

## INTER-SUBJECT RELATIONS RESEARCH IN PROFESSIONAL STUDIES OF FUTURE AGRICULTURAL ENGINEERS

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**Abstract.** The relevance of the problem of interdisciplinary connections in education is determined by objective processes in modern education and the trend of integrating scientific knowledge in theoretical research and practical activities. Application of interdisciplinary connections contributes to the acquisition of various practical skills and abilities, stimulates cognitive interest in the study of physics as a science, allows to better assimilate the material of other disciplines of the natural science cycle, develop cognitive and creative abilities, and influence the formation of sustainable motives for obtaining knowledge in special disciplines. The purpose of the study: to substantiate the didactic efficiency of establishing and implementing interdisciplinary links in physics in order to improve the professional knowledge of the students of agricultural and technical educational institutions. As a result of the study, it is proved that solving problems of an interdisciplinary nature and properly organised laboratory classes contribute to a more successful formation of a system of the students' knowledge. The comparative analysis of the results of the study of special disciplines and physics made it possible to conclude that the level of formation of interdisciplinary connections of knowledge has increased, and, accordingly, the level and cognitive activity of the future specialists in the agro-technical industry has increased by 17%.

**Key words:** interdisciplinary connections, physics, professional orientation, problems, laboratory practice.

### Introduction

Improvement of the quality of training of the operators requires improvement of the educational process. One of the effective means in terms of teaching young people working professions, preparing them for life are interdisciplinary connections (IC) as an obligatory element of the educational process. The teaching experience shows that social science, pedagogical, natural science, mathematics and general technical subjects are considered by students as unrelated. The students very often do not see what is common in their content. This is a consequence of the fact that many existing teaching methods are still focused on an inductive-empirical scheme of generalisation and formation of general concepts on the basis of only one subject. Interdisciplinary concepts are systems of knowledge of various sciences; they have other development mechanisms. Therefore, their formation cannot be carried out only by means of one discipline.

The problem of psychological and pedagogical substantiation and introduction of interdisciplinary connections into the educational process, in particular physics, was reflected in the works of P.S. Atamanchuk, A.V. Kaspersky, I.M. Kozlovskaya, S.M. Pastushenko, V.P. Sergienko, O.V. Sergeeva, B.A. Susya, M.I. Shut and other Ukrainian researchers and educators [1; 2]. Questions of polytechnical orientation of interdisciplinary relations in the field of general and vocational education are considered in the works by P.R. Atutova, N.I. Dumchenko, P.I. Stavsky and others. So, P.R. Atutov developed a concept of the functional nature of polytechnical knowledge, the conditionality of the system of polytechnical knowledge by the content of academic subjects. Considerable attention is paid to the problem of interdisciplinary connections between the natural and mathematical disciplines, mainly at the level of general education schools and vocational schools [1; 3]. In the works by A.I. Eremkina, S.N. Nikolaenko and others the authors consider the functions of interdisciplinary connections [2; 4; 5]. They show that the interdisciplinary connections perform the following functions: coordinate learning activities; contribute to the coordination in time of studying the material of individual disciplines, eliminate duplication; provide continuity in the formation of knowledge; give generalised orientation to the educational process; contribute to the systematisation of knowledge; provide unity in the interpretation of the content of knowledge, ensure unified approach to the formation of cognitive skills and abilities; contribute to the education of the students. At the same time, it should be noted that the methodological function of interdisciplinary connections as the basis of the integrity of the educational process was studied superficially, the inversion (transforming the target nature of knowledge) function was not singled out.

In many European investigations the discussion of interdisciplinarity is considered in various directions [6-10]. According to M.Borrego and L. Newswander interdisciplinarity requires a deep understanding of at least one area of knowledge. Interdisciplinarity, which is a result of general or liberal arts education, includes critical thinking skills that are useful even when the student is not in their area of expertise [11-12]. Yet, in our opinion, the problem of theoretical substantiation and practical implementation of interdisciplinary connections of the course of physics in higher agrarian and technical educational institutions has received insufficient attention.

The purpose of this study is to substantiate theoretically the didactic efficiency of establishing and implementation of interdisciplinary connections of physics in order to improve the professional knowledge of the students of agricultural and technical educational institutions.

### **Materials and methods**

The basis of the course of physics for agro-engineering areas are facts, concepts, quantities, laws, theories, the physical picture of the world, methods for studying physics, practical application of the laws of physics, as well as their manifestation in nature and technology. Facts, concepts, laws, theories of a physics course should be presented to the students in a systematic way in accordance with the didactic principles of systematic and consistent presentation of knowledge. The greater amount of knowledge and impossibility to increase the time for studying the material that reflects the professional orientation of the physics course require careful selection and systematisation of the educational material. Based on this, the material of the physics course was divided into two parts: invariant and variable. The invariant part is the material that corresponds to the fundamental component of the course. This part can be changed; it is specific for different educational institutions and different groups of professions and directions of training.

The content of the variable part is built on the basis of interdisciplinary connections and is aimed at the formation of the students' knowledge and skills, taking into account the future professional activities. The variable part should contain material related to the professional component of the student's training: the principles of operation of the agricultural machinery; technologies related to the theoretical content of the physics course and systematised in accordance with the important directions of the scientific and technological progress. At this stage there was a real opportunity to use professionally oriented material, related to the future activities of a specialist, which contributed to the formation of motivation and interest in studying a physics course and intensified the students' work [13-15].

At the first stage of the experiment, based on a theoretical analysis of the existing experience in the theory and practice of teaching, applicants for the higher education, there were revealed the shortcomings of the state of teaching professional disciplines and physics in a real pedagogical process of agrarian and technical education. Most of them are related to various aspects of education, and they convince that it is necessary to introduce integration of education, to apply inter-disciplinary links of the course of physics, since they stimulate cognitive interest in the study of physics as a science, allow to better assimilate the material of other disciplines of the natural science cycle, develop their cognitive and creative abilities that influence the formation of sustainable motives for obtaining knowledge in special disciplines.

The main objective of the experiment was implementation of experimental research into the teaching practice. At this stage of the study a scheme was formed of the peculiarities of teaching physics, introduction of inter-subject links with physics, a referential scheme was developed to plan integrated classes for the teachers under the conditions of pedagogical integration. In addition, the experimental research work was performed in the following order: the initial level of the first-year students in specialty "Agroengineering" was clarified. This made it possible to form experimental and control groups of students. 201 students, 7 teachers of technical disciplines and physics took part in the experimental work.

### **Results and discussion**

A specific feature of teaching physics in higher agrarian and technical educational institutions is that this process should not only provide a high level of natural science training but also have a clear focus on the future specialty. One of the necessary conditions for the professional training of the future specialists is professional orientation of training. We consider that in order to solve this problem, it is necessary to conduct a detailed analysis of the relationship between the course of physics and the main

general technical and professional disciplines. This, first of all, will make it possible to determine what physical knowledge, skills and abilities will be required in the further study of professional disciplines, and, second, it will allow the most skilful use of examples of agricultural content in the physics classes, related to the students' future professional activities. The low level of fundamental knowledge in the continuous training of the future specialists leads to accumulation of knowledge in the study of professional disciplines without a deep understanding of the physical essence of the processes. An engineer with poor fundamental training cannot understand in detail the production processes with which he will work, confidently get involved in the work and find the right ways to rationalise this work which he is summoned to do. The path to a true understanding of the issue of technology and production lies through a systematic study, including the fundamentals of physics. In the process of studying physics the students should see that knowledge of the laws of physics has led and is leading to the creation of various technical devices, the physical foundations of which the students can explain, having a high level of fundamental training. Therefore, during the physics classes the students learn on the basis of the laws of physics to explain the phenomena observed in nature, production, agricultural machines and mechanisms. An analysis was carried out of a connection between physics and the main general technical disciplines of practical and professional training. For example, the study of the discipline "Theoretical Mechanics" is based mainly on the kinematics and dynamics of a material point. It is studied in the course of physics. The study of the cycle of disciplines of professional and practical training is interconnected with the study of sections and specific topics of the physics course. Thus, it is impossible to study the professional disciplines "Mechanical and technological properties of agricultural materials", "Agricultural machines" without the knowledge of such sections and topics of the course of physics as "Kinematics", "Dynamics", "Forces of elasticity", "Conservation laws". The study of the disciplines "Energy means in the agro-industrial complex", "Hydraulics and water supply" and others require knowledge of the material of various sections of the physics course, such as "Physical foundations of mechanics", "Fundamentals of molecular physics and thermodynamics", "Electrics and magnetism" [16-17].

When preparing specialists for the qualification of a mechanical engineer, the principles of the relationship between the subjects are implemented as follows: the arrangement of agricultural machines, their correct operation is the object of study of the course "Agricultural machines", which is included in the plan of disciplines of the professional and practical training cycle, and the natural science disciplines, such as physics. Chemistry is the study of the phenomena and laws on the basis of which and by means of which these machines are designed and operate. Consequently, agricultural machinery is studied as a complex, by several subjects, using the same evidence and definitions.

Several subjects or separate themes may be connected indirectly through another intermediate subject. To such subjects belong the subjects of a general technical cycle; indirect communication between the objects can be implemented in three stages. The first stage: in chemistry, in the "Metals" section, they study the structure, chemical composition, corrosion of metals, etc. The second stage: when studying "Material Science and Theory of Structural Materials", based on the knowledge of the course of chemistry, they study in more depth the changes that occur in metals during certain types of the heat treatment. The third stage: in the subjects "Tractors and Automobiles", "Agricultural Machinery" they study the materials from which the parts and mechanisms are made.

To establish a connection between the subjects of professional-practical and general technical cycles, they can be conditionally grouped as follows: "Tractors and Automobiles" and "Agricultural Machinery" – with physics, chemistry, mathematics; "Material Science and Theory of Structural Materials" – with chemistry, physics; "Fundamentals of Agronomy" – with chemistry, biology and physics. The natural science subjects, in turn, are grouped with the professional disciplines that are associated with them.

The knowledge of physics is the basis not only of the studies of theoretical issues of general technical and professional disciplines but also the fulfilment of professional tasks [14-15]. Therefore, when explaining new physical concepts, phenomena and laws, we used examples of the future specialty of the students and their knowledge of the disciplines of professional and practical training. An example of the content of the questions of the course, based on the analysis of interdisciplinary connections between physics and professional disciplines, is presented in Table 1.

Table 1

**Use of industrial experience and professional teaching in the study of the section “Molecular physics and basics of thermodynamics” of the course of physics**

<b>Physical concepts</b>	<b>Examples from the production experience</b>
Movement of liquids and gases	Hydraulic ram. Wind turbines. Air jet nozzles for sprayers, pollinators. Carburettor. Viscosity of various types of oil. Magnitude of the drag of cars.
Fundamentals of molecular kinetic theory	Heat treatment of automotive and tractor parts: nitriding, cyanidation (cementation). Diffusion as a means of moving nutrients in plants. Osmosis. Turgor.
Charles' law (isochoric process)	a) In the cylinder of the internal combustion engine the pressure increases due to the increase in temperature during the combustion of the combustible mixture. A flash occurs in a short time, so we can assume that the volume does not change. b) From a long drive on a dry asphalt road surface, the air pressure increases in the cylinders of the car wheels.
Increase in gas pressure with decrease in volume	In the cylinder of the carburettor engine or in the cylinder of the diesel engine, when the piston moves from the bottom to the top, the volume will decrease by 6–7 times, and the pressure will increase to 10 or more atmospheres.
Adiabatic process (increase in gas temperature during sharp compression)	When air is compressed in the cylinders of the diesel engine, the temperature increases so that the fuel ignites.
Properties of gases	Increase in the air temperature under the diesel piston during compression. Vacuum pump and vacuum cylinder of milking machines. Spray bottles.
Properties of liquids	Capillarity of soils, plants, animals. Lubricant liquids.
Thermal conductivity	a) Internal combustion engines have a cylinder block. The aluminum block head has a higher thermal conductivity than cast iron. Therefore, it protects the engine from overheating and allows to increase power. b) Since water is a poor conductor of heat, it serves to cool internal combustion engines.
Work on thermodynamics	During the working cycle of the internal combustion engine, the work is performed by the piston.
Quantity of heat	During the combustion of fuel, a certain amount of heat is generated in the cylinder of the internal combustion engine; it is partly transferred to the environment.
Heat capacity	Water is used as a coolant in internal combustion engines because it has a high heat capacity.
Properties of solids	Ferrous alloys and their mechanical characteristics. Non-ferrous metals, alloys. Types of deformations of the parts of agricultural machines: stretching – valve stems of the distribution mechanism, cables; bending – sheets of springs, the car frame beams, tractors, axles; torsion deformation – in the cardan shafts.
Expansion of bodies when heated	Accounting for thermal expansion in the structure of pistons of the internal combustion engines, adjustment of the intake and exhaust valves. Thermal gaps. Use of bimetallic plates in the car direction indicators, temperature switches in incubators, greenhouses, temperature, pressure sensors.
Change of aggregate state	In closed cooling systems of the internal combustion engines, water boils at a temperature of 105-107°C since the pressure there is increased relative to the atmospheric pressure. Frost prediction, based on the dew point. Conditions that accelerate evaporation of water from the soil.

To substantiate the efficiency of introduction of the interdisciplinary relationships into the professional training of the future agricultural engineers, an experiment was conducted with a statistical

analysis of its results. According to the curriculum of the preparation of applicants for higher education in speciality “Agroengineering”, the following disciplines are indicated in the professional and theoretical training: material science, mechanics of materials and structures, theory of mechanisms and machines, electrical engineering, electronics and microprocessor technology, and others. Technical sciences are sciences that study relationships of the development of technology and determine the best ways how to use them in the future professional activities. One of the fundamental sciences for these disciplines is physics. According to the goals of the experiment, reliability of the didactic means of inter-subject communications with physics was determined; the efficiency of the integration model of knowledge of professional disciplines and physics in the educational process was experimentally tested. A multi-stage test of the knowledge and skills of the applicants for higher education throughout the entire period of the research made it possible to obtain objective data about acquisition of the educational material on an integrated basis. The formation level of integrated knowledge in technical disciplines and physics, the ability to apply them in practical activities made it possible to identify the reasons that affect the quality of assimilation of professionally oriented disciplines and physics. Analysis of the results of the experiments showed that the average performance in the experimental group in physics increased by 17.02%, the quality of knowledge by 33.89%; in technical disciplines – the academic performance in the experimental group increased by 3.4%, the quality of knowledge by 11.82%. In the control group progress in physics increased by 11.83%, the quality of knowledge by 10.15%; in technical disciplines – the academic performance increased by 5.34%, the quality of knowledge by 8.44% (Figs. 1-2). The results of the students’ learning activities are confirmed by archival data, which proves the methodology of integrated learning.

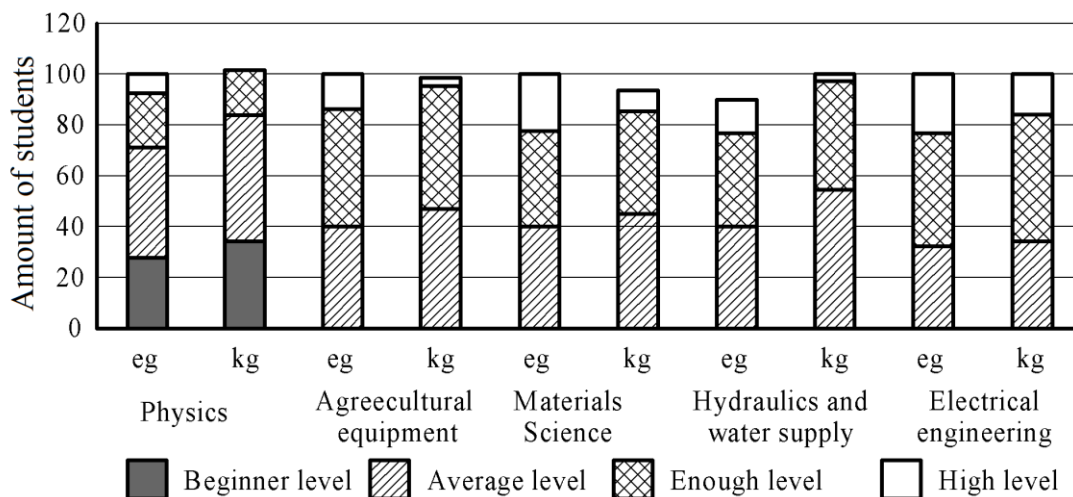


Fig. 1. Results of the students’ knowledge in technical disciplines and physics

Analysis of the results of the students’ educational achievements (Fig. 3) gave grounds to confirm the hypothesis about the need to build interdisciplinary connections in teaching physics to improve the professional knowledge of the students of agrarian and technical educational institutions.

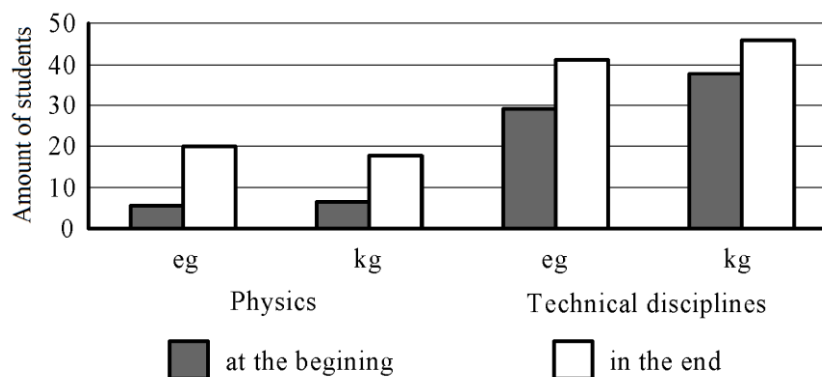


Fig. 2. Results of the students’ knowledge in technical disciplines and physics

Thus, the results of the experiment confirm the working hypothesis of the study, which indicates the effectiveness and efficiency of the proposed methodological approaches to the formation of integrated knowledge in technical disciplines and physics for the students of agrarian and technical educational institutions.

Consequently, the use of interdisciplinary connections in the classroom allows:

- increase the students' motivation to study the subject;
- better acquire the material, improve the quality of knowledge;
- activate the students' cognitive activity in the classroom;
- facilitate the students' understanding of the phenomena and processes to be studied;
- analyze, compare facts from different fields of knowledge;
- carry out a holistic scientific perception of the surrounding world;
- fully implement the professional and educational opportunities of every student.

Implementation of interdisciplinary connections in the course of physics increases the efficiency of professional orientation of education, deepens the knowledge of fundamental sciences, promotes an organic combination of the theoretical and practical components in training of a future agricultural specialist, intensifies the search for new approaches to designing and organising the educational process.

### Conclusions

1. Comparative analysis of the results of the study of technical disciplines and physics made it possible to draw a conclusion that the level of formation of interdisciplinary connections of knowledge has increased, and, accordingly has increased by 17% the level and cognitive activity of the future specialists in the agro-technical branch.
2. Stepwise formation of a scientific picture of the world using interdisciplinary connections of natural disciplines during training promotes qualitative transformation of all the aspects of the students' cognitive activity: knowledge acquires a systemic character, which ensures their comprehensive application and deepening of cognitive interests, developing an ideological orientation that contributes to the formation of a holistic personality.

### Author contributions

Conceptualization, S.N.; methodology, S.N., V.I. and O.B.; formal analysis, V.I. and L.Z.; investigation, O.B., I.D., M.T. and V.V.; data curation, V.V. and M.T.; writing – original draft preparation, L.Z., I.D.; writing – review and editing, I.D., K.V., O.B. and V.I.; visualization, I.D. and K.V. All authors have read and agreed to the published version of the manuscript.

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