional qualities as emotional stability, critical thinking, flexibility, mobility, responsibility for work results, the ability to solve complex tasks by dividing into many simple tasks, the ability to distribute tasks among participants to explain complex processes in simple and understandable words, to acquire skills in performing work on modern equipment, using various engineering resources and tools.

As part of the development strategy “Seeking feedback” such forms of feedback between the student, instructor and mentor were used as joint discussion of learning outcomes and forms of their achievement, assessment, correction of work, discussion with the mentor of all stages of realization of the tasks set. The requirements for the tasks to be performed and criteria for their evaluation were explained to all students in advance. Throughout the entire period of on-the-job training, students received feedback from the course instructor and mentor on the completed tasks, indicating the strengths and weaknesses of the work. This helped to make timely adjustments to the practical on-the-job training. When performing practical tasks, students used technical data sheets of devices and equipment. Taking into account the recommendations of the teacher and mentor in the professional behavior of students observed the following changes: increase in the level of self-analysis, critical attitude to the situation and information, increased interest in the future profession, improved discipline, time management, organization and responsibility, the desire to work independently, increased confidence when discussing issues related to the development of electrical circuits, understanding the peculiarities of the development of microwave devices, increased initiative, improved skills of teamwork Participation in the creation of component libraries allowed them to familiarize themselves with the variety of component base in SMD design.

Under the development strategy “Coaching” 14 consultations with mentors and teachers were held for students. Within the framework of this strategy case technologies were applied. Students performed such case assignments as 1) development of LC filters circuit for limiting microsecond and millisecond interference by preliminary modeling with initial parameters of supply voltage (220 V) and frequency (50 Hz); 2) calculation of power consumption and development of the electrical power supply circuit of the wireless data acquisition device using STM32F401XXX microcontroller, SIM 800 modules, ESP32, RAK3271; 3) soldering the components of the device, consisting of circuits for switching on the display, switching on the USB interface, external real-time source block (RTC), external memory block (EEPROM); 4) measuring the quality indicators of television and

radio broadcasting equipment; 5) carrying out operational switching of electrical equipment, television and radio broadcasting equipment; 6) tuning and adjustment of receiving and transmitting television and radio broadcasting equipment; 7) calculation of LC filters and others. The students' self-assessment of the acquired personal and professional competencies showed that the students have become more aware of the elements of circuitry, learned to read digital electronics schemes independently, acquired practical skills in the development of printed circuit boards, in particular for microwave devices, search, selection and assembly of components in SMD version, improved understanding of professional terminology and its application in the correct context. To improve the efficiency of students' work at the workplace, it was recommended to 1) organize continuous independent work of students to improve their practical skills and broaden their horizons, 2) use tasks that require more detailed analysis of situations and alternative solutions, which will help students to study the material more deeply and learn to consider problems from different points of view, 3) conduct regular consultations to deal with the most difficult topics and typical mistakes, which will allow students to get feedback in the mode of their work, and 3) conduct regular consultations with the students. The average score on a 10-point scale for this development strategy was 8.

According to the development strategy “Self-learning” students performed independent work with scientific literature and Internet resources. The average score on a 10-point scale for this development strategy was 7.67.

Under the development strategy “Trainings and seminars” 7 trainings and seminars were held in the company or by the company's employees in the university.

Comparison of the results of evaluation of students' practical work in the company showed that the most effective strategy was “Learning from the experience of others” (the evaluation result amounted to 8.67 points). The least effective strategy was “Special assignments (projects)” (the evaluation result amounted to 5.85 points). The obtained result indicates that when teaching students of engineering and science educational programs, universities should pay more attention to the development of professional and technical skills through the involvement of students in project and practice-oriented assignments and cases, as well as the development of self-study and self-analysis skills.

When piloting experiential learning programs for students in the workplace, the development of key skills such as teamwork and team interaction, critical thinking, professional and technical skills were assessed to analyze student progress. Let's take a closer look at the students' progress in each of these skills:

1. Teamwork and team interaction. Baseline: at the beginning of the on-the-job training program, most students had poorly developed teamwork skills. Many preferred individual work and did not always coordinate effectively with colleagues. Final level: teamwork became more coherent; students learned to better distribute roles in the team, take into account the opinions and ideas of other participants. Within the framework of the ongoing approbation of practical training programs in the workplace, students' teamwork and team interaction skills improved by 40%. At the same time, students became more confident in sharing knowledge and helping each other, which also contributed to their mentoring skills.

2. Critical thinking. Initial level: critical thinking is developed at the basic level. In most cases, students were inclined to standard methods of analysis and did not always ask clarifying questions, which hindered a deep understanding of the problem. Bottom line: by the end of the work-based learning program, students became more confident in analyzing proposed problems, seeking alternative solutions, questioning obvious answers, and testing hypotheses. Students' critical thinking skills increased by 40%, and students' initiative in verifying information from various sources increased.

3. Professional and technical skills. Initial level: the initial level of professional skills varied depending on the level of students' training, but in general there were difficulties in applying theoretical knowledge in practice. Outcome: skills related to the application of theoretical knowledge of physics and engineering methods in solving practical problems improved by 20%. Students learned

to work with modern engineering tools, conduct experiments and analyze the results in the conditions of real professional tasks.

At the end of approbation of practical training programmes for students in the workplace, students' self-assessment of such important skills as communication, leadership, creativity, self-organisation, stress tolerance, and emotional intelligence was carried out. Self-assessment was carried out using a 10-point scale (1 point corresponds to the lowest assessment, 10 points correspond to the highest assessment). The analysis of the obtained results showed (Figure 2) that students give the highest self-assessment to emmotional intelligence (8.69 points). The lowest self-assessment was given by students to such skills as stress tolerance (7.78 points) and leadership (7.96 points). The result indicates that within the framework of practical training programmes in the workplace students should be more actively involved in solving problem situations, have the opportunity to participate in such practical tasks that will help them to identify and analyse problems faster, make adequate decisions and help themselves and others more effectively, increase confidence that successes and failures largely depend on their own actions. At the same time, while studying at the workplace in the company, students should be more involved in project activities, allowing them to develop social communication skills, discipline, the ability to see the big picture and anticipate possible problems, motivate and inspire project team members, resolve conflicts, and engage in self-learning.

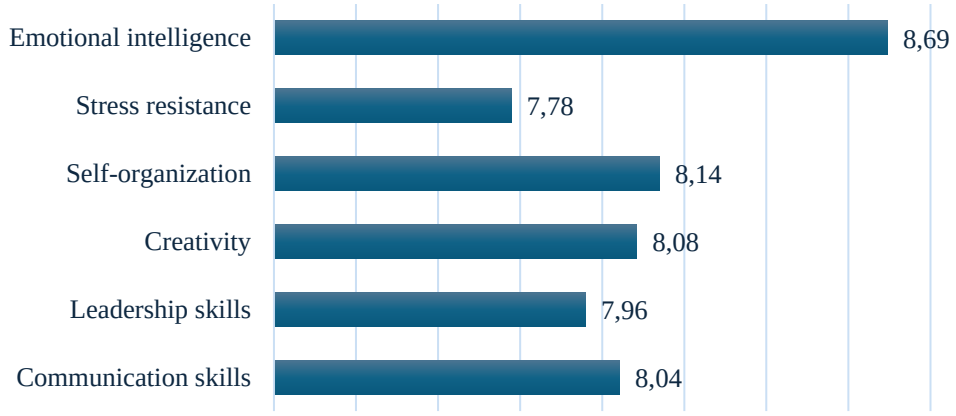

Figure 2. Results of students' self-assessment of skills development in the workplace learning process
Source: compiled by the author

The conclusions drawn from the self-assessment results are supported by the results of students' assessment of self-reflection and self-efficacy skills of students participating in the piloting of work-based experiential learning programmes (Figure 3).

Figure 3. Results of self-reflection and self-efficacy skills assessment by students participating in the piloting of practical workplace learning programmes
Source: compiled by the author

As can be seen from the data presented in Figure 3, less than half of the students participating in the testing of practical training programs at the workplace conduct a self-assessment of their personal and professional competencies. Only 50% of the surveyed students analyze successful and unsuccessful initiatives when performing practical tasks, projects, and solving problematic tasks. From 51.4% to 62.5% of the surveyed students, when performing problematic and practical tasks, are ready to take responsibility and risks, assess factors affecting the development of their professional skills and competencies, and know their strengths and weaknesses.

Thus, the results of the study showed that practical training programs for students in the workplace should provide students with the development of professional and technical skills, important personal qualities necessary for graduates of educational programs of engineering and natural science profiles for successful adaptation in a professional environment and career development.

Conclusion. Based on the results of approbation of the programmes of practical training of students in the workplace on the educational programmes of bachelor's degree “6B06201 - Radio Engineering, Electronics and Telecommunications” and “6B05304 – Physics” it is possible to note their effectiveness in the development of professional and technical skills, skills of teamwork and team interaction, critical thinking, important personal qualities necessary for graduates of educational programmes of engineering and science profiles for successful integration into the professional environment and career

Based on the analysis of the effectiveness of the applied on-the-job training strategies, it has been established that when training students of engineering and natural science educational programmes, universities need to involve students more in project and practice-oriented tasks and cases, in solving problem situations, which will allow them to acquire the necessary practical experience in identifying and analysing problems, making adequate decisions and effective interaction, increase their confidence that successes and failures largely depend on their own.

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ЖҰМЫС ОРНЫНДА ИНЖЕНЕРЛІК ЖӘНЕ ЖАРАТЫЛЫСТАНУ-ҒЫЛЫМИ БІЛІМ БЕРУ БАҒДАРЛАМАЛАРЫНЫҢ СТУДЕНТТЕРІН ОҚЫТУДЫҢ ТИІМДІЛІГІН АРТТЫРУ ҮШІН ӘРТҮРЛІ БІЛІМ БЕРУ СТРАТЕГИЯЛАРЫН ҚОЛДАНУ

Аңдатпа

Қазіргі заманғы әлеуметтік және технологиялық трансформациялар жағдайында жоғары оқу орындары студенттердің кәсіби коммуникацияға, жеке және үздіксіз оқытуға, жобаларды, зерттеулерді орындауға, проблемаларды талдау мен шешуге тарту арқылы жұмысқа орналасу үшін қажетті дағдыларды үздіксіз дамытуды қамтамасыз ету керек. Бұл ретте университеттер білім беру бағдарламаларын, оқыту стратегияларын, оқыту нәтижелерін тұрақты мониторингтеуді, өзектендіруді және түзетуді, оқуда студенттерге бағдарланған тәсілдерді қолдануды қамтамасыз етуге, оқытудың жайлы және сенімді ортасын құруға, уақтылы және сындарлы кері байланысты қамтамасыз етуге тиіс. Осыған сәйкес жұмыстың мақсаты компаниядағы жұмыс орнында инженерлік және жаратылыстану-ғылыми білім беру бағдарламалары бойынша оқитын студенттерін практикалық оқытудың ең тиімді стратегияларын анықтау болды. Зерттеу мақсатына қол жеткізу үшін Қарағанды және Ақмола облыстарының компанияларында жұмыс орнында студенттерді практикалық оқыту бағдарламалары әзірленіп, сынақтан өткізілді, жұмыс орнында практикалық оқыту бағдарламалары шеңберінде негізгі дағдыларды дамытуда білім алушылардың үлгерімі мен өзін-өзі бағалау нәтижелеріне талдау жүргізілді. Зерттеу жүргізу барысында бағалау хаттамалары, онлайн сауалнамалар және өзін-өзі бағалау әдістері әзірленіп, қолданылды. «6В06201 – Радиотехника, электроника және телекоммуникациялар» және «6В05304 – Физика» бакалавриат білім беру бағдарламалары бойынша оқитын студенттерді жұмыс орнында практикалық оқыту бағдарламаларын сынақтан өткізу нәтижелері негізінде олардың инженерлік және жаратылыстану-ғылыми бейіндегі білім беру бағдарламаларының түлектеріне кәсіби ортаға және мансаптық дамуға сәтті интеграциялау үшін қажетті кәсіби және техникалық дағдыларды, топта жұмыс істеу және топтық өзара іс-қимыл, сыни ойлау, маңызды тұлғалық қасиеттерді дамытудағы тиімділігі анықталды. Жұмыс орнында қолданылатын оқыту стратегияларының тиімділігін талдау негізінде инженерлік және жаратылыстану-ғылыми білім беру бағдарламаларының студенттерін оқыту кезінде ЖОО-лар проблемалық, жобалық және тәжірибеге бағдарланған тапсырмалар мен кейстерді орындауға студенттерді көбірек тарту қажет, бұл оларға проблемаларды анықтау мен талдауда, барабар шешімдер қабылдауда қажетті практикалық тәжірибе алуға, бағалауды арттыруға мүмкіндік береді өзін-өзі тиімділік, әлеуметтік және кәсіби қарым-қатынас пен өзара әрекеттесу дағдыларын жетілдіруге мүмкіндік береді.

Түйінді сөздер: практикалық оқыту, жұмыс орнында оқыту, инженерлік білім беру, жаратылыстану-ғылыми білім беру, оқу жағдайлары, кейс-технологиялар, жобалық оқыту, оқыту стратегиясы.

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ПРИМЕНЕНИЕ РАЗЛИЧНЫХ ОБРАЗОВАТЕЛЬНЫХ СТРАТЕГИЙ ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ОБУЧЕНИЯ СТУДЕНТОВ ИНЖЕНЕРНЫХ И ЕСТЕСТВЕННО-НАУЧНЫХ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ НА РАБОЧЕМ МЕСТЕ

Аннотация

В условиях современных социальных и технологических трансформаций вузы должны обеспечить непрерывное развитие у студентов необходимых для трудоустройства навыков посредством их вовлечения в профессиональную коммуникацию, индивидуальное и непрерывное обучение, в выполнение проектов, исследований, анализ и решение проблем. При этом, университеты должны обеспечить регулярный мониторинг, актуализацию и корректировку образовательных программ, стратегий обучения, результатов обучения, применение ориентированных на студентов подходов в обучении, создавать комфортную и доверительную среду обучения, обеспечивать своевременную и конструктивную обратную связь. В соответствии с этим целью работы являлось определение наиболее эффективных стратегий практического обучения студентов инженерных и естественно-научных образовательных программ на рабочем месте в компании. Для достижения цели исследования в работе были разработаны и апробированы программы практического обучения студентов на рабочем месте в компаниях Карагандинской и Акмолинской областей, проведен анализ прогресса обучающихся и результатов самооценки в развитии ключевых навыков в рамках программ практического обучения на рабочем месте. При проведении исследований в работе были разработаны и использованы протоколы оценивания, онлайн анкеты и методы самооценки. На основании результатов апробации программ практического обучения студентов на рабочем месте по образовательным программам бакалавриата «6В06201 – Радиотехника, электроника и телекоммуникации» и «6В05304 – Физика» установлена их эффективность в развитии профессиональных и технические навыков, навыков работы в команде и командного взаимодействия, критического мышления, важных личностных качеств, необходимых выпускникам образовательных программ инженерного и естественно-научного профилей для успешной интеграции в профессиональную среду и карьерного развития. На основе анализа эффективности применяемых стратегий обучения на рабочем месте показано, что при обучении студентов инженерных и естественно-научных образовательных программ вузам необходимо больше вовлекать студентов в выполнение проблемных, проектных и практико-ориентированных заданий и кейсов, что позволит им приобретать необходимый практический опыт в выявлении и анализе проблем, принятии адекватных решений, повышать оценку самоэффективности, улучшить навыки социального и профессионального общения и взаимодействия.

Ключевые слова: практическое обучение, обучение на рабочем месте, инженерное образование, естественно-научное образование, учебные ситуации, кейс-технологии, проектное обучение, стратегия обучения.