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**THE PROGRAMME FOR EXPERIMENTAL RESEARCH INTO HIGH SCHOOL STUDENTS' COMPETENCE IN PHYSICS AND MATHEMATICS FOR TECHNICAL UNIVERSITY STUDIES**

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The Programme for Experimental Research into High School Students' Competence in Physics and Mathematics for Technical University Studies

The article presents the logic of an experimental study of the level of physico-mathematical training of senior pupils for their studies at an engineering university. The hypothesis, stages, tasks, and methods of the study have been defined. The formation of a selection and of the entire assembly as well as that of the experimental basis of the research has been described. The scientific literature concerning the methodological principles of conducting empiric educational research has been analyzed; the type of the designed educational experiment has been defined. The set-up, recital, formation, and analysis stages of experimental research have been described and their connection with the tasks and techniques of the research has been shown. The program has been characterized of an educational experiment aimed to determine the effectiveness of a didactic model based on a proprietary complex methodological support of pre-university physico-mathematical training of senior pupils. The article justifies the criteria (goal-oriented, motivational, cognitive, pragmatist, reflexive, and efficiency-oriented) та levels (high, medium, low) of empiric research results in accordance with the designed components of physico-mathematical training of senior pupils for their studies at an engineering university. Prospects for the introduction of the designed program of an educational experiment into the process of pre-university physico-mathematical training of senior pupils have been defined.

*Key words:* educational experiment, empiric study, a programme for studying the level of physico-mathematical training of senior pupils for their studies at an engineering university.

***The significance of the research.*** Using the pedagogical experiment to study the high school students' level of competence in Physics and Maths for Tech University studies allows: to explore the existence and nature of the correlations between the components of the process under research (target, motivational,

cognitive, activity, reflective, effective); to identify the aspects of pre-university training of high school students for Tech University studies; to establish the quantitative and qualitative performance indicators subject to pedagogical transformations being made (teaching model of Pre-University Physics and Mathematics training that is built on the author's complex scientific and methodological support).

*The survey of scientific literature* proves that the experiment as the scientific method is aimed at changing the experimental phenomenon under certain conditions [2, p. 157] to test with experiment the identity of theoretical assumptions [8] by introducing innovations in the educational process to get its higher results on the next test and assessment [4]. The survey of works on the methodology of scientific research (S. U. Goncharenko [1], A. E. Konvers'kyi [7], V. A. Kushnir [6], V. S. Kurylo and E. M. Hrykov [4], etc.) allows to structure the program for experimental research of high school students' level of Physics and Maths competence for training at Tech University as a set of the following components: purpose, hypothesis, objectives, stages, methods, general totality, selection totality, research facilities, diagnostic tools. Thus, *the objective* of the article is to define the characteristics of the program structural components of the pedagogical experiment that is aimed at identifying the effectiveness of teaching models for Physics and Maths training at high school for Tech University studies.

Determination of the structural components of the research program allows to implement the basic requirements for the pedagogical experiment: the homogeneity of the objects of the research, focus on quantitative measurement of the parameters under research, reproducibility of the research results, searching common relations between the dependent and fixed parameters [4].

The body of major structural components and relations between them is illustrated in Fig. 1.

Objectives	Stages	Methods
On the basis of theoretical and methodological analysis to develop <i>criteria and levels</i> for Physics and Maths training at high school for High Tech University studies; to define the <i>experimental and selection totality</i> , its <i>research facilities</i> ; provide relevant <i>diagnostic tools</i> .	Organizational – the development of the research program	Analytic-synthetic, structural and functional, development, planning, documents review
Define the present state of high school students' competence in Physics and Maths for Tech University studies, to form the <i>experimental and control group</i> of students to be tested	Identifying - the study of the present state of the process	Monitoring, questioning, testing, documents review, expert assessment
Implement <i>the teaching model</i> and its components into a process of high school students' pre-university Physics and Maths training	Modelling – the implementation of the transformation model	Coordination, modelling, supervision, activity organization, content analysis
Hold a second diagnosis of high school students' pre-university competence in Physics and Maths; compare and analyze the results in the experimental and control groups.	Analytical – the determination of the model effectiveness	Quantitative and qualitative analysis, comparison, statistical methods

Fig. 1. The program for experimental research into high school students' competence in Physics and Maths for Tech University studies.

As shown in Fig. 1., *the purpose* of the pedagogical experiment is aimed at testing *the hypothesis of the research* – a high level of high school students' competence in Physics and Maths for Tech University studies is provided by the implementation of some teaching models that include:

- using an integrated, activity, competence, learner-centered approach as a methodological basis for Physics and Maths training at high school for Tech University studies;

- analysis of the teaching principles and approaches for Physics and Maths training at high school for Tech University studies;

The purpose of the experiment: to study how effective is the impact of a teaching model of Pre-University Physics and Maths training of high school students for Tech University studies.

Hypothesis: the high level of students' competence in Physics and Maths for Tech University studies is provided by the introduction of some teaching models:

- implementation of the logical and structural approach to the problem of the quality of high school students' pre-university Physics and Maths training;

- development and implementation of the author's complex scientific and methodological support of high school students' pre-university Physics and Maths training for Tech University studies.

The purpose of the article is achieved by step-by-step implementation of complex interdependent stages and relevant experimental research objectives: organizational, identifying, formal, analytical.

*The organizational stage* is aimed at theoretical study and practical development of the experiment program by studying the basic categories and its methodological principles, the formulation of experimental hypothesis and methods of its assessment; development of *criteria and levels* for Physics and Maths training at high school for High Tech University studies; the *experimental and selection totality*, its research facilities; provide relevant *diagnostic tools*. the development of diagnostic tools for pre-university training of high school students; the organization of scientific cooperation with the experiment participants (scientific- teaching staff of

High Tech Universities of Ukraine, high school students), their readiness to the experimental work. This stage implements the first objective of the experimental work: on the basis of theoretical and methodological search results to justify the criteria and levels of Physics and Maths training of high school students for Tech University studies; to define the general and selection totality; provide relevant diagnostic tools.

*The organizational stage* is aimed at theoretical study and practical development of the experiment program by studying the basic categories and its methodological principles, the formulation of experimental hypothesis and methods of its assessment; development of *criteria and levels* for Physics and Maths training at high school for High Tech University studies; the *experimental and selection totality*, its research facilities; provide relevant *diagnostic tools*. the development of diagnostic tools for pre-university training of high school students; the organization of scientific cooperation with the experiment participants (scientific- teaching staff of High Tech Universities of Ukraine, high school students), their readiness to the experimental work. This stage implements the first objective of the experimental work: on the basis of theoretical and methodological search results to justify the criteria and levels of Physics and Maths training of high school students for Tech University studies; to define the general and selection totality; provide relevant diagnostic tools.

*The identifying stage* is aimed at identifying the present state of the process and results of Physics and Maths training of high school students for Tech University studies; it involves monitoring of the academic progress of high school students in Maths and Physics and psycho-educational assessment of subjective factors of the process under research; testing the pre-university competence in Physics and Maths and streaming the results into equal control and experimental groups. Therefore, the second task of the experiment is formulated as the following: to define the present state of high school students' competence in Physics and Maths for Tech University studies; to form the experimental and control group of students to be tested.

*The modeling stage* involves design and implementation of the didactic model of pre-university training of high school students in physics and mathematics for technical university; design and use of complex scientific and methodological materials in the process of training in physics and mathematics in experimental groups; development of the tasks of different types to use in training of high school students in physics and mathematics; experimental testing of pedagogical support of pre-university training of high school students in physics and mathematics for technical university; defining the elements of the training process that need improvement. Training manuals and textbooks (i.e. in mathematics – 20, in physics – 14, 6 of them recommended by the Ministry of education and science of Ukraine) were developed by the author, based on the above mentioned scientific concept of the scientific and methodological complex of training in physics and mathematics.

So, the forming stage of the experimental work is aimed at controlling the effectiveness of the model of pre-university training of high school students in physics and mathematics for technical university. It defines the necessity of the implementation of the complex of scientific and methodological materials and pedagogical support as the main elements of the didactic model. Abovementioned correlates with the third task of the experiment: implement the didactic model into the process of pre-university training of high school students in physics and mathematics for technical university.

*The analytical stage* is targeted at qualitative and quantitative comparison of the results of secondary diagnostic control test of the level of knowledge of the students in experimental and control groups; control of the effectiveness of the model of pre-university training of the high school students in physics and mathematics including didactic materials developed by the author; having seminars and instruction meetings on the results of experimental work; systematization and scientific analysis of the results of the experiment, statistical analysis and summarizing, preparing a monograph, introducing obtained scientific achievements at the institutes (faculties) of the pre-university training. At this stage the main results and conclusions confirming the hypothesis were drawn.

The analytical stage realizes the fourth experimental task: conduct secondary diagnostics of the level of pre-university preparation; compare and analyze the results at experimental and control groups.

The credibility of the results of the experiment is provided by the number of cognitive procedures, which make up the defined stages of scientific research. This is provided by the validity of choice of control and experimental groups as well as by the reliability of the methods of statistical selection of the experiment along with the validity of the diagnostic tools.

The investigation of the effectiveness of the designed didactic model of pre-university training of high school students in physics and mathematics for technical university is provided by means of monitoring of the results of pre-university training in physics and mathematics in the experimental groups, and comparison of the achieved results with the results in the control groups.

To define control and experimental groups it is necessary to form the experimental research base along with general and selected populations of the research.

*The experimental research base* included the Institute of Preparatory Training of the National Aviation University; the Pre-enrolment Training Center of the V. N. Karazin Kharkiv National University; the Faculty of Pre-University Training of the National University of Food Technologies; The Faculty of Preparatory Training of the Luhansk Taras Shevchenko National University.

*General population* of the research unites students of high school, who are taking the preparatory courses at technical university (institutes of pre-university study, pre-enrollment courses, faculties of pre-university (pre-enrollment) education, centers).

*Selected population* of the research unites students of high school, who are taking the preparatory courses at the universities of the defined experimental base. In order to provide the representation of the results of the experimental work the volume of selected population is calculated with confidence probability of 99%, which must comprise 900 to 1406 respondents [5, P. 46]. In our case it is 1650 students.

The classification of the experimental researches by V. D. Melash [3], allows to define the pedagogical experiment on defining the level of pre-university preparation in physics and mathematics as artificial (by the method of forming the conditions), converting (by the purpose of the research—improvement of the level of pre-university preparation of students in physics and mathematics), complex (as per the structure of the process—pre-university preparation), multivariate (by the number of factors influencing the study process - both external and internal).

Accordingly, the experimental factor is the implementation of didactic model of pre-university training of high school students in physics and mathematics for technical university (which was theoretically proved in chapter 3) – viewing it as an independent value which is implemented and controlled in order to confirm the hypothesis -in other words if the model influences the level of preparation of students (is the dependent variable).

Defined independent and dependent variables are the categories of the analysis in the designed pedagogical experiment, for that reason shown as the empirical parameters, which call for the appropriate methods of investigation.

At pic. 1. You can see that the selected methods of investigation are defined by the content and purpose of each stage of experimental work. The whole set of general and special methods of experimental work can be divided into theoretical, empirical and mathematical.

*The theoretical methods* of scientific cognition (analytic-synthetic and structural-functional ones, simulation, design, comparison, quantitative and qualitative analyses) allowed to present the investigated process of pre-university Physics and Mathematics high school students training in a consistent manner; to determine its structural components, impact factors and their reflection in the psychological and educational literature; to substantiate the theoretical and methodological approaches and the concept of the complex scientific-methodological support; to abstract and classify the initial positions and the results of the investigation; to simulate the investigated process in theory and construct a didactic model of the physical-mathematical training of high school students prior to



Technical University studies; to justify the author's complex scientific-methodological support of the investigated process.

*The empirical methods* of cognition (experiment, monitoring, study of documents, questionnaire survey, testing, expert evaluation, observation, content analysis) were aimed at proving the efficiency of using the didactic model of the pre-university Physics and Mathematics training of high school students prior to Technical University studies; determining the current state of pre-university Physics and Mathematics preparation for studying by various components (target, motivation, cognition, activity, reflexiveness, effectiveness); studying the quality of the educational process in the institutes (departments) of pre-university training (education).

*The mathematical methods* (the methods of mathematical statistics: F-test - the Fischer angular transformation, O – the signs test) were used to transfer the observation results into quantitative values and check their certainty and reliability.

In addition a group of *organizational methods* - planning, coordination, organizing the investigation participants' activities was used to prepare and carry out the experiment.

A criterion in the scientific literature means basis for assessment, definition or classification of the investigated phenomena, processes or systems. That is, the criterion in the pedagogical experiment performs the qualimetric function of transfer of the qualitative features of the investigation into quantitative data. That is, the criteria can be considered as quantitative models of quality components of the phenomenon under investigation; projecting this idea on the problem field of our investigation, the criteria of physical and mathematical training level of high school students for Technical University studies are the quantitative display of qualitative results of the structure analysis of pre-university Physics and Mathematics training, i. e. its components (target, motivation, cognition, activity, reflexiveness and effectiveness). Conducting the system analysis the researcher is required to maximize similarity (consistency) of the criteria and components of the phenomenon under investigation. The difference in the components and criteria is that the former reflect

qualitative (nominal, simulated) characteristics of the process under investigation, and the latter – quantitative ones (empirical, experimental) [9]. According to the projected structure of the pre-university Physics and Mathematics training of high school students, we chose the investigation criteria of target, motivation, cognition, activity, reflexiveness and effectiveness for experimental work.

The specified level system of the experiment results evaluation involves the characteristic of criteria (target, motivation, cognition, activity, reflexiveness and effectiveness) and pre-university levels of Physics and Mathematics training of high school students (low, medium and high).

*The low level* of Physics and Mathematics training of high school students for Technical University studies in accordance with its components is characterized by: the lack of conscious goals for successful learning in the technical field; reproductive nature of cognitive activity; immature independent learning activity of high school students; their immature cognitive needs studying Physics and Mathematics; low level of learning achievements in the education system “CEI (comprehensive educational institutions) – pre-university training – HTEI (higher technical educational institutions)”, lack of extracurricular educational activity; disadaptation to HTEI educational environment; conviction in the lack of gift for Physics and Mathematics.

*The medium level* of Physics and Mathematics training of high school students for Technical University studies is characterized by the: unstable nature of cognitive purposes of high school students for further Technical University studies; lack of desire for self-actualization while preparing for studying; lack of focus on the development of interests in the study of Physics and Mathematics; predominance of motivation to avoid failure in education; average level of learning achievements in education “CEI - pre-university training – HTEI”; situational nature of participation in extracurricular activities; adaptation to the process of pre-university preparation; lack of confidence in personal gift for Physics and Mathematics and its development.

*The high level* of Physics and Mathematics training of high school students for Technical University studies is characterized by: realism and awareness of objectives

for acquisition of a technical profession; value attitude to learning activities; creativity and autonomy in cognitive activity; focus on the development of physical and mathematical interests; prevalence of success achievement motivation in learning; high level of academic performance in the education system “CEI – pre-university training – HTEI”; extra-curricular activity and creativity; adaptation to the process of professional training; awareness of personal physical and mathematical abilities and ways of their further development; high performance of final evaluation in the process of pre-university training.

*In general*, the credibility of the pedagogical experiment results is provided by sufficient sampling; choice of assessment of knowledge and skills in Physics and Mathematics as a main indicator of experimental work; taking into account subjective and objective factors influencing the process of pre-university training of high school students; recurrence and duration of diagnostic surveys; using the methods of mathematical statistics to verify the reliability of obtained quantitative data.

**Thus**, we have described the pedagogical experiment program in order to show impact effectiveness of the didactic model which is based on the author's complex scientific and methodological support to the process of pre-university Physics and Mathematics training of high school students for Technical University studies. The purpose, hypothesis, objectives, stages, methods of experimental work have been substantiated; the construction process of the general and sampling frame and the experimental database of the research has been described. Based on the theoretically substantiated components of Physics and Mathematics training of high school students for Technical University studies (target, motivation, cognition, activity, reflexiveness and effectiveness) and corresponding criteria, the three levels of such training outcomes (high, medium and low) have been designed. *The prospects for further research* are determined as experimental verification of the developed didactic model of Physics and Mathematics training of high school students for Technical University studies; definition of the effectiveness of the proposed educational transformations; approbation of the author's complex scientific-methodological support of pre-university Physics and Mathematics preparation of

high school students; reproduction of effective practices of pre-university training in scientific and methodological literature.

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Муранова Н. П.

Програма експериментального дослідження рівня фізико-математичної підготовки старшокласників до навчання в технічному університеті

У статті представлено логіку експериментального дослідження рівня фізико-математичної підготовки старшокласників до навчання в технічному університеті – визначено його гіпотезу, етапи, завдання, методи; описано процес побудови генеральної та вибіркової сукупностей та експериментальної бази дослідження. Представлено результати аналізу наукової літератури щодо методологічних засад проведення емпіричних педагогічних досліджень; визначено тип спроектованого педагогічного експерименту. Описано організаційний, констатувальний, формувальний і аналітичний етапи експериментальної роботи, а також їх зв'язок із завданнями та методами дослідження. Охарактеризовано програму педагогічного експерименту щодо виявлення ефективності впливу дидактичної моделі, основу якої складає авторське комплексне науково-методичне забезпечення процесу доуніверситетської фізико-математичної підготовки старшокласників. Обґрунтовано критерії (цільовий, мотиваційний, когнітивний, діяльнісний, рефлексивний, результативний) та рівні (високий, середній, низький) результатів емпіричного дослідження відповідно до спроектованих компонентів фізико-математичної підготовки старшокласників до навчання в технічному університеті. Визначено перспективи впровадження спроектованої програми педагогічного експерименту в процес доуніверситетської фізико-математичної підготовки старшокласників.

Ключові слова: педагогічний експеримент, емпіричне дослідження, програма вивчення рівня фізико-математичної підготовки старшокласників до навчання в технічному університеті.

Муранова Н. П.

Программа экспериментального исследования уровня физико-математической подготовки старшекласников к обучению в техническом университете

В статье представлено логику экспериментального исследования уровня физико-математической подготовки старшекласников к обучению в техническом университете – определены его гипотеза, этапы, задачи, методы;

описано процесс построения генеральной и выборочной совокупностей и экспериментальной базы исследования. Представлено результаты анализа научной литературы о методологических основах проведения эмпирических педагогических исследований; определено тип спроектированного педагогического эксперимента. Описано организационный, констатирующий, формирующий и аналитический этапы экспериментальной работы, а также их связь с заданиями и методами исследования. Представлено характеристику программы педагогического эксперимента о выявлении эффективного влияния дидактической модели, основанием которой является авторское научно-методическое обеспечение процесса доуниверситетской физико-математической подготовки старшеклассников. Обоснованы критерии (целевой, мотивационный, когнитивный, деятельностный, рефлексивный, результативный) и уровни (высокий, средний, низкий) результатов эмпирического исследования в соответствии с спроектированными компонентами физико-математической подготовки старшеклассников к обучению в техническом университете. Определены перспективы внедрения спроектированной программы педагогического эксперимента в процессе доуниверситетской физико-математической подготовки старшеклассников.

*Ключевые слова:* педагогический эксперимент, эмпирическое исследование, программа изучения уровня физико-математической подготовки старшеклассников к обучению в техническом университете.

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