ПЕДАГОГИЧЕСКИЕ НАУКИ / PEDAGOGICAL SCIENCES
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THE DEVELOPMENT OF THE ELECTIVE COURSE ON THE THEORY OF KOLMOGOROV COMPLEXITY IN ENGLISH FOR SENIOR STUDENTS OF PHYSICAL AND MATHEMATICAL PROFILE

СОЗДАНИЕ ЭЛЕКТИВНОГО КУРСА ПО ИНФОРМАТИКЕ ПО ТЕМЕ «ТЕОРИЯ КОЛМОГОРОВСКОЙ СЛОЖНОСТИ» НА АНГЛИЙСКОМ ЯЗЫКЕ ДЛЯ УЧАЩИХСЯ СТАРШИХ КЛАССОВ ФИЗИКО-МАТЕМАТИЧЕСКОГО ПРОФИЛЯ

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Abstract. The article is devoted to the problem of preparation and implementation of an elective course in computer science as one part of the course of teaching high school students of physical and mathematical profile. Currently, specialties where a foreign language is used in its applied function, often as the means to study another subject area, are popular. This is due to the fact that many students want to use their English–speaking knowledge and skills in their future profession. It is possible to impart an applied nature and practical orientation through conducting elective courses that would familiarize the students with the basics of their future professional activity. The use of English for conducting elective courses contributes to the formation of communicative competence of students and the development of academic skills. The aim of the work is to create an elective course in English "Theory of Kolmogorov complexity".

Methodological basis of the research was personal–oriented, system–activity and competence approaches to teaching. The elective course proposed is the introduction of students into a new area of computer science — the theory of the complexity of information, which is closely related to cybernetics.

The result of the study was the development of an elective course program in English, which includes not only a methodology for conducting and a plan of course, but also various types of

assignments that contribute to better understanding of the material offered to students and can initiate research work on this topic. Particular attention is paid to communicative orientation, involving the use of English in the future professional activities of students.

The results of the research can be applied in the practice of school instruction in computer science, and also serve as a basis for the preparation of teaching aids and special courses for high school students in physical and mathematical profile.

Аннотация. Статья посвящена проблеме подготовки и реализации элективного курса по информатике в рамках обучения учащихся старших классов физико–математического профиля. В настоящее время популярностью пользуются специальности, где иностранный язык используется в своей прикладной функции, зачастую в качестве средства для изучения другой предметной области. Это объясняется тем, что многие школьники хотят использовать свои англоязычные знания и умения в своей будущей профессии. Придать обучению прикладной характер и практическую направленность возможно за счет проведения элективных курсов, которые знакомили бы учащихся с основами их будущей профессиональной деятельности. Использование английского языка для проведения элективных курсов способствует формированию коммуникативной компетентности школьников и развитию академических навыков.

Целью работы является создание элективного курса на английском языке «Теория колмогоровской сложности». Методологическую базу исследования составили личностно–ориентированный, системно–деятельностный и компетентностный подходы к преподаванию. Предлагаемый элективный курс является введением учащихся в новую для них область информатики — теорию сложности информации, которая тесно связана с кибернетикой. Результатом исследования стала разработка программы элективного курса на английском языке, которая включает в себя не только методику проведения и план занятий, но также различные виды заданий, которые способствуют лучшему освоению предложенного материала у учащихся и могут положить начало исследовательской работе по этой тематике.

Особое внимание уделено коммуникативной направленности, предполагающей использование английского языка в будущей профессиональной деятельности учащихся.

Результаты исследования могут найти применение в практике школьного преподавания информатики, а также послужить основной для подготовки учебных пособий и специальных курсов для учащихся старших классов физико–математического профиля.

The theory of information complexity is undoubtedly one of the most important branches of modern mathematics. Some statements of given theory of algorithmic complexity seem to be simple but they are at the same time difficult to solve. These problems are of interest to modern students who are going to enter the faculties connected with information technologies. It is worth noting that the algorithmic constructions used in the theory of information complexity are the basis of most modern mathematical applications. In addition, the popularity of this theory is due to the extensive application of theoretical foundations in modern high technologies. When considering the course on the topic "Theory of Kolmogorov complexity" in the course of computer science for high school students of physical and mathematical schools, it is important to pay attention to the increasing role of information technology in the life of modern society.

The main problem of teaching computer science in schools is the lack of a systematic approach to teaching. School lessons are, as a matter of fact, reduced to memorizing the basic constructions of a machine code, while the important skills — formalization of algorithmic approaches and the formation of logical thinking are bypassed. The study of the fundamentals of algorithmic theory is primarily aimed at developing the logical and algorithmic thinking of students. At present, there are practically no detailed guidelines on the teaching of the theory of algorithms and the theory of computational complexity for school students. The proposed version of the course is different in that it focuses on the part of the theory of algorithms that relates to the study of the capabilities of computers and the complexity of computations.

The choice of English in these classes is conditioned by the possibility of forming a communicative culture among students, which promotes the use of English in the professional field of activity and in everyday life. In order to create favorable conditions for the practical mastery of the language in the school educational process, it is important to choose methods that will help students show their abilities and initiative. The use of English for conducting the proposed course is aimed at forming the communicative competence of students and all types of speech activity, as well as the development of academic skills.

Thus, the purpose of this course is to orient students towards individualizing of learning, as well as to prepare them for a responsible and conscious choice of future professional activity and to develop the ability of students to use a foreign language in their professional activities.

The offered course's tasks are the following:
1) to form a cognitive interest in the subject;
2) to promote professional self-determination;
3) to develop communication skills in English;
4) to study the special terminology of the subject in English;
5) to provide a higher level of knowledge.
The course in English enables:
1) to use actively the information that was received by the student;
2) to deepen the knowledge gained through discussions;
3) to get skills of individual work with specialized literature in English;
4) to develop research skills;
5) to develop communication skills in English;
6) to prepare for lifelong learning.

The following forms are considered as the main forms of conducting the suggested course:
1) presentation of students on a pre-selected topic;
2) a detailed conversation on pre-announced issues;
3) discussion by the students of the tasks proposed by the teacher;
4) protection and discussion of reports (abstracts).
It is worth noting that these forms can be combined with each other (mixed forms).

To illustrate how the offered course can be implemented across the curriculum, we focus below on the plan of this course and tasks for them. Given below are some illustrative plans, but this is not intended to be an exhaustive listing of all proposed theory, with which students are going to encounter. Most part of the classes should be provided by the tasks, given to the students for oral report and discussions.

Table.

AN ILLUSTRATIVE PLAN OF THE COURSE

Topic of the class	Example Problem Given
Introductory lesson. The concept of an algorithm. Formalization of the concept of an algorithm.	
Computability of functions.	Give an example of computable functions and an example of a non-computable function. Prove that the value of this non-computable function cannot really be computed by any program.
The concept of a Turing machine.	Write a program for Turing machines that compute elementary functions: $x + y$, $x + c$, where c is an arbitrary constant (using a table of commands).
The concept of time complexity of the algorithm. Configuration of Turing machines.	Solve the previous problem using configurations of Turing machine. Calculate the execution time of each program. Try to find a function which restricts the execution time of the programs, which are given above. Make a short speech about the different programs for computation of different functions and their execution time.
Kolmogorov complexity. Optimal ways of describing the algorithm.	Let two arbitrary ways of describing D1 and D2 be given. Show, that there is a way of describing D, which is not worse than both of them.
Kolmogorov complexity. The main idea.	Why we can't talk about the Kolmogorov complexity of a specific word x according to its definition, without indicating which optimal way we are going to use? Then what is the point of Kolmogorov complexity?
Kolmogorov complexity as the amount of information.	Let x and y are two words. If we concatenate one to the other how many bits of information will new word have? Why? If we rearrange the order of the letters in the word, will Kolmogorov's complexity change?
Algorithmic transformations of information	Prove that the amount of information does not increase under algorithmic transformations (more precisely, it increases by no more than a constant depending on the transformation algorithm).
The non-computability of a function that computes the Kolmogorov complexity and the Berry paradox	Final lesson. Summarizing.

The literature proposed for study:
1. Ming Li, Paul Vitányi, An Introduction to Kolmogorov Complexity and Its Applications
2. Downey R., Hirschfeldt D. Algorithmic Randomness and Complexity.

It should also be noted that the proposed literature should be the main source, but the students should be ready to independently search for and analyze foreign literature on the subject of the course. Below is an approximate plan of classes, the peculiarity of which is the alternation of work in the classroom between the teacher and the students. It is assumed that the teacher will ask the subject of the lesson, and the students will have to expand it through oral presentations and discussions on topics suggested in the right column.

At present, elective courses have firmly entered the life of schools that, in accordance with the requirements of the Federal State Educational Standard (1), implement specialized education at the higher level of general education. The profiling of the educational process presupposes the creation of conditions for the training of high school students in accordance with their professional interests and intentions with respect to lifelong learning. Profiling is designed to develop such professionally significant personal qualities as creative and critical thinking, ability to reflect and self-esteem. Profile education can improve the information and communication culture of graduates. Today there are contradictions between the needs of the school in updating the content at the senior level and the insufficiently developed scientific and methodological base providing a profile orientation, including one in a foreign language; between the personal needs of high school students in mastering a foreign language as a means of communication in the field of professionally–oriented interests and the lack of real conditions for meeting these needs; between the demand for various elective courses and the lack of educational and methodological support.

In connection with Russia's desire to enter the European educational space, profile–oriented teaching of English takes on special significance. It was revealed that the profile–oriented teaching of English in practice is realized in teaching of various kinds of elective courses in which the English language interacts with the disciplines of the humanitarian and other cycles and acts simultaneously as a learning objective and as a means of studying another subject area. Taking into account the theoretical aspects of the development of profile–oriented programs (principles of construction, program functions), this paper proposed the development of an elective course in computer science on the theme "Kolmogorov's theory of complexity", which is one of the branches of science called computer science. According to the typology proposed in the article [1, p. 1], this elective course can be attributed to the perforating courses of a higher level. The course was developed in English. It is important to say that this course can help students both in improving their skills in English and choosing the future direction of education. It should also be noted that this course was designed taking into account all the features of teaching students of the physical and mathematical profile, which will allow to integrate it into the educational process.

This course can also be useful to those students who plan to continue their studies in higher education institutions in the specialties related to cybernetics, since the theory of information complexity is the basic subject in the first course of these faculties.

The results of the proposed study can be used in teaching computer science in English in the upper grades of specialized gymnasiums.

This study contains a number of promising areas:
1) improvement of the tasks of the educational–methodical manual;
2) further development of the typology of classes on the elective course with the support of integration;
3) a description of the conditions for creating programs and manuals for applied elective courses.

Sources:
(1). Federal state educational standard of secondary (complete) general education (2013). Moscow, Prosveshcheniye, 63

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