Strategies for effective vocational training of high school students in electrical engineering

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Abstract. The vocational training in agricultural and technical High School should be provided and organized in a systematic, rational, effective ways. The integration of Ukrainian High School in European education considers the training of a universal specialist competent both in theoretical study and practical application of farming and engineering. The first attempts have already been done: dual education projects are encouraged by the Ministry of Education of Ukraine. The paper reports on teaching Physics through the implementation of profession based elements. Therefore, the aims of this paper are threefold: (1) to characterize the scientific knowledge in connecting theoretical and practical areas of study, to determine the basic characteristics according to standardized training programme future specialists in agriculture and engineering should have, (2) to develop the strategies for integrating the profession-based approach to teaching academic disciplines on the basis of the pedagogical experiment that involved 176 student-respondents and 41 teacher-respondents and (3) to create integrated curriculum, profession-based lecture samples and problem book in Physics for students majoring in Power Engineering in Agricultural Complex. The survey was carried out on the basis of the State Agrarian and Engineering University in Podillia, Lviv National Agrarian University and Nizhyn Agricultural University. To gain evidence about the effectiveness of implementation of profession-based material in Physics course in vocational training of future power engineers we used specially designed questionnaires, interviews and observation of behaviour. The results of the study proved that the use of profession-based material promotes the formation of student natural knowledge, as well as a wide range of practical skills and abilities. Providing the professional competence in training stimulates cognitive interest in t studying Physics as a science, helps to absorb material from other science disciplines, to develop their cognitive and creative abilities and to influence on the formation of persistent motifs to obtain knowledge from special disciplines.

Introduction

The system of Higher Education in Ukraine has been reformed for more than 10 years and we can't ignore the positive results it has already gained. But the immensity of carried

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out changes and transformation processes in the society doesn't allow us to talk about the completeness of these changes but require further implementation. Modern labour market starts to experience the need for «transprofessional» workers - flexible and universal specialists due to their brainwork and abilities to work in different professional environments (PERKIN, 2002). The situation on the verge of centuries is such that young experts almost always have to apply not only profession-based knowledge but also show competence in other areas. Moreover, the project of dual education has been presented to public discussion in Ukraine. The aim of the project is to educate a qualified expert in cooperation with employers. This project is beneficial to all participants. The student gets a higher level of practical training (only 30% of learning time is devoted to theoretical study in university, the rest of training takes place at factories, plants, agricultural farms etc.), the employer will get the employee he needs, and the university will get greater opportunities for training students. The implementation of dual education in technical and agricultural universities will ensure deep professional skills and working experience (the students get the opportunity to work on modern equipment), learning the corporate ethics. As can be seen, modern Ukrainian universities are focused today on training skilful specialists in short terms. That is why the subjects in the university should be identified carefully and the curriculum should be made thoroughly. That is why we consider the implementation of profession-based elements in Physics course an up-to-date issue.

The researches on student readiness to the training activities are represented in the works of Ukrainian [1, 4] and foreign scientists [2, 5-8, 10]. The studies deal, primarily, with the formation of professional competence, its basic principles and its importance in future engineer training [1, 3, 11-15]. We should admit, that the theme of research is fairly wide, however, the issue of future specialists training in power engineering has not been mentioned yet.

Data and research methodology

The purpose of the article is to define the basic principles of professional competence formation and to determine the most effective ones that form the readiness to future professional activities; to describe the procedure of implementation of vocational and oriented strategies in Physics training for students majoring in agriculture and engineering; to test the effectiveness of applying the profession-based elements in Physics course that will facilitate more meaningful study and successful application of Physics knowledge in disciplines of professional and practical training of the future engineers. The pedagogical experiment was carried out on the basis of 3 technical universities located in Kamianets-Podilskyi, Lviv and Nizhyn. 176 student-respondents and 41 teacher-respondents participated in the experiment. The study is based on the following theoretical methods: analysis of philosophical, psychological and pedagogical literature on research to select and interpret the actual material; analysis of concepts, theories and techniques, aimed at identifying strategies for providing the profession-based approach to High School training and empirical methods: questionnaires, interviews and observation to assess detailed insights into students' learning.

Results and Discussion

The main characteristic of a qualified specialist is the ability to perform professional tasks skillfully and responsibly. Only with these qualities, the specialist can be the central figure of scientific and technical progress. We consider the following strategies for improving Agricultural and Power Engineering in Ukraine:

1. The integration of Education, Science and Production.
2. Strengthening the role of Science in Higher Education institutions. First of all, as the basis for the system of Power Engineering staff training in the Agricultural industry.
3. The creation of Educational-Scientific-Production complexes for training highly qualified power engineers with the use of innovative technologies.
4. Evaluation of the specialist through the creation of the general qualifying characteristics and quality standards.
5. Strengthening the individual approach, development of student creative abilities.
6. The creation of an integrated curriculum and teaching guides.
7. Target training of future specialists.

Today it is necessary to improve the system of Higher Education with the help of extension of university contacts with employers, which in the future should lead to forward-looking specialist training taking into account the foreseeable trends at the labour market. An important aspect of university training optimization is strengthening the practical focus of training, teaching full-range experts who possess both deep single-discipline knowledge and practical skills. However, another focus in university engineering training is done not only on professional but also the personal component that will allow the graduate to detect the initiative, flexibility, self-development according to changes in the work relationship. In this context the universal cultural specialist training, forming a humanist personality, as the basis of its comprehensive development, the establishment of student civic position, the ability for responsible action and collaboration with other people. In this way, the high adaptation potential of Ukrainian graduates will be provided. The mentioned teaching strategies in High School will allow to extend the objectives of both the society and the individual.

The fundamental training in Physics, Mathematics and other theoretical disciplines that can supply the education system with a scientific basis is very important in Technical High School. High-quality training of power engineers assists the rapid perception of modern technology and the professional mobility of engineers.

An engineering graduate has to do with the tools and technological processes, based on physical laws in his professional activities. Technical rethinking of production – the mechanization and automation, the use of computer facilities - require Physics knowledge, skills and abilities to competently perform specific production tasks [13, 14].

Therefore, a modern specialist must be prepared for activities in the relevant field in organizations and enterprises of all forms of ownership. On the basis of standardized training programme analysis, we found out that future specialist in agriculture and engineering should be competent in:

- the basics of general theoretical subjects (physics including) to the extent necessary for the performance of their functions;
- special disciplines covering the content, the legislative, normative documents, regarding its activities;
- peculiarities of agricultural production;
- current status and directions of scientific and technical progress in the relevant field;
- the main branches of the industry and the possible ways of optimization and improvement of agricultural production; the basics of planning and design of production processes;
- the economy-wide disciplines.

So, to train graduates majoring in power engineering is possible only on the basis of fundamental scientific training. This means that a student should form deep knowledge of the fundamentals of sciences, for example, Physics, that is the foundation of scientific and technical progress. But what is important, the fundamental scientific disciplines can’t be

taught isolated. The student should know how and where to use the laws of Physics and Mathematics in professional activity.

For a more profound study of profession-based approach in Power Engineering High School, we developed a questionnaire to find out the attitude of students to study Physics. (Table 1).

Table 1. The questionnaire on the attitude of students to studying Physics

1. Are you interested in Physics course in terms of your future profession?	No, I'm not
	Partly
	Yes, I'm. It is the theoretical basis of major
2. Do you consider physical concepts in professional items?	No, I don't
	Partly
	Yes, I do
3. Do you separate professional installation (harvester, plough, car, transporter) laws and phenomena of Physics course?	No
	Partly
	Yes, I do

The answers to the questions about student's attitude to studying Physics from the point of view of the future profession are shown in Table 2.

Table 2. The attitude of students to the studying Physics from the points of view of the future profession

Questions	Variants of answer, %			
	No	Partly	Yes	Didn't answer
Are you interested in Physics course in terms of your future profession?	10	65	18	7
Do you consider physical concepts in professional items?	15	61	13	11
Do you separate professional installation (harvester, plough, car, transporter) laws and phenomena of Physics course?	17	58	11	14

The majority of responses indicate the intuitive interpretation of Physics course necessity in the future profession. However, the specific representation about the position of Physics in the future professional activity has from 10 to 18% of the students. The answer to the question: «Where exactly the laws and phenomena of Physics course are used?» suggests that most students can not apply Physics knowledge to professional situations and do not identify the physical phenomena in agricultural and engineering processes.

Besides, we made the observation on the educational process to identify the place of profession-based material in studying Physics. As a result, we developed the curriculum in Physics, the content of the lectures and lecture assignments, exercises and profession-focused tests. The students were given tests according to the developed methodology. The results of the tests showed that the students found it difficult to perform the tasks. To determine the level of their intelligibility and complexity we used observation, the analysis of students' responses, conversations and questionnaires.

We developed the curriculum in Physics, lecture samples and profession based tests. The students were offered the following tests:

Topic: Electric charges and electric field

1. DC Generator works to charge a battery car. Determine the amount of electricity that has passed through the accumulator for 4 hours, if the amperemeter shows the current value of 20 A.

2. It is known that to transport combustible liquid the automobile tankers are grounded. Why are the tankers full of water and milk not grounded?

3. The elongated grains are electrified more than shorter or spherical ones, and the grain mixture placed in an electric field, focuses along the field lines. Explain these phenomena.

Topic: Laws of DC current

1. Determine the thread resistance of 21V tractor lamps that operate on 6 V.

2. In the battery checklist the customers are warned to detach the wire directed to the Mass from the negative terminal battery in case the tractor stops for more than 10 hours. What caused this warning?

3. The starter batteries are known to be charged from DC generator. Will the current rate depend on the battery level? Can the current be equal to zero? If it is possible, determine the conditions for this case.

Topic: Work and current rate

1. 0.25 Kw engine drives the separator for 3 hours. How much milk will be separated, if for every consumed 1.5 Kw per hour are used for 1000 liters of milk?

2. G-21 Generator of GAZ-51A automobile produces a current of 18.3 A a t 12V supply. Identify the power of generator.

3. Explain why are the ground rods used in terms of low power and why are the ground contours used at high power?

Topic: Electromagnetism

1. Why is there an impedance coil in the carburetor of internal combustion engine.

2. Chassis of wheel tractor and wheel axle form a closed path. Is the current stimulated in his close circuit during the tractor movement.

3. Determine the EMF arising in the primary winding of magneto, set on the starting engine of the tractor MTZ-80 at spark producing. (when blurring the circle). Inductance of the primary coil is L = 0.06 gn, capacitor capacity, which is turned on parallel to the chopper (C = 0.25 ufd), current at the moment of circle break 2A.

Topic: Alternating current

1. Why is the battery located as close to the stator and is connected to it with a help of a thick copper tyre?

2. The zero and the phase wires are of the same cross-section at livestock facilities. Why?

3. The alternating current is created in the induction coil of the ignition system of the tractor with the help of the chopper in the secondary electrical winding. Will its graph look like sinusoid?

78% of the students majoring in Power Engineering have chosen the following topics important for their future career: 2, 3, 5, 6, 8, 9, 10, 12, and the students majoring in «Agronomy» stated that topics number 3, 4, 6, 8, 10, 12 will help future agronomists in their job.

It proves the fact that students perceive the need for Physics knowledge in a cycle of professional and practical training disciplines, primarily, in the context of their further professional activities.

However, the question «Describe the professional facilities and technological processes that use basic concepts and laws of the proposed sections of Physics course» was difficult to answer. During the experiment, it was found that the students have some difficulties with solving the issues. This is due to the fact that most of the disciplines of the professional and practical training cycle, with the exception of «Entry to speciality» and «Electrical cars», are learnt after the Physics course. That is why the tasks were created on the basis of separate

operations or elements of operations, separate units of agricultural parts. We didn't focus on complex agricultural processes.

To examine the issue from different perspectives we conducted a survey for teachers that involved 41 lecturers of Mechanization Faculty of Lviv National Agrarian University and Nizhyn Agricultural University. Teachers' responses to questions of the questionnaire are given in Table 3:

Table 3 Questionnaire for teachers

1. Do you consider the specifics of the future student profession?	
Yes, I do	7 %
No, I don't. Never	25 %
No, I don't.	68 %
2. How do you feel about the idea of the implementation of the principle of professional orientation in studying Physics?	
Positively	82 %
Negatively	13 %
I don't pay attention	5 %
3. What is the essence of the principle of professional orientation in studying Physics?	
I have no idea	33 %
4. Do you use the principle of professional orientation in your teaching practice?	
Use frequently	7 %
Use seldom	25 %
Don't use	68 %
5. Why do you rarely use the principle of professional orientation in teaching?	
It makes no sense	6,7 %
Lack of curriculum hours	37,2 %
Insufficient training in Physics	45 %
Weak student background	11,1 %
6. Does the principle of professional orientation in student training benefit better knowledge and skills in future professional activity?	
Benefit	87,2 %
Don't benefit	17 %
Don't know	5,8 %

Despite the fact that 87,2% of teachers have a positive attitude towards the idea of synthesizing the theoretical knowledge and professional training in studying Physics, the issue of providing the strategies into university classroom has not been studied yet.

The question «Should Physics curriculum be profession based?» was answered by85% of Physics teachers and 90% of major subject teachers. Both consider that teaching Physics should be focused on future professional activities and convince that «access to the profession» in Physics classroom is necessary. The answers to other questions that concern the content and structure of the Physics course are grouped and given below. Teachers believe that it is desirable:

- to group topics and sections of Physics course (to variate the curriculum) according to the major, that will help to realize the principle of professional orientation in training;

- To focus on solving the problems with profession content and based on professional facilities;
- to undertake laboratory studies in Physics at the installations close to professional.

Teachers also believe that Agricultural and Engineering universities should develop own integrated curriculum, problem books and laboratory workshops, which would reflect the principle of professional orientation in training.

The practical results of this phase of the pedagogical experiment included the project of profession-based curriculum, which shows the distribution of educational material into invariant and variant; profession-based lecture patterns, laboratory classes [13] a problems book in Physics with profession-based tasks [14].

Conclusions and recommendations

The developed Physics integrated curriculum for Agricultural and Engineering High Schools is based on up-to-date and improved means of training that were examined in the laboratory conditions according to the following parameters such as visibility, ease of use, reliability and durability, in accordance with the current requirements of didactics, technical aesthetics and safety. The conformity to the mentioned requirements ensures successful activities of the future expert in the agrarian and technical industry. The implementation of the modern requirements to the professional training of farmers requires the development of the new methodological system of learning Physics. Such a system should be based on system activity-related and student-centred approaches to learning. All of the educational and methodical complexes in Physics should be developed on the basis of new information and communication technologies. It, consequently, involves the implementation of electronic learning aids and methodical support of Physics distance learning, computerization of educational process, providing telecommunication network access to Internet, basic and specialized software products.

To sum up, the Ukrainian Agricultural and Engineering High School faces a lot of challenges today. The analysis of standardized training programmes for students of technical universities showed that academic disciplines should be taught in the context of future professional activities and integrated into a cohesive learning paradigm based on real-world applications. The results of the student questionnaire and testing showed that respondents agree that Physics is important for their future career, but the participants of the experiment don't know exactly where Physics knowledge can be applied. The analysis of teachers' comprehensive answers made it possible to confirm that academic disciplines should be taught on the basis professional approach. According to the questionnaire, one of the reasons for such low training indicators is that Physics course in a traditional system of education is abstract enough, problem books and laboratory workshops are not focused on professional activities of future agronomists and engineers.

We considered all the recommendations and created an integrated curriculum where Physics topics correspond to the major, profession-based lecture samples and a problem book in Physics for students of majoring in agriculture and engineering. It is also desirable to have laboratory studies at special machinery and agriculture showrooms.

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