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VISUAL SUPPORT OF THE "SORTING AND SEARCHING ALGORITHMS" COURSE OF BASIC PROGRAMMING

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This paper is investigated the requirements and general theoretical approaches to the construction the computer mathematics system for educational purposes of studying algorithmization and programming, which have their own specificity. The basic form of practical activity of the student is laboratory work. Specific problems are the problems of program representation by both special and general mathematical models.

*It is advisable to carry out the initial study of algorithmization in the course of informatics of high school using specialized educational-oriented so*ftware-methodological software. *The article considers a subject-oriented approach to the construction of information systems to support the learning process while studying the course of algorithmization and programming. This approach is applied to the implementation of the software-methodological complex "Video Interpreter for searching and sorting algorithms". The software-methodical complex is created for application in educational process during teaching of discipline "Fundamentals of algorithmization and programming" as means of debug-ging a deeperunderstanding of the processes occurring in the computer, improvement of logic of writing of programs.*

The article considers the purpose of the program-methodological complex "Video Interpreter for searching and sorting algorithms" and the integrated environment of the course "Fundamentals of Algorithms and Programming" are described.

The use of the program-methodological complex "Video Interpreter" in the educational process allows to organize at a high level students' educational and research activities; to activate students' independence in mastering knowledge; reduce the time needed to set up the program; accelerate the develop-ment of students' logical thinking.

***Keywords**: systems of computer mathematics for educational purposes, computer software, support of learning processes, visualization.*

1. Introduction

The trends of the last decades demonstrate the rapid growth of the amount of knowledge needed by modern humanity, the widespread introduction of professionally oriented information systems in society, the total penetration into all spheres of human activity of global information and communication networks. This necessitates the intensification of the learning process, the improvement of the quality of learning and the enhancement of students' intellectual abilities through the informatization of the educational process.

Modern education tools are fundamentally different from the education tools of the past. Interactive multi-purpose learning systems are becoming increasingly popular, i.e, effective both in the classroom, in the workshops, and in their own use [1, 2].

Complexly addressing specific learning process maintenance tasks allows the use of computer-based system of computer mathematics for educational purposes (SCMEP) in the learning process [3, 4].

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SCMEP is a software system for natural science and mathematics courses that use mathematical models and domain methods based on symbolic transformations and computer algebra.

General theoretical and methodological bases, formulation of functional requirements and development of the SCMEP model as a system for supporting the learning processes in the exact disciplines are described in [5].

A separate study is required by the SCMEP for algorithms and programming.

Conducted in the work [6] theoretical analysis of scientific researches and publications on the problem of creation of complex software systems for mathematics educational purpose, familiarization with practical experience in the problem of research of SCMEP in mathematics have revealed a number of contradictions between the requirements for software systems for mathematics and educational purpose.

The identified contradictions made it possible to formulate the problem of pedagogical provision of the wholeness of the process of teaching mathematics with the help of SCMEP in mathematics.

The section "Basics of Algorithms and Programming" occupies a special place in the academic programs in the discipline "Informatics" of a comprehensive school. If the purpose of the other sections is to provide students with the skills, knowledge and competencies of the user of modern information technologies, then the educational material of this section is aimed at shaping the future specialist in the field of computer technology development. Thus, this section is included in the discipline syllabus, in particular in order to provide early guidance for students who have demonstrated aptitude in computer science.

The modern curriculum of the "Basics of Algorithms and Programming" section enables the teacher to choose both the teaching language of programming independently and to a great extent independently determine its didactic content. In particular, the teacher can choose an object-oriented or structural methodology of algorithmization, choose any of the programming languages: Pascal, C, Visual Basic, etc. The teacher can use professional development environments in the teaching process. For example, you can choose professional development environments (Borland Pascal, Free Pascal etc.) to study Pascal programming. The teacher can also use programming-oriented development environments (PascalABC, Lazarus, etc.). [6]

However, an analysis of these environments shows that they do not complete all the tasks of supporting the learning process of programming.

There are specific tasks that require both the development of new algorithms and specialized software systems for educational purposes based on the technology of symbolic transformations and algorithms of computer algebra [7].

It is expedient to carry out the initial study of algorithmization in a computer science course of a general school using specialized educational-oriented program-methodological software – SCMEP on algorithmization and programming. This should be an integrated algorithm environment that supports the structural methodology of algorithm migration in combination with object-oriented software systems builders.

The SCMEP (electronic) didactic materials on algorithms and programming should include the textbooks, manuals, methodological manual, reference library, reference book, dictionary, etc. The functionality of these modules is outlined in [8, 9].

The SCMEP of algorithms and programming must support the process of creating algorithms (programs). From a technological point of view, information support for the process of creating an algorithm (program) is possible provided that it takes place in a specialized business environment. Activity Environments are the main SCMEP software modules.

While learning the algorithms of information processing represented by different data structures, such an environment should be a programming environment.

The principle of clarity is of particular importance in the study of algorithmization and programming.

Through the thoughtful use of visual aids can enhance the emotional impact on students, increase the availability of material, accelerate the activation of students' mental activity. There are currently a number of visualization systems for algorithms (Balsa, Tango, Vizi тощо) [10,11]. But these systems provide only one aspect of educational systems for educational purposes – clarity.

To comprehensively solve the problem of teaching the section "Basics of Algorithms and Programming" at school will allow SCMEP on Algorithmization and Programming with a built-in activity environment for rendering algorithms, which allows you to dynamically display the details of their work.

2. About the SCMEP for algorithms and programming

Scientists of the Department of Informatics, Software Engineering and Economic Cybernetics of Kherson State University under the guidance of Professor M. Lvov has long been engaged in the implementation of the concept of computer mathematics for educational purposes. A number of SCMEP for the Ministry of Education and Science of Ukraine have been developed. Here are some of them (copyright certificates [13-15]):

−Program methodical complex "Video interpreter of searching and sorting algorithms".

−Integrated environment for "Basics of algorithms and programming" studying in higher educational institutions.

In our study, we describe the program methodical complex "Video interpreter of searching and sorting algorithms" to support the course "Basics of algorithms and programming" (hereinafter – VideoInterpreter) [12, 13]. It is designed for the secondary school at the request of the Ministry of Education and Science of Ukraine (MESU), recommended by MESU for use in the educational process (received the stamp of the MESU), and is used in the educational process in secondary schools of Ukraine. She successfully passed the certification procedure UkrSEPRO, the relevant commissions of the MESU, established the MESU testing procedures in secondary schools of Ukraine.

The methodology of teaching the basics of programming, reveals the maximum possibilities of the computer in the organization and management of didactic process, automation of the stages of the learning process should be SCMEP of algorithmization and programming. It has:

−to build on the already existing and generally accepted notation to write algorithms (e.g., notation of Pascal);

−to support the development of algorithms for problem – and subject-oriented performers (abstract data types);

−to provide the programmer all the tools one of the most common implementations of a programming system (e.g., Borland Pascal);

−to be easy to use and intuitive to work with.

−suitable for use by the teacher for teaching the educational material, demonstrations of process development and execution algorithms, quickly check the properties of the algorithms written by the students;

−suitable for use by students – for practical classes and laboratory work;

−to include in its composition all, the essential didactic and methodical support.

−to support the choice of interface language (Ukrainian, Russian, English).

The main feature of the software VideoInterpreter is to take into account the specifics of the subject area and to implement in a single methodology and in the interaction of all electronic learning tools: electronic manual, programming environment, program demonstration environment, reference book etc.

The Software Methodical Complex (SMC) "VideoInterpreter of searching and sorting algorithms" consists of the following blocks (Fig.1):

− *Programming environment* with a collection of source code for SMC algorithms and a collection of source code for user algorithms and programs.

− *Demonstration environment* with a collection of demonstrations of SMC VideoInterpreter algorithms and a collection of demonstrations of user algorithms.

− *Electronic textbook* on algorithms "Search and sort algorithms".
− *Electronic reference book* to Pascal programming language.

Programming Environment allows you to:

− write your own algorithm using the Pascal standard (video demonstration output modules with Data and Index types);
− use a Pascal compiler or demonstration environment to run the program;
− save the program in the user's collection;
− download the finished application from the system or user collection;
− observe the program implementation process in a demonstration environment.

While writing the program, the user works in the mode of the *VideoInterpreter Programming Editor* (Fig. 2), namely with the structural representation of the programming language constructs (block diagrams).

Fig. 1. Software Methodical Complex "Video interpreter of searching and sorting algorithms" Version 1.0

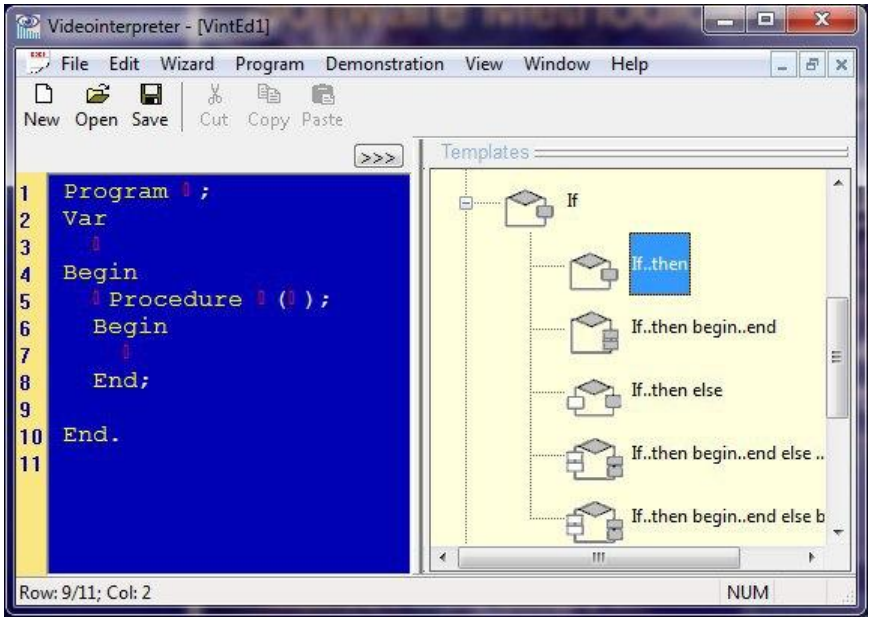


Fig. 2. The module window programming Environment

The *programming environment editor* is specialized. It is designed for beginner programmers. Special tools include: patterns of basic language control structures, control of display of procedure bodies, functions, sections of descriptions, some specific editing tools.

The programming environment implements: Integer, Boolean and Data types; description of constants and variables, including arrays; evaluate expressions; the assignment; branching (if-then-else); loop (while, repeat); the compound operator.

But there are limitations to the programming language for describing algorithms for demonstration. Such algorithms do not use sections of types, modules (Uses), Input – Output operators (Read, Write, Readln, Writeln), operators With, file processing operators, operators of line processing, variables of standard simple types (Real, Char) and functions that return values of these types, variables of simple types that are defined by the programmer (type interval, scalar type), variables of structured types (Record, Set, File, String, type of link), arrays as parameters of procedures and functions.

The word Data is used to indicate the system's own data type, which is displayed in the columns in the demo (Data type = 0..99). The Data type must be used to run a demo of the algorithm.

Only one-dimensional arrays of Data and Boolean types can be used in algorithms. The maximum size of a one-dimensional array is 1..MaxSize (MaxSize = 31).

Arithmetic and logical operations are not defined for Data variables, only comparisons of magnitude and assignment of the simplest form are defined.

The Electronic training aids "Searching and sorting algorithms" (Fig.3) is a modern multimedia hypertext application, built in the form of a structured collection of topics and algorithms, it includes text fragments, graphical illustrations of algorithm execution, source module texts.

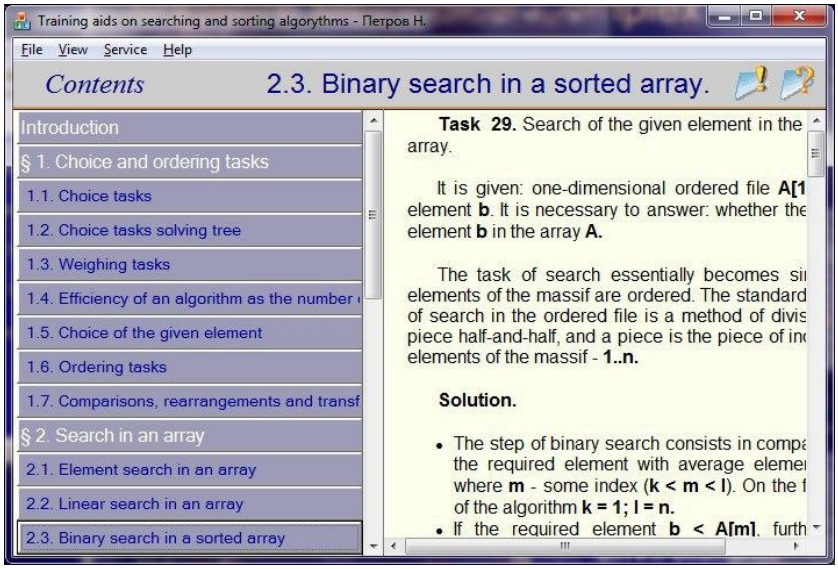


Fig. 3. Window of the module Electronic training aids

The purpose of the textbook:

- Study of information processing methods, grouped in the form of a sequence of identical data.
- Formation of representations about the computational complexity of an algorithm that processes complex data structures
- Formation of structural programming skills.
- Formation of ideas about the analysis of algorithms and programs.
- Fixing program debugging skills in the programming environment.

Access to the manual is possible from the operating system, VideoInterpreter Environment, Programming Environments, Demonstration Environments – in the standby state of the

demonstration or in the state of interruption (temporary stop) of the demonstration. The system opens the section of the manual that contains material from the demonstrated algorithm.

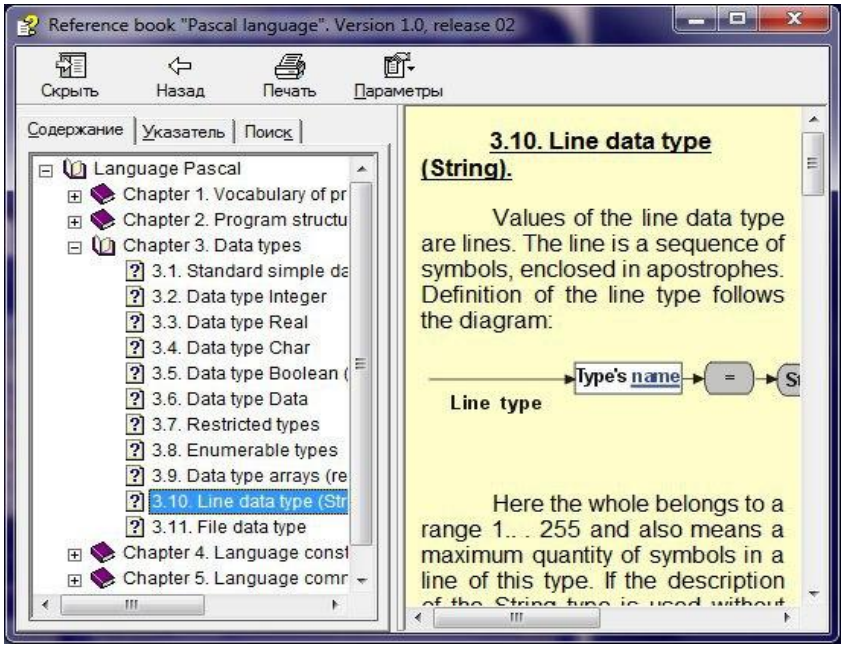
Contextual access from the manual to the demonstration environment is also possible. You can use the Demo button or context menu command to go directly to the Demonstration Environment and view the execution of algorithm described in the appropriate section.

Some of the tasks included in this guide do not directly relate to sorting and searching tasks, but the methods for solving them are used in sorting and searching tasks.

The textbook lists self-solving tasks with an asterisk for the ones that seem to be the most interesting. Some of these tasks have directions.

Working with the software and methodological complex involves personalization, enabling the user to take notes when needed in the textbook fields.

Electronic *Pascal programming language reference* book (Pic.4) is a modern hypertext document in the same standard as *training aids*, which includes text fragments, tables, syntax diagrams, flowcharts, other graphical objects, source module texts, which can be accessed by any user, which part of the complex. The Electronic reference book is linked to the electronic *training aids* of the complex via hyperlinks and, if necessary, provides contextual help to the terms found in the text of *training aids*. The Electronic reference can be used as a *training aids* on Pascal programming language.



Pic. 4. The Electronic reference book module window

Each topic of the guide is a methodologically thought-out reference syllabus for relevant teaching material, intended for use by both the teacher and the student in computer science lessons. The necessary material is consistent in content and terminology with the school textbook and supplemented with descriptions of the object types Data, Index, which are used in the description of search and sorting algorithms. Access to the Programming and Demonstration Environment *reference* book is organized as well as the *training aids*.

The *reference* book links are only installed inside the *reference* book itself. Using the content, the user can display one of the sections of the *reference* book on the system. It can also use keyword search.

Demonstration environment (Pic. 5) is intended for demonstration of algorithms at lectures, during practical classes and laboratory works. The use of this module allows more attention to be paid to the analysis of algorithms (the various data sets as a result of the demonstration determine the main characteristics – the number of comparisons and the number of permutations).

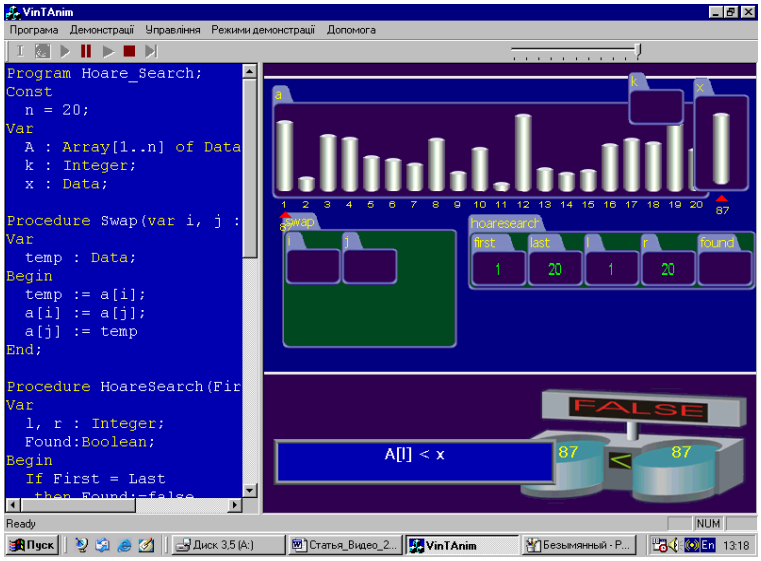


Fig. 5. The Demonstration Environment module window

An effective traditional method for understanding the concept of programming is manual tracing (execution) of algorithms. It allows the student to act as an algorithm executor, to demonstrate data changes in the computer's memory elements and to execute commands depending on the conditions. Using manual tracing takes a long time, so a new approach is proposed – step-by-step implementation of algorithms in the Demonstration Environment VideoInterpreter. In addition, the VideoInterpreter has the ability to continuously view the algorithm, input data, and more.

In the demonstration environment, the user has the opportunity to select and open an algorithm for demonstration from the system's collection or from the user's collection, to initiate the data of the demonstration, to organize the demonstration, to perform the demonstration in continuous or incremental modes.

In the kernel of this module is the specialized interpreter of subset of language Pascal oriented to the programs as sorting and search.

The system VideoInterpreter gives the program that an user writes for demonstration the name with expansion .alg, and to the program prepared for demonstration – the name with expansion .dem.

Using dynamic images of operations of assignment, comparison, transfer of parameters in procedures and functions, recursive calls of procedures and functions, process of input data generation makes the demonstration environment extremely useful means of studying the basics of algorithmization.

Here are the main features of the demo environment:

- loads the algorithm into the demonstration environment. An algorithm loaded into the demo environment can be stored in the user's collection and rendered.

- opens a system collection that contains basic algorithms for the course «Basics of Algorithms and Programming». Each algorithm in the system collection can be downloaded into the demonstration environment and rendered.

- opens a user collection containing algorithms created by the user of the integrated environment. Each algorithm in the system collection can be downloaded into the demonstration environment and rendered.

- generates data to visualize the execution of an algorithm in a demonstration environment in one way (ascending, descending, randomly, data input or downloading data).

- executes the algorithm in a demonstration environment.

- switches step by step / continuous run mode and allows visual display of exchanges and comparisons when running the algorithm in a demonstration environment.

- calculates the number of permutations and the number of comparisons when performing an algorithm in a demonstration environment on a specific data set.

Thus, thanks to the possibilities of the environment, the teacher is able to diversify types of practical tasks in algorithmization [2]:

- to execute the algorithm from a collection system or a custom collection for specific data;
- to create an algorithm for solving the problem;
- determine the efficiency of the algorithm;
- compare the performance of algorithms for a given dataset;
- research and simulate data for a particular algorithm (random, best and worst cases, etc.);
- to summarize the results of the analysis of algorithms when comparing different methods of solving a problem;
- offer a more efficient algorithm for solving the problem.

SMC VideoInterpreter keeps two collections (libraries) of algorithms – collection of the system and collection of user. In collection the systems are collected those algorithms that entered to train aid. This collection an user cannot change. She is intended only. At the same time an user has the opportunity to make the copy of any algorithm out of collection of the system, by arbitrary character to edit her, creating thus the own algorithm on the basis of algorithm of the system. Own algorithms it is recommended to keep in collection of user.

The class of tasks of the SMC VideoInterpreter is various algorithms for processing of data arrays, including sorting, searching for unique elements (highs, lows, etc.). However, the use of the program is not limited to this class of tasks. Other user-defined applications are also possible.

SMC "Video interpreter of searching and sorting algorithms" is designed for effective use by teachers and students in the educational process.

Software and methodological complex VideoInterpreter consists of the following parts:

- for the teacher: an electronic textbook, a guide to the Pascal programming language and a collection of algorithms for demonstration support of the lecture part of the lesson;
- for the student: a special programming environment for practical work and laboratory work, an electronic textbook, a guide to Pascal programming language.

Use of the program-methodological complex in the educational process The Video Interpreter allows to organize at a high level the educational-research activity of students, which will significantly improve their mastery of their knowledge; to activate students' independence in mastering knowledge; reduce the time needed to set up the program; accelerate the development of students' logical thinking.

When used by the teachers of the SMC VideoInterpreter, the quality of the organization of the educational process will change, namely – the time allocated for studying a separate thematic unit and the time required for conducting current and thematic control will be reduced; increase the objectivity of students' knowledge control; there will be an increase in trends of individualization and differentiation of the educational process.

When assessing the possibilities and directions of the application of the SMC VideoInterpreter in the educational process, the teacher should proceed from the following provisions:

−The main subject of this subject area – the section "Basics of algorithms and programming" is an algorithm (program). The practical activity of a programmer is to write a program, that is, to construct an object algorithm (program). The basic properties of this object are syntactic and semantic correctness, efficiency in time and memory.

−The algorithm (program) is presented to the student in the form of a complex construction, composed of other, more simple objects – descriptions of data, commands, auxiliary algorithms.

−The specifics of this subject area are that algorithms determine the transformation of other objects – data, and the sequence of these transformations the student must plan, imagining their implementation in time and space – memory space. By converting the main object – an algorithm, the student changes the progress of the algorithm. Thus, the student, on the one hand, deals with a static object – the text of the algorithm, and on the other – has to imagine and plan its dynamic properties.

When programming, the student always uses one or the other programming system that provides assistance, providing him with the tools of syntactic control, debugging, etc.

The teacher, using a subject-oriented system of practice support, plays a central role in the learning process. It schedules students 'educational work, monitors its progress and evaluates students' performance. At first glance, nothing has changed for the teacher. In fact, the main feature of the use of subject-oriented systems of support for practical activity is the release of the teacher from many routine activities and give his work a creative, guiding character.

Traditionally there are three methods of algorithms description used in school methodology: flow-chart, educational algorithmic language and programming language. This programmatic-methodical complex it can draw on during work with flow-charts. A basic attractiveness of flow-charts is clearness of algorithmic structure. Ability must become the basic consequence of capture of structural methodology students at the construction of algorithms to "think structures", for example, by such terms, as cycles are inlaid, cycle with the inlaid branching and others like that. The structural image of flow-charts helps such presentation of type of algorithms.

Basic components of the algorithmic thinking: structural analysis of task, distribution of intricate problem on more simple, bringing a new task over to the task, uniting of that is already known, planning of situations and reactions on the got answer, use of formal methods of record of decision of task. All of it carries universal character and has application practically in all industries of activity of man. Task of teacher – to develop these components of thinking for students.

Realization and use of auxiliary algorithms or procedures are one of effective facilities of programming, it is important that is why, that students present to the soba all chart of actions of performer at the call of auxiliary algorithm with concrete arguments and return to the main program with the got results.

The system supports procedural programming: parameter transfer, implementation of recursive procedures. It is necessary to pay attention to students that a fundamental difference is not between a basic and auxiliary algorithm, but, after completion implementation of auxiliary algorithm, a performer necessarily goes back to the that point of basic algorithm, where the organized subroutine call was from.

On traditional methodology a teacher for demonstration evidently of process of implementation of auxiliary algorithm uses protocols or tables, where by means of pointers draws the course of performance of algorithm. In the environment of Demonstration of VideoInterpreter in the step-by-step execution of algorithm state a student has the opportunity to watch not only after the course of performance of algorithm but also after changes that take place in memory cells, where the current values of variables are kept.

3. Conclusions

This paper investigates the requirements and general theoretical approaches to the construction of the SCMEP for algorithms and programming, which have their own specificity. The basic form of practical activity of the student is laboratory work. Specific problems are the problems of presentation of the program as special and general mathematical models.

It is advisable to carry out the initial study of algorithmization in the course of informatics of high school using specialized educational-oriented software-methodological software.

SMC "VideoInterpreter of searching and sorting algorithms" was created for use in the educational process on the topic “Basics of Algorithms and Programming” as a means of debug-ging, a deeper understanding of the processes occurring in computer, improving the logic of writing programs. SMC “VideoInterpreter for Search and Sorting Algorithms” software envi-ronment is versatile. It allows you to quickly build a module that executes and clearly demon-strates the operation of any sorting algorithm.

Software users are students of general and specialist schools, computer science teachers, and others who study the basics of algorithmization and programming.

A deeper understanding of the process of performing the algorithm is achieved by students using such visual as a visual demonstration of the algorithm's work that can be done in a sys-tem

demonstration environment. Manual testing allows the student to act as an algorithm per-former, demonstrate changes in data in computer memory, and execute commands depending on the conditions.

The result of the inclusion of the VideoInterpreter system in the course "Basics of Algorithms and Programming" was to equip it with tools to study the effectiveness of algorithms.

This should be an integrated algorithm environment that supports a structured algorithm methodology in combination with object-oriented software systems builders.

The use of the SMC "VideoInterpreter" in the educational process allows to organize at a high level students' educational and research activities; to activate students' independence in mastering knowledge; reduce the time needed to set up the program; accelerate the develop-ment of students' logical thinking.

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Візуальна підтримка курсу основ програмування «Алгоритми сортування та пошуку»

У статті розглядаються вимоги та загальнотеоретичні підходи до побудови системи комп'ютерної математики для освітніх цілей вивчення алгоритмізації та програмування. У запропонованому дослідженні висвітлено вимоги та загальнотеоретичні підходи до побудови SCMEP для алгоритмів та програмування, які мають свою специфіку. Основна форма практичної діяльності студента – лабораторні роботи. Конкретними проблемами є проблеми представлення програми як спеціальних, так і загальних математичних моделей.

Доцільно проводити початкове вивчення алгоритмізації в курсі інформатики закладів загальної середньої освіти за допомогою спеціалізованого навчально орієнтованого програмно-методичного програмного забезпечення У статті розглядається предметно орієнтований підхід до побудови інформаційних систем для підтримки освітнього процесу під час алгоритмізації та програмування. Цей підхід застосовується до реалізації програмно-методологічного комплексу «Відеоінтерпретатор для пошуку та сортування алгоритмів». Мета програмно-методологічного комплексу «Відеоінтерпретатор для пошуку та сортування алгоритмів» та інтегрованого середовища курсу «Основи алгоритмів та програмування».

Використання в освітньому процесі програмно-методичного комплексу «Відеоінтерпретатор» дозволяє організувати на високому рівні навчальну та дослідницьку діяльність; активізувати самостійність учнів в оволодінні знаннями; скоротити час, необхідний для налаштування програми; пришвидшити розвиток логічного мислення здобувачів.

Ключові слова: системи комп'ютерної математики для освітніх цілей, комп'ютерне програмне забезпечення, підтримка процесів навчання, візуалізація.