The "new materials in technology" elective course

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Abstract. The article deals with laws and phenomena of molecular physics that are the basis for development of new materials with predetermined properties and methods of handling them. The proposed elective course familiarizes students with the basic lines of the progress in science and technology with respect to developing new materials, with general regularities of production and technology of processing materials, and with scientific principles of production of materials for the current technology. It offers detailed topical planning, methods of training in molecular physics, and forms of various lessons in it. Besides, this elective course provides good opportunities for development of creative abilities of students, formation of polytechnic knowledge and skills in the sphere of development of materials for current technology. The article contains brief description of practical physical work as a means of improvement of the level of cognitive interest of secondary school students.
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Introduction

The problem of formation of the cognitive interest of students becomes one of the most urgent in view of development of the industry-specific education. The concept of industry-specific training determines the strategy of changes of the content and the structure of general education [1, 2]. Elective courses of advanced level target advanced study of physics and have both topic-based and temporary coordination with the specialized physics course [3, 4]. Selection of such a course will allow to study physics at an advanced level. This article studies scientific and methodological literature related to formation of education motives and cognitive interests with students in the course of studying physics. This elective course primarily targets development of the cognitive interest and organization of unassisted practical activity of students [5, 6].

Materials and methods

Concerning this problem, works in the sphere of industry-specific education, theory and practice of teaching physics by foreign, Russian, and Kazakhstani scientists have been studied. The methodological basis for the course is the theory of cognition; the theory of development and formation of a human as an active, creative, and socially adapted to activity person; modern theories of industry-specific education; the theory of integral pedagogical process; and the systemic approach to studying new machinery and technology of production. The innovative features of the program in the system of preliminary industry-specific training are the extension of discipline competences in physics by using practice-oriented devices of the cognitive activity, which activate cognitive interest of students through motivational approach and empirical methods. Elective lessons use such methods of teaching as: teacher's explanation, reports of students at seminars, discussion of reports on certain issues in physics, solution of problems, fulfillment of laboratory works, excursions. Special attention is paid to the methodology of holding seminars, which allows to teach students how to handle literature, select material for reports and reviews [6]. Students unassistedly carry out a lot of practical work, experiments of partially research nature – for example, they determine the hardiness of composite materials, study the physical and mechanical properties of liquid crystals and the microstructure of dispersion-strengthened materials, etc. The research shows that the "New Materials in Technology" elective course is closely associated with the main course and bases on carrying out cross-disciplinary relations with other disciplines.

Discussion

This course allows a teacher to show the main stages of development of automatics, emphasize the dominating role of automation in the contemporary production, and covers the most important lines of the progress in science and technology. The program of the course allows to extensively study the problems of the Molecular Physics section and assumes further development of students' skills. The elective lessons selected by students are one of the education forms that ensure the most comprehensive reflection of achievements in science and technology in the physics course [7, 8].

They allow to introduce significant additions to enhancement of the content of school courses without changing the curriculum, stable programs and textbooks. This purpose has determined the development of the "New Materials in Technology" elective course. The methodological developments of the elective course prepared by us have been forwarded to the regional institute of teachers improvement and are recommended for usage in teachers' practice. The purpose of the elective course is enhancement of knowledge on development of new materials with pre-determined properties and on the technology of their processing, extension of scientific area of students' thought, ensuring comprehensive development of students' creative abilities. The "New Materials in Technology" elective course familiarizes students with main lines of the progress in science and technology in developing new materials, general regularities of production and technology of processing materials, and scientific principles of production of materials for the current technology [8]. The "New Materials in Technology" course provides students with the scientific understanding of the main issues of materials production. Besides, this elective course provides good opportunities for development of creative abilities of students, formation of polytechnic knowledge and skills in the sphere of development of materials for current technology. During the "New Materials in Technology" elective course, students receive systematic knowledge and practical skills in applying molecular physics at developing new materials They extend their knowledge of structural and functional singularities of crystalline construction and powdered materials. This knowledge is based on the first stage school physics material; still it does not copy it but extends and expands it. The topics of development of new materials with pre-determined properties selected for studying within the course of molecular physics are of great industrial and economic importance. The detailed study of the applied course of molecular physics allows to familiarize students with the prospects of development of construction materials production, and with physical properties of new materials and technology of their production and processing [8]. The theoretical ground for this course are the laws and the phenomena of molecular physics that are the basis for development of new materials with predetermined properties and methods of handling them. At studying these regularities, the knowledge of the production of construction materials and the understanding of the technological processes of production of the materials and products are also improved. Students are familiarized with the progressive technology of material machining, namely such its types as vacuum metallurgy, diffusion coating, ultrasound, etc. At development of the elective course, we based on the requirements of the enhanced study of physics by means of applying the knowledge to particular technical objects and kept to the following tasks:

a) to familiarize students with main lines of the progress in science and technology and problems of development of new materials;

b) to ensure assimilation of the scientific principles of development of new materials for the current technology;

c) to enhance practical knowledge obtained in the sphere of production and technology of processing construction materials;

d) to form skills in research and creative activity of students;

e) to encourage occupational self-determination of students in the circumstances of the progress in science and technology.

As shown by our research [8, 9], formation of polytechnic knowledge and skills is possible via the "New Materials in Technology" elective course (34 hours).

1. Introduction (1 hour). Prospects of development of new materials. Importance of the materials for expedition of the progress in science and technology. Objectives of the "New Materials in Technology" elective course.

2. Physical grounds for developing new materials with predetermined properties (8 hours). Structure and properties of the materials. Singularities of the molecular structure of the materials in various states of matter. Interacting forces between molecules and atoms in the materials. Powder metallurgy. Surface phenomena. Wetting. Development of dispersion materials. Structure of imperfect crystals. Development of ultra-pure, mono- and semi-crystalline materials. Space lattice. Defects in crystals. Strength by destruction. Phase and structure transformations in materials. Liquid crystals. Amorphous materials and their properties. Physical properties of new materials: strength, elasticity, plasticity.

3. Technology of processing new materials (6 hours). Mechanical machining of construction materials. Cold, impact, and explosion compactions. Forging. Cogging. Hammering. Singularities of heat treatment of powder materials (normalization, calcining, re-crystallization, quenching, softening). Thermochemical treatment of materials. Nitriding. Carbonization. Progressive technology (high pressures, ultrasound, plasma spray, diffusion coating).

4. Materials of modern technology and their application in industry (5 hours). Construction powder materials. Materials based on nonferrous metals and

alloys. Refractory metals and their alloys. Plastics as a construction material. Polymer composite, wear-resistant, and corrosion-proof materials.

1. Excursions (4 hours).

Physical practical work (10 hours).

1) Study of properties of liquid crystals.

2) Study of breaking point of composite materials.

3) Heat treatment of construction materials (aluminum and copper alloys).

4) Study of the microstructure of dispersion-strengthened materials.

5) Determination of the temperatures of phase transformation of alloys (bismuth and tin).

Results

The practical importance of the work resides in the fact that its results can be used by teachers at educational institutions [10, 11]. The result of the work is the development of several laboratory-based works in the "New Materials in Technology" elective course, which were focused on development of the cognitive interest of students. Experimental check gives reasons to say that the developed course allows students to apply the acquired knowledge creatively, allows to form and develop the students' skills, to familiarize students with physical principles of development of such materials. The course's structure provides for not only giving a scope of scientific and practical information, but also for training of independency, initiative, ability to think logically and rationally, implementing a wide range of various operations and actions included in the unified method of scientific cognition. These competences have practical application in the life, they will be in demand in the future of the students and will help them find their place in the society. Thus, the developed course is focused on raising interest to physics and contributes to better assimilation of the material, creation of conditions for independent creative activity of students, and on causing interest to practical activity based on the materials of the applied physics [11, 12].

Summary

The program of the "New Materials in Technology" course provides for not only extension of knowledge, but also for further development of the students' skills. The said works of the practice in physics that contribute to improvement and extension of the polytechnic skills of the students are recommended by us to students of urban and rural secondary schools. The problems of development of new materials with predetermined properties selected for studying within the course of molecular physics are of great industrial and economic importance. Generally, the experience of holding the "New Materials in Technology" elective course evidences that its content is quite comprehensible for students, and the application of the developed guideline at lessons produces certain positive effect.

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