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INTERDISCIPLINARY APPROACH TO TEACHING PHYSICS TO STUDENTS MAJORING IN AGRARIAN ENGINEERING AND AGRONOMY

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ABSTRACT

This study reports on interdisciplinary approach to teaching physics to the students majoring in agrarian and mechanical engineering. Physics plays a crucial role in mastering major disciplines by students of technical universities. Ukrainian higher education provides primarily mono-disciplinary approach to teaching academic and major subjects, so called teaching isolated disciplines. The interdisciplinary aspect of teaching physics corresponds to the requirements of modern society to educate competitive and qualified specialists in agricultural and engineering spheres. The study aims at defining the essence of interdisciplinary links between physics and major subjects, at specifying the peculiarities of job-focused physics tasks, at demonstrating the necessity of implementation the professional context in the process of studying. The paper investigates this issue by analyzing, comparing, systematizing the pedagogical literature.

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The study is based on monitoring and pedagogical experiment that proved the insufficient level of professional orientation of physics course. Pedagogical experiment was carried (out from 2014 to 2017). The students of State Agrarian and Engineering University in Podilya, Tavriyskiy State Agrarian University majoring in Agrarian Engineering and Agronomy and the students of Sumy National Agrarian University majoring in Agricultural mechanization took part in the survey. The sample involved 150 students. The study demonstrated such advantages of interdisciplinary approach to teaching physics through occupation-based task scenarios as student engagement and highly qualified specialists, subject interaction. The results of the experiment showed the insufficient level of professional competence of physics course. The material in this article, he patterns of physics course tasks accompanied by illustrations for students of mechanical engineering and agrarian departments, in particular, can be used in educational process.

Keywords: interdisciplinary approach; physics course; mechanical engineering; agriculture; professional competence; major subjects; higher education

1. INTRODUCTION

Preparing individuals for productive contribution through developing creativity, erudition, moral and aesthetic sensitivity, motivation to self-study is an up-to-date issue of higher technical education in Ukraine. Our country is at early stage of developing the European standards of education. Teaching through involving the interdisciplinary approach to academic disciplines will benefit in the process of studying.

To solve this issue many studies on interdisciplinary education, its basic principles and role in teaching (BOLOTOV, 2003; HUTORSKOI, 2005), classification and functions of multidisciplinary links have been done by Ukrainian (RYBINS'KA, 2006) and foreign researchers (LYALL, BRUCE, TAIT, MEAGHER, 2011; MARCU, 2007).

The studies were focused on professional education of Master students in international affairs (TRETKO, 2013), border guard students (KUZ, 2015), teaching chemical engineering on an interdisciplinary degree programme in biotechnology (FOLEY, 2016) and medical physicists (MARCU, 2007; CARUANA et al., 2009) through interdisciplinary approach. However, studies on interdisciplinary approach to

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the issue of teaching physics to students majoring in agrarian engineering and agronomy are still lacking.

The research problem of the study is to consider the interdisciplinary links between physics and major disciplines, to discuss the goals and characteristics of profession-based tasks in physics. The specific objectives of the present study are:

a) To give the reasons for interdisciplinary links between topics of general physics course and majors of Agrarian Engineering department;
b) To give examples of physics tasks for students majoring in Agrarian Engineering and Agronomy.
c) To prove the necessity of interdisciplinary approach to teaching physics in technical universities.

2. DATA AND RESEARCH METHODOLOGY

To achieve the aim of the study and implement the tasks set, the following research methods were used: theoretical (comparison, analysis and systematization of pedagogical literature), empirical (education process monitoring, pedagogical experiment to show the importance of interdisciplinary approach to teaching physics and statistics method to assess the results of the experiment).

The pedagogical experiment was carried out from 2014 to 2017. The students of State Agrarian and Engineering University in Podilya, Tavriyskiy State Agrarian University majoring in Agrarian Engineering and Agronomy and the students of Sumy National Agrarian University majoring in Agricultural mechanization took part in the survey. The sample involved 150 students.

3. RESULTS AND DISCUSSION

The issue of professional competence determines both the depth of knowledge in the sphere of certain professional activities and the ability to use your qualification, professional skills and experience in a real-case scenario. It characterizes the personal and social potential of a specialist, his abilities to apply optimal and suitable working strategies.

The process of future specialists' study should be focused on professional context. To develop the strategies for maximizing the career orientation through studying we must analyze the connection between general physics course and major disciplines.

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One of the main characteristics of higher education process in Ukraine is that subjects on specialty are studied much later (during the 3-d and 4-th years of studying). Consequently, the students have no motivation to study academic disciplines during the first year at university. As a result, fundamental, general technical and general theoretical knowledge is not applied during a long period of time. Therefore, we deal with the delivery of passive information to the students. Interdisciplinary approach has huge potential. It helps to avoid isolated learning skills and frequent gaps in student's education.

Physics is science with its roots in many subjects. For example, such technical discipline as Theoretical Mechanics is based, primarily, on the laws of Kinematics and Particle Dynamics, which are taught in the course of physics. Such subjects as Hydraulics and Water Supply, Heat Engineering and Heating and Soil are based on Molecular Physics (properties of solids, liquids and gases, ìsoprocess, transfer phenomenon, etc.).

The Material Science course is studied on the basis of already taught topics of physics course, let's take, for example, Rotation of a rigid body around the fixed axis (torque, moment of inertia, the law of dynamics for rotary motion, etc.) and Forces of Elasticity (deformation, relative and absolute elongation).

Electricity and Magnetism unit of physics course is the base of Electrical Technology. Moreover, professional and practical training disciplines are also connected with certain units and topics of physics course. Accordingly, the study of such academic disciplines as Technology of Agricultural Production and Agricultural Machinery is impossible without feedback on Kinematics, Dynamics and Elastic Forces.

Moreover, we may use both the assistant potential of interdisciplinary links between physics and Introduction to the course, Material Engineering, Engineering Mechanics, and advanced type of interdisciplinary links between physics and Electrical engineering, Agricultural machinery, Mechanical and Technological properties of agricultural materials, Electric power installation for agrarian and industrial complex, Earth Sciences, Agricultural Meteorology.

To make the most effective use of these professionally oriented examples we should use them according to students' major. Table 1 presents the way the topic

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Rotary motion can be explained to students of different specialties in technical universities.

Table 1: Rotary motion in terms of different majors

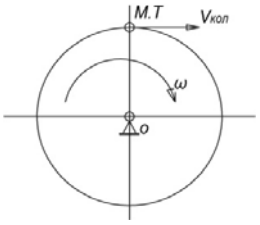
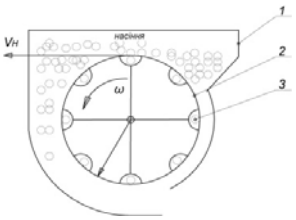
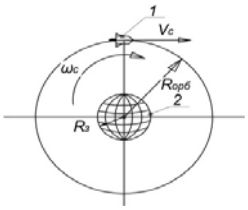
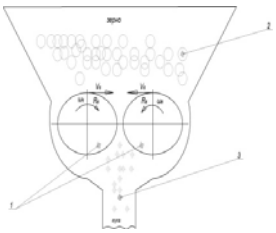
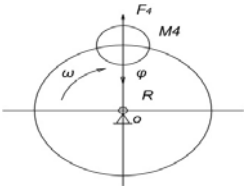
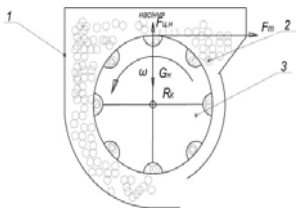
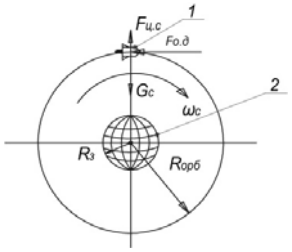
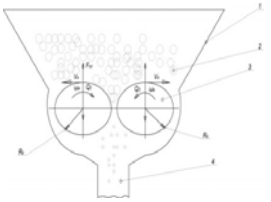
Graphic presentation of the topic	Majors		
	1. Agrarian Engineering	2. Space Technology	3. Food Engineering
	1. Kinematics of rotary motion of mathematic place		
 M.T. – material particle R – radius of rotation ω – rotary velocity V – angular velocity.	1.1  1 - seed cup 2 - barrel; 3 - seeds $R_к$- radius of barrel; $ω_к$- speed rotation of the barrel; $V_н$- angular velocity of the seed	1.2  1 - Earth satellite; 2 - the Earth $R_{орб}$- satellite orbital radius $R_з$- radius of the Earth's orbit $ω_{с-}$ rotary velocity of satellite V_c- angular velocity of satellite	1.3  1 - roll mills; 2 - grain; 3 - flour $ω_в$- rotary velocity of roll mills $R_в$- radius of roll mills $V_в$- angular velocity of grain at roll mills
2. Dynamics of rotary motion			
 $M_ч$ – material particle ω- angular velosity of material particle R- radius of rotation G-– material particle weight F- align force that effects the material particle	2.1  1 - seeder unit;2 - seeds 3 - barrel G - seed weight; $F_{ц.н.}$- align force that effects grain; $F_т$- friction force $ω_к$- rotational velocity of barrel $R_к$-radius of barrel	2.2  1 - Earth satellite 2- the Earth G_c- satellite weight; $F_{ц.с}$- align force that effects satellite; $F_{о.а}$- atmosphere drag force	2.3  1 - ammunition pouch; 2 - grain; 3 - roll mills; 4- flour $G_з$- grain weight; $F_{цз}$- centrifugal force that effects grain $F_т$-fractional force; $ω_в$- rotary velocity; $R_в$- radius of roll mills

Table 1 represents one of the techniques the topic rotary motion can be taught to students majoring in agrarian engineering, space technologies and food engineering. Consequently, kinematics and dynamics of rotary motion is explained with the help of seed cup, Earth satellite and roll mills schemes.

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Later such physics-based knowledge will help the students to calculate the power movement parameters of key parts, details and devices. Carefully planned interdisciplinary curriculum and students' realization of benefits from interdisciplinary studying will help, on the one hand, to motivate the students and to train a competitive specialist. On the other hand, interdisciplinary approach to studying physics will assist shortening the time and financial expenses of the university.

It is impossible to provide interdisciplinary approach to teaching physics without incorporation of realistic, work-based task scenarios in the course of physics. Professionally oriented tasks of physics course are aimed at:

- shortening the distance between theory and practice on the basis of interdisciplinary links between physics and subjects of professional and practical training, making the students face the same kinds of challenges they can meet at work;
- developing different kinds of brainwork,
- experiencing personal student progress on the basis of gradual complication of tasks, so-called «easy-to-difficult» strategy.

Surveys among students showed higher efficiency when it comes to connection of physics with major disciplines. The students are able to make calculations of kinematic and dynamic characteristics of agricultural machinery and mechanisms. The crucial value of professionally based tasks is that they provide deep understanding of physical quality of the processes that take place in agricultural machinery, mechanisms and devices.

Let us look at the tasks the students of State Agrarian and Engineering University majoring in «Processes, Machinery Equipment of Agricultural Production» do (ZBARAVSKA; BENDERA; SLOBODYAN, 2010):

- Fodder distributor (FDT-10) goes at rate of 0.87 km an hour. The average motion speed of fodder according to the floor is 0.77 m a second. Determine the speed of transporter fixed at fodder distributor, if its movement is perpendicular to the speed of fodder distributor. Graph 1 illustrates the task description concept.

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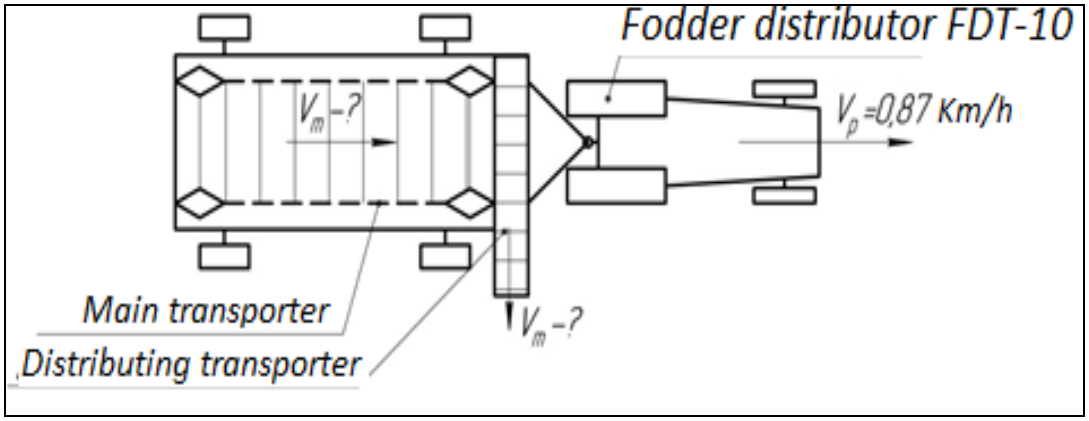

Graph 1: Scheme of fodder distributer movement

Such kinds of tasks are both perfect feedback on general physics laws and motivation for students. Tasks that create conflict situations have huge potential. The process of finding the answer activates thinking, attention and enjoyment. It has been found that it is desirable to use common and frequently used industrial and mechanical engineering terms and meanings, taking into account the fact that we deal with the first year students.

We have adopted the following tasks in physics with professional development scenarios. Here we have examples of tasks in «Frictional force».

- Why are the treadles and control pedals of agricultural machinery raised-tread? Why are the working surfaces of plowshare and earth-board, cultivator and share blades glib? Why do they glint in the sun after a long period of exploitation?
- What kind of friction is used in grain harvester in terms of power transmission between sheaves and belt?
- Why is it impossible to let dust and solid particles get into lubricant grease and diesel oil?
- Why does the depth of raised pattern of tractor and harvester tires chop down after a period of long-term operation?
- To create the tasks for Mechanical and Engineering department a teacher, to our mind, should also consider the information about:

  a) different branches of local and regional production;

  b) the perspectives of their development;

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c) ecological problems the production can cause.

Such accent has been made to focus on the importance of preparing specialists for local industry and on the danger of labor outflows.

The same topics of physics course are taught to the students majoring in Agronomy. However, the tasks are designed in conformity with the needs of agricultural industry. For example:

- What way do bur beggar, pin clover, narrow-leaved senecio use the frictional force?

Graph 2: Narrow-leaved senecio, bur beggar, pin clover

To get the answer to this question the students should use interdisciplinary links between physics and botany. The seeds of dandelion, narrow-leaved senecio have hooks easily dispersed by wind. Fuzz of narrow-leaved senecio hook sticks to animals and people.

Therefore, they cover long distances. The secret is that seeds use the forces of intermolecular interaction. Bur beggar uses the frictional forces to be transported at long distances. Its fruits are cuneated, flattened and have two or three lacerate bristle at wide end. They are dispersed both by people, animals and with the help of water. Their bristles cling to bottom at low water and later the fruit runs to seed.

The frictional force between bristle and soil or fur resists the separation of the seed. Pin clover fruit has a so-called tail it screws in the soil with. In dry weather the tail curls, in rainy weather uncurls, and goes deeper into the soil. Fuzz on the surface of the fruit prevents it from moving upwards.

To make the most effective use of field-oriented tasks in mechanical engineering and agronomy contexts we advise to advantage of visual support. Using the visual aids in professional content is beneficial. Pictures, paper handouts (complete

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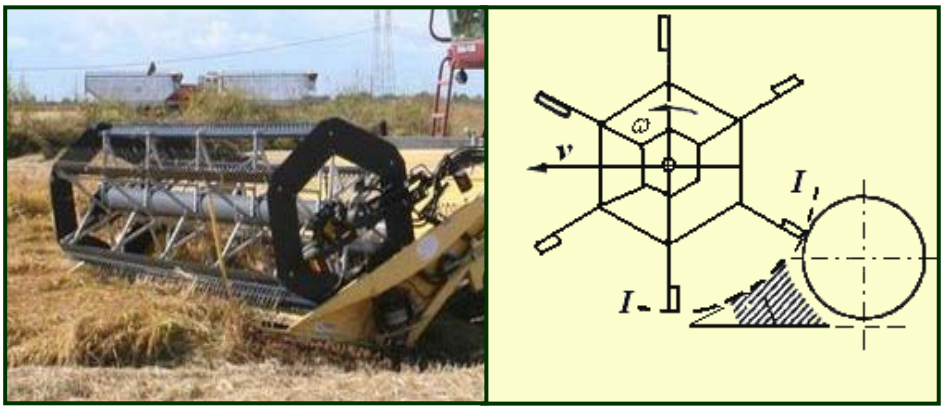
and incomplete), artifacts or prompts (machine elements and mechanisms, herbarium). An experienced teacher should remember that industrial content should not dominate. The crucial value of physics in agriculture and industrial issues must be shown and the students must realize that physics is necessary for specialists of agrarian sphere.

The gradual complication of task content is supported by the structure of educational process. We consider lectures to be the approximate stage of learning and practical classes to be the training stage of learning. Consequently, the aim of lecture course tasks is to provide orientation of theoretical material to the students, to illustrate items with the help of agricultural objects, to determine physical regularities in the functioning of agricultural objects. Besides, the lecture course provides the orientation on basic directions of professional activities through demonstration the strategies of completing the given tasks.

The students majoring in Agrarian Engineering were given the definition of term «tracing» while studying Kinematics. What is important, the movement pattern of details, machine parts, and agricultural production in scientific and experimental, calculating and designing, constructional and technological contexts was highlighted. The following tasks on identification of friction index of different surfaces and materials, movement pattern of reel board according to relation between car speed and board speed are used. The first example is of vital importance in designing a kind of agricultural machinery, the second one is connected with quality of harvesting.

The theoretical material can be illustrated not only with the help technical schemes. It is not about abstract information about particle movement, but the detail of reverse wrapping drum of the harvester. (Graph 3).



Graph 3: Computer model of harvester reel movement

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The students were given tasks that are more difficult at practical classes. These tasks were focused on the influence of ratio of car speed to reel bat speed on reel operation, kinematic and dynamic characteristics of crank mechanisms and connecting rod gear, determining the rotational inertia of piston rod.

The field-based tasks we developed demand different level of brainwork. They benefit in maximizing the cognitive activities of students, because specialized tasks are supposed to be primarily connected with the productive activities. Practical classes and laboratory trainings focused on research student work in special laboratories fit with appropriate equipment.

Student researches on influence of harmonic vibration of car parts, on unit operation or research on calculation of friction index, slope angle of the surface and speed of grain transportation in harvester loading bunker were successful and effective. Production tasks are aimed at the formation of technical competence.

The pedagogical experiment was carried out from 2014 to 2017. The students of State Agrarian and Engineering University in Podilya, Tavriyskiy State Agrarian University majoring in Agrarian Engineering and Agronomy and the students of Sumy National Agrarian University majoring in Agricultural mechanization took part in the survey. The sample involved 150 students.

The level of theoretical knowledge in physics and its practical application in terms of traditional approach to teaching physics was determined with the help of 12 test forms. The first year students were given the tasks in Physical basis of Mechanics: elements of kinematics, dynamics, laws of conservation of momentum and energy. While the second year students were tested in Electrics and Magnetism: electrostatics, direct current, magnetic field, statistic field in material substance, quasi-stationary magnetic field.

First six test forms were simulation tasks. For example, the students were asked to represent the laws of impulse conservation, energy and moment, Rowland law, Gauss electrostatic law.

Next six test forms were aimed at determining the work-based objects where the physical laws are applied. The students had to number agricultural objects and technologies where laws of dynamics, conservation, elements if kinematics and Rowland law were used. Besides, there were more complicated tasks on identifying

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physical laws that provide tiller operation, on determining the influence of humus quantity on soil heat conduction.

The results of the tests carried out by the students are given in Table 2.

Table 2: Test results (percentage of correct answers)

Tests	Number of the task	*Correct student answers, %*	
		The first year students	*The second year students*
1st-6th test forms variants	1	21%	*22%*
	2	17%	*18%*
	3	9%	*10%*
7th-12th test forms variant	1	14%	*15%*
	2	7%	*9%*
	3	*5%*	*6%*

The results obtained show that both the first and second year students succeed in making the simulation tasks connected with simple reflection of physics course issues (47% and 50%). While the progress in doing the tasks based on concrete objects of future professional activity is worse (26% and 30%). The experiment showed insufficient training in physics issue connected with future profession of agrarian engineer. Therefore, the assignments section of physics course should contain profession problem sets.

4. CONCLUSIONS AND RECOMMENDATIONS

Physics education in Ukraine has not undergone any reforms but they are needed. Interdisciplinary approach to teaching physics in technical universities promotes academic excellence in higher education. In addition, it provides many benefits in comparison with traditional pedagogy that concentrated primarily on one discipline.

Physics has vivid links with engineering and agricultural disciplines. We suggest that teaching physics through professional context has a lot of advantages. Students are highly motivated as physics is rooted in life experience and professional context. Interdisciplinary organization of curriculum on the basis of assistant and advanced types of links between disciplines will advantage in providing not isolated knowledge in context-related disciplines, shortening the term and expenses on studying, getting higher level of professional qualification.

Interdisciplinary approach to studying physics in universities cannot be applied without carefully organized system of career-based tasks. All the task patterns in physics course presented in the study are designed to concern professional issues

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taking into account the peculiarities of local production, to develop different kinds of brainwork, to provide student experiencing of personal progress.

The implementation of graded professional education in Ukraine stipulates further researchers on strategies for professional orientation of fundamental disciplines. It will make the differentiation of the context and functions of certain stages in professional training, the coordination of pedagogical activities, the elimination of doubling the training content, the cutting down on inefficient time consumption, the provision of deep career-based knowledge and skills.

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