

Multimedia Applications and their Benefit for Teaching and Learning at Universities

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Abstract: - Multimedia applications together with individual approaches within the didactic process substantially influence education. They give us an excellent chance how to support not only demonstrating and visualizing the explained subject matter to be much clearer and comprehensible, but also enable us to prepare such study material for students that optimizes their study habits. The top applications of multimedia are represented by virtual reality. Well organized and fulfilled virtual learning environment has been becoming important part of teaching and learning. On a few examples of multimedia products created by our students on a script given by the author of this paper we discuss their benefit when explaining and visualizing the subject matter and testing knowledge of students through several kinds of self-tests and we also mention advantages of the professional virtual learning environment containing such study material.

Key-Words: - Multimedia study material, virtual learning environment, self-preparation of students, on-line testing

1 Introduction

“Information technology has changed many things in the world. Computers, networks are used widely in almost everything. Anytime and anywhere are the slogans of people living in the 21st century.”[1]

Multimedia applications together with individual approaches within the didactic process have also substantially influenced education. The top applications of multimedia are represented by virtual reality. Well organized and fulfilled virtual learning environment has been becoming important part of teaching and learning.

Along with large software products dealing with a wide spectrum of objects developed by a team of professionals there are also various smaller programs dealing with objects appropriate to course subject matter created on a script given by the teacher with regard to students needs.

This paper illustrates especially advantages of smaller multimedia presentations and programs prepared for students studying in the full-time form of study. On a few examples of such multimedia products created by our students on a script given by the author of this paper we discuss their benefit when explaining and visualizing the subject matter and

testing knowledge of students through several kinds of self-tests.

At the end of the paper we also mention advantages of the professional virtual WebCT learning environment containing such study material.

2 Optimization of students' study habits

Students find modern technology very handy when looking up things of their own interest. The teachers should take advantage of this fact and should try to prepare for them such multimedia study material, which would optimize their study habits. It means to create applications making students' study more effective, time-efficient and explained topics more comprehensible.

When teaching a subject we always lay stress on applying the following principles so that our students, at least most of them, have entirely understand the explained subject matter.

Motivation to the topic

As a motivation to the given topic we often use puzzle. We let students solve it, discuss their

solutions and after explanation of the appropriate subject matter we compare students' solutions with an efficient solution based on the explained matter.

Teaching in contexts

We investigate a particular problem from more than one point of view if possible, modify a problem and discuss the mutual relationships among solved problems. In this way students are encouraged to think about each problem more than usual. By comparing the various attitudes the students are able to get deeper into the problem and to understand it. In order to enrich students' view of discussed subject matter and deepen their awareness of it, we try to describe a particular problem with real life examples. We ask students to give their own examples describing the topic to be sure that they can understand it.

Visualization of the particular issue as well as it is possible

Demonstration and visualization make the subject much clearer and comprehensible. "Students need images and visualization in addition to words. Science learning is about creating images in mind, and teaching should support such image formation." [2] We use created suitable multimedia applications as a complement of our lectures.

Intensification of students' self-preparation

We try to prepare interesting study material for self-preparation of students to force them to study regularly as possible to be prepared for lessons. Lessons can be run more efficiently, like a discussion or consultation, then.

3 Multimedia Presentations

Multimedia presentations are usually used to describe a topic and illustrate it using visualization of objects and processes. They mostly enable to test the explained matter using several prepared exercises as well.

Firstly, let us briefly describe two of several presentations used within the subject Graph Theory and emphasize their different usage.

Remark: *The subject Graph Theory* is a compulsory subject taught in the fourth term. Its aim is to develop and deepen students' capacity for logical thinking. Students gain a basic level of competence in graph theory and graph algorithms. Well-prepared students in the area of graph theory and graph algorithms should be able to describe various practical situations with the aid of graphs, solve the given problem expressed by the graph, and translate the gained solution back into the initial situation.


Secondly, let us illustrate one of three animations visualizing the same topic used within the subject Algorithms and Data Structures.

Remark: *The subject Algorithms and Data Structures* is a compulsory subject taught in the first term. The aim of the subject is to develop logical thinking of students, teach them to create simpler algorithms and to understand more difficult ones. The subject is placed before the other subjects dealing with algorithmic and programming skills.

3.1 Large Presentation - "Combinatorics"

The mathematical discipline combinatorics is strong equipment for increasing of logical thinking and students gain the basic knowledge in this area at the secondary school. In the subject Graph Theory we presume that our students are familiar with the basic combinatorial concepts.

In the case that they need *revise their knowledge*, they have the presentation called "Combinatorics" (see Fig.1 – Fig.3) created in the Macromedia Director environment by the student within his thesis available.

The presentation "Combinatorics" consists of the *explanatory part* (definitions, theorems and solved examples; using the symbols  users move forward or back) and *demonstrated examples* (using



one of the numbers users go to the solution of the appropriate example) to the given topic.

Examples are ordered according to their level from the easiest to the most difficult.

The presentation also contains a *collection of unsolved examples with references to their results*.

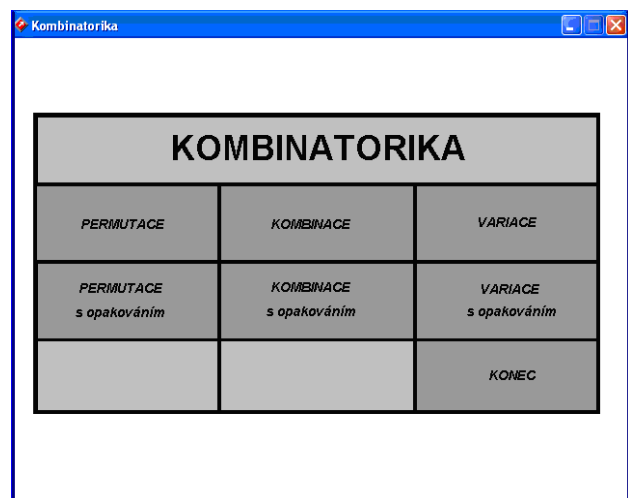


Fig.1 Presentation "Combinatorics" – main menu

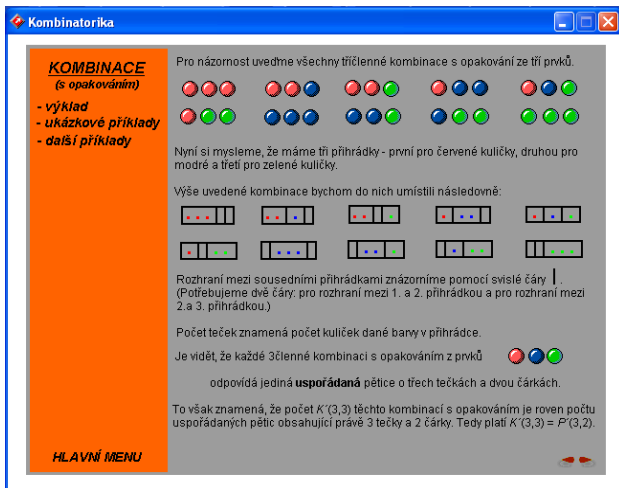


Fig.2 Presentation “Combinatorics” – explanatory part

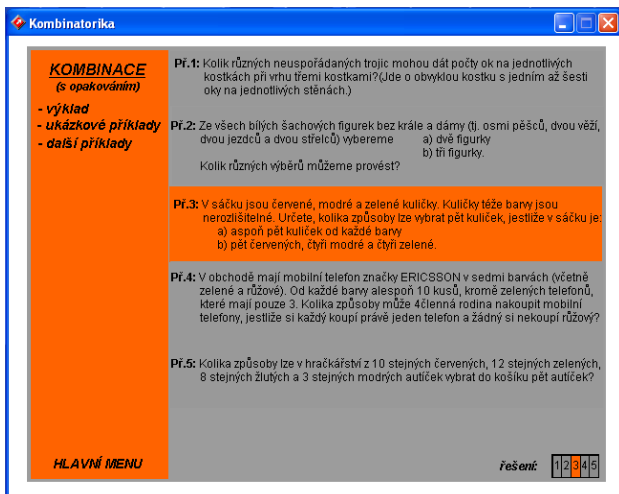


Fig.3 Presentation “Combinatorics” – demonstrated examples

3.2 Short Presentation - “Zoo”

The presentation “Zoo” (see Fig.4) is created in the Macromedia Flash environment by our student as part of his bachelor work. It explains and illustrates *step by step* how to find an Euler trail using the Edmonds-Johnson approach. On the right side there is explanation and below the main window containing a graph the progress of the used data-structure is demonstrated. The method is applied to the *practical example* how to walk through the whole zoo.

With the help of this presentation students can briefly revise the topic when it is needed. Students who miss the lecture can use it as a *useful complement* of the printed study text.

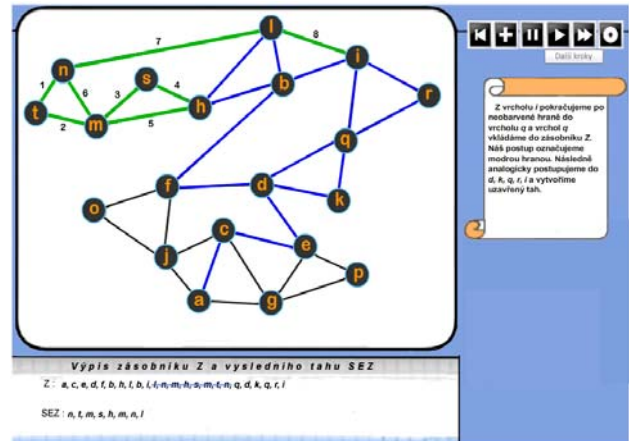


Fig.4 Presentation “Zoo” - finding an Euler trail

3.3 Animation – “Sorting by Choice”

The animation “Sorting by Choice” (see main steps on Fig.5 – Fig.7) is one of three animations visualizing prime sorting methods used in the first lecture within the subject Algorithms and Data Structure as an illustration of the fundamental concept of this subject; concept algorithm. All three animations are created in the Macromedia Flash environment by our student as part of his bachelor work.

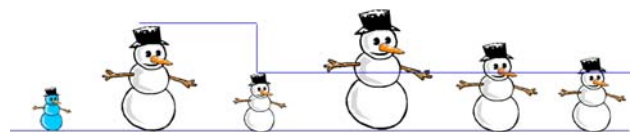


Fig.5 Sorting by choice: choice of the smallest white snowman

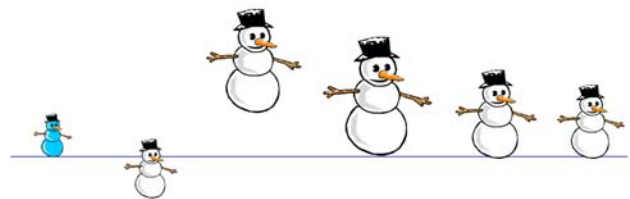


Fig.6 Sorting by choice: interchange of the chosen smallest snowmen with the first white snowmen

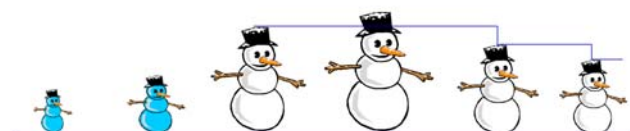


Fig.7 Sorting by choice: order-indication of the chosen smallest white snowman by blue colour

With the help of these animations, we introduce all three basic approaches (prime sorting methods) to the one topic and illustrate each whole process (algorithm) on sorting snowmen by their size.

(Remark: All three animations can be seen on http://lide.uhk.cz/fim/ucitel/milkoev1/en_index.htm in the part ALGDS - Lectures - Students presentations prepared for the subject ALGDS.)

3.4 Summary

The first presentation offers *students* the possibility to completely revise the large subject matter. The second presentation serves them as detailed visualization of the given topic explained within the lecture. The small animations serve *teacher* as an understandable motivation to the given topic within the lecture.

4 Multimedia Programs

Biggest advantage of the programs, as opposed to the presentations, is the fact that there is the possibility to create an infinite number of needed examples. At first let us devote attention to the illustrious multimedia program “Graphs” [3] used also within the subject Graph Theory (see the chapter). Then we briefly introduce the program “Algorithms” [4] used within the subject Algorithms and Data Structure (see the chapter 3).

4.1 Program “Graphs”

The program “Graphs” was created in the Delphi 5 environment by our student within his thesis. The main purpose of this application is a visual representation of basic graph-concepts and graph-algorithms using a colouring process on graphs created within the program.

The program is divided into tree parts:

- Creation and modification of a graph
- Presentation of graph characteristics
- Application of several fundamental graph algorithms

The program enables the creation of a new graph, editing it (see Fig.8), saving graph in the program, and saving graph in bmp format.

It also makes it possible to display some graph properties of the given graph, to add colour to vertices and edges, and to change positions of vertices and edges by “drop and draw a vertex (an edge respectively)”.

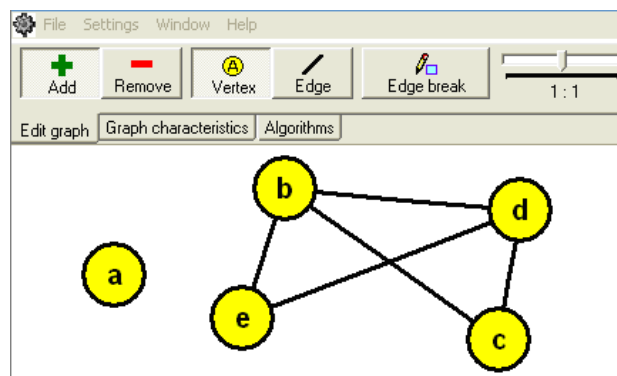


Fig.8 Program “Graphs” – editing a graph

It allows the user to open more than one window (see Fig.9) so that two (or more) objects or algorithms can be compared at once.

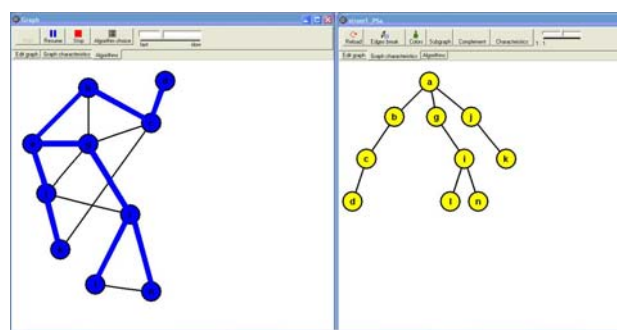


Fig.9 Program “Graphs” – two opened windows; left: breadth-first-search of the given graph; right: its breadth-first-search tree

Thus, the program “Graphs” enables the teacher to complete his/her explanation within lectures in such a way that the topic is more comprehensible; the option to open more than one window enables him/her to explain the problem from more points of view and show mutual relations among used concepts and algorithms. The possibility to save each created graph in bmt format allows him/her easy insertion of needed graphs into the study material (see as an example figures Fig.10 - Fig.12 and Fig.14) and thus saves his/her time when preparing text material and presentations.

The possibility to use colours allows the teacher to emphasize needed objects and relations (see the following example used as a motivation to the concept graph).

Example

An international company opened five positions for translators from the following languages: Russian, German, English, French and Spanish.

Five candidates apply for the job.

Mr. Smith can speak all 5 languages;

Mr. Parker can speak English, French and Russian;

Mr. Thomas can speak German and Russian;

Mr. Brian can speak English and German;

Mr. White can speak Russian and German.

Is the company able to provide all opened positions so that each of candidates would translate just from one language? If it is possible, propose the solution.

Solution

The situation can be easily represented by the following graph.

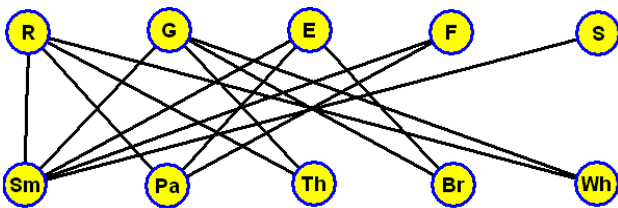


Fig.10 Graph-representation of the given task

Looking at the graph, it is obvious that the vertex *S* must be connected with the vertex *Sm*. Thus, at first, we color the edge $\{S, Sm\}$ blue and the other edges incident with the vertex *Sm* red to demonstrate that we have rejected them. Then it is obvious that the edge $\{F, Pa\}$ must be denoted by the color blue and hence the other edges incident with the vertex *Pa* by the color red, etc. Finally, the blue edges represent two possible solutions (Fig.11 and Fig.12).

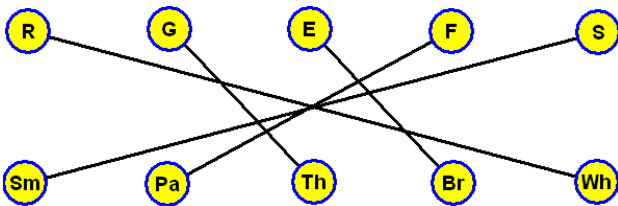


Fig.11 The first solution of the given task

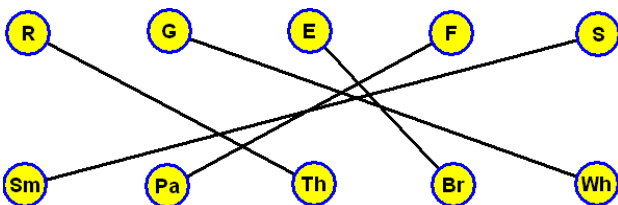


Fig.12 The second solution of the given task

Using the program “Graphs” students can *revise subject-matter within the area of graph theory and more deeply understand it*. They can use not only graphs prepared by the teacher but also graphs created by themselves and explore the properties of

these graphs. The possibility to open more than one window enables them *to follow mutual relations among used concepts and algorithms*. The option “Save Graph in bmp format” enables them *easy creation needed graphs for their tasks* (texts and/or presentations) where they describe various practical situations with the aid of graphs and solve the given problem.

4.2 Program “Algorithms”

The program “Algorithms” is prepared for the *subject Algorithms and Data Structures* (see the chapter 3).

In the subject Algorithms and Data Structures our approach to creation of algorithms is based on the imagination of a brick-box, a nice and useful game for children. There are only several base elements available from which children are able to create incredible buildings.

Thus when we lead our students’ first steps by creation of algorithms we explain to them that it is like building interesting objects out of just a few basic elements. It means that we start our teaching with basic algorithmic structures (basic elements from the brick-box): sequence, selection (*non-full* and *full* selection) and iteration (*while* iteration and its shorter description for the case with known number of iteration-body repetitions with the step 1, i.e. *for* iteration) and typical algorithmic structures (a few parts made out of these elements) written in Czech meta-language (Czech transcription of pseudo Pascal - the basic commands) and then we let students get into the secrets of making whole algorithms (building whole constructions) written in Czech meta-language as well. (Detailed description of our approach can be found in [5].)

Students write algorithms on papers.

Because students have been forced to write their algorithms on paper there was an important question: “How can students get feedback for their solution written on papers in the Czech meta- when studying at home and preparing for lessons?”

Of course, they have two books [6] and [7] containing many solved examples, prepared for the subject Algorithms and Data Structures, available. Nevertheless, there are a lot of other tasks that we give our students to solve.

This was the main reason, why the program “Algorithms” was created. It was developed in Borland Delphi environment (see Fig.13) within the thesis. The program is user friendly and provides entire graphical comfort for users.

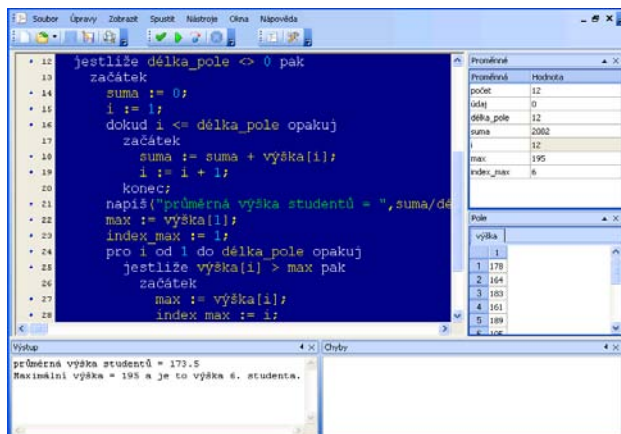


Fig.13 Design of the program “Algorithms”; main window with an algorithm, two right windows displaying the actual values of used variables (of simple variables in the window above and of an array in the window below) and two windows below: left window displaying output values and right window displaying errors

Using the program “Algorithms” students can place their solution (algorithm written in the Czech meta-language) of the given task in the program and the program *shows them step by step how their algorithm work*, if it is correct or not. The program also shows actual values of used variables in each step of the algorithm’s process.

The program is not only a *substantial help to students in their self-study* but it helps also teachers to prepare text materials (lectures, tests etc.).

4.3 Summary

The program “Graphs” *enables the teacher to complete his/her lectures in the way that explained topics can be more comprehensible*.

Both programs *save the teacher’s time* very much when he/she prepares text materials and presentations.

Using these programs *students can revise explained subject-matter and deeper understand it*. They can very *easy prepare their assignments* with the aid of programs as well.

Students studying the English study program at our faculty can also use both programs because it is possible to localize them into English language.

5 On-line self-testing

“The feedback provided through tests has helped students to recognize what they needed to know, appreciate what they already knew and understand, what they needed to do in order to learn, and what

they didn’t know.”[8] Our students can test their knowledge using programs described in the previous text. However they have various other possibilities how to do it. At our university we have been using the professional virtual WebCT learning environment for several years. Among WebCT tools there are also tools enabling to prepare tests.

5.1 Tests in the WebCT environment

There are three kinds of on-line tests in the WebCT environment in the option called Assessments: Quizzes, Self tests and Surveys (see [9]).

A *quiz* is an online test that students complete and submit for marks. The marks are recorded in Grade Book. (Remark: Grade Book is the WebCT tool that serves to the teacher to view, enter, and manage grades for students.) Quizzes are used to assess students’ knowledge within the given subject.

A *survey* is an online questionnaire that students complete and submit anonymously. It allows students to give feedback or opinions.

A *self test* is an online test that students complete and submit for marks so they can assess their understanding of study material. However, the marks are not recorded in Grade Book.

In the classical (non electronic) tests prepared to test knowledge in natural science subjects there have been used two main types of questions for years (centuries); the type Calculated and the type Multiple Choice. However, in the textbooks directed to the education of foreign languages there have been used several other types of questions even those that give a chance to solve tasks in an enjoyable way. These types are available in the WebCT environment as well and we tried to use all of them when preparing test-questions for the subject Graph Theory. Let us introduce their list and short description (see [9]).

Calculated: Students are presented with a mathematical formula and must enter the answer.

Combination Multiple Choice: Students are first presented with a list of answers. They are then presented with various combinations of those answers and must select one of the combinations as correct.

Fill in the Blank: Students are presented with a question containing blanks and must provide the missing text.

Jumbled Sentence: Students are presented with a question containing blanks for which they must provide the missing text by selected word or phrase from drop-down lists.

Matching: Students are presented with two lists and must match terms in one list with terms or definitions in the other list.

Multiple Choice: Students are presented with a list of answers and must select one or more answers as correct.

Paragraph: Students must answer the question by entering multiple sentences.

Short Answer: Students must answer the question by entering a brief response.

True False: Student must select whether the statement is true or false.

It is very important that the WebCT environment enables to include figures (see Fig. 14) and tables within the questions. Without this possibility it would be unthought to create questions for the subject Graph Theory based on images of graphs.

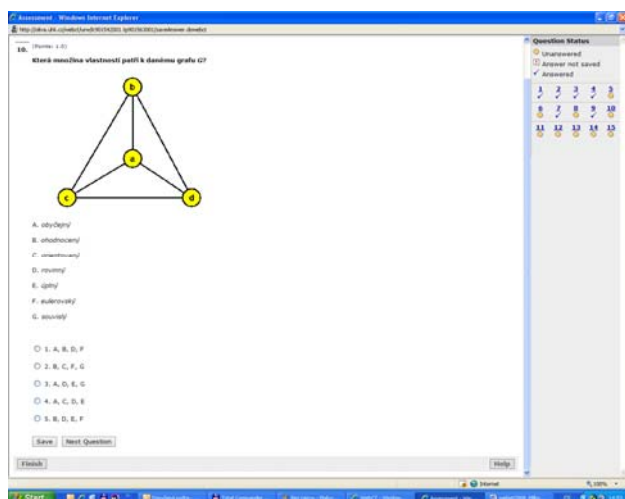


Fig.14 Combination Multiple Choice question

We do not use on-line testing as a part of examinations. *The prepared tests serve for students to recognize themselves what knowledge they need still to improve.* Students can, but don't have to solve them during the term. However, similar tasks occur in the exam test. It is up to the students whether they deal with these questions and if they do not understand them well they can discuss them with their teacher during the lessons.

The types of questions prepared by WebCT tool need not be easy to fulfil for each subject. In the following text we illustrate two different applications used for testing students' knowledge partly within combinatorics and partly within algorithms.

5.2 Webpage "Tests with Help"

The tests denoted as "Tests with Help" are intended to test our students' level of understanding within combinatorics. It is created as a webpage and the link to it is placed in the WebCT environment within the subject Graph Theory.

Students select a part of combinatorics (permutation, variation or combination with or without repetition) at first. Clicking on the selected part, they can see several tasks. They start to solve them. Next to each task there are three buttons: *first help*, *second help*, and *whole solution* (1. nápověda, 2. nápověda, and celé řešení in Czech, see Fig.15). If they are helpless when solving the task they click on the *first help* to get initial advice. If they are still helpless they click on the *second help*. The button *whole solution* serves them by checking if their solution is correct or as the total solution to the problem.

On the Fig.15 both helps are used in the first task (První úloha in Czech), the first help only is used in the second task (Druhá úloha in Czech) and no help is needed in the third task (Třetí úloha in Czech).

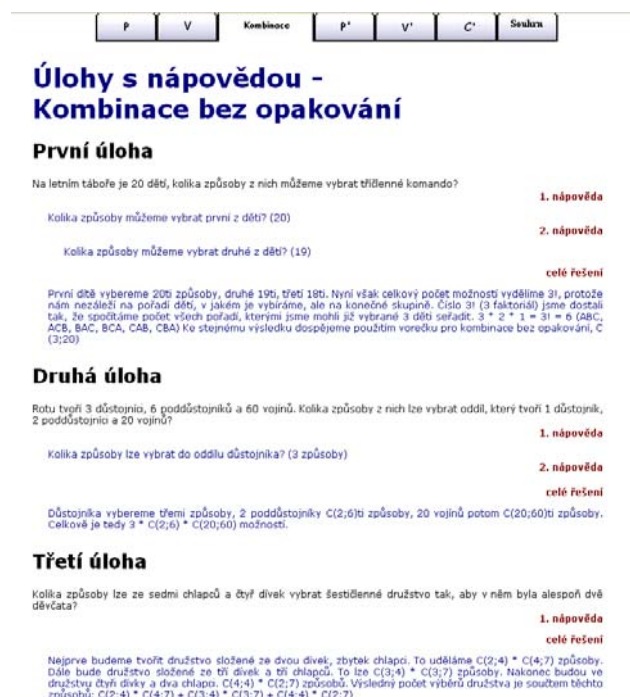


Fig.15 Design of "Tests with Help"

5.3 Web application "algds"

The application "algds" [10] is created in PHP language and it is intended for testing knowledge gained in the subject Algorithms and Data Structure (see section 4.2 and the Fig. 16).



Fig.16 The introduction screen of the application “algds”

We have used to include in our lectures various short tasks that we immediately complete together with students. Similar tasks occur in exam tests later. Students have the possibility exercise such tasks within the application “algds”.

This application enables three types of questions:

Complete the given algorithm

Order the given algorithm

Solve the given algorithm

The test *Complete the given algorithm* demands to complete omitted parts in the algorithm solving the given task. The test *Order the given algorithm* demands to order all commands written in wrong order to get algorithm, which correctly solves the given task. The test *Solve the given algorithm* demands to determine values of some variables used in the algorithm using the given enter data.

The link to the application is placed in the WebCT environment within the subject Algorithms and Data Structures. The application is seen also on http://lide.uhk.cz/fim/ucitel/milkoev1/en_index.htm in the part ALGDS - Lectures - Students presentations prepared for the subject ALGDS.

Let us illustrate the above mentioned types of questions on the following tasks. For each type of question we give an example on a task solved in the appropriate lecture at first, and then we introduce the screen of a task solved within the application “algds” (see Fig.17 – Fig.19).

Task 1: Complete the algorithm solving the following task. “In the sequence of n integers saved in the array a (in items $a[1]$, ..., $a[n]$) determine the first minimum value and then sum of all integers behind the found minimum value.”

```
begin
  minimum := a[1];
  sum := .....;
  for i := 2 to n repeat
    begin
      sum := sum + .....;
      if a[i] ≤ min then
        begin
          minimum := .....;
          sum := .....;
        end;
    end;
  end;
end.
```

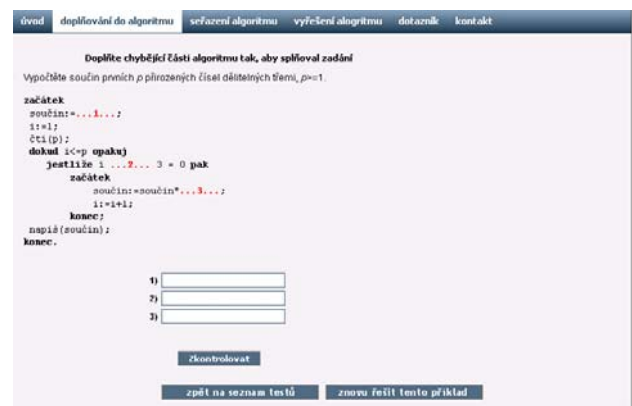


Fig.17 Web application “algds” - *Complete the given algorithm* (i.e. complete the omitted parts 1, 2, and 3)

Task 2: By using the following three commands

```
sum := sum + integer;
step := step + 1;
read(integer);
```

complete the algorithm solving the task “Write the sum of p integers, $p \geq 1$, that you consecutively save into the variable $integer$ using command $read(integer)$.”

Determine also all possible order of these commands.

```
begin
  read(p);
  sum := 0;
  step := 1;
  while step ≤ p do
    begin
      *****
      *****
      *****
    end;
  write(sum);
end.
```

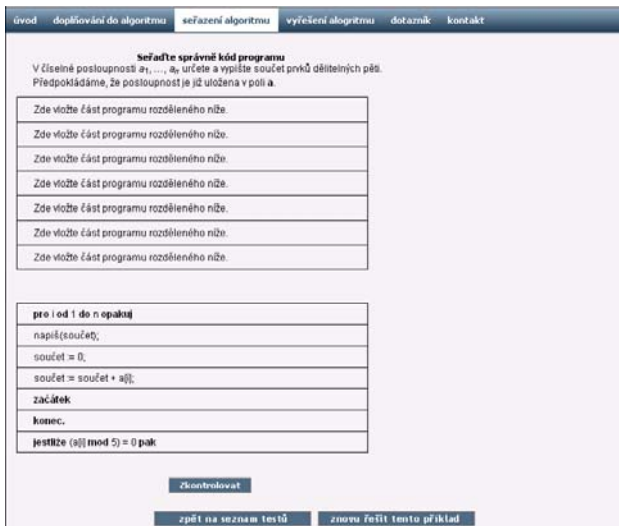



Fig.18 Web application “algds” - Order the given algorithm (i.e. place the commands bellow in correct order to the table above)

Task 3: “There are n integers saved in the array a (see the table). Determine the values in the array a after finishing the following algorithm. Write them to the table bellow (see Table 1).”

```
begin
  n:=6;
  x:=a[1];
  i := 2;
  while i ≤ n - 1 do
    begin
      if a[i] > x then
        begin
          a[1]:= a[i];
          a[i]:= x;
        end;
      i := i + 1;
    end;
end.
```

a[1]	a[2]	a[3]	a[4]	a[5]	a[6]
11	8	19	7	16	17

Table 1 table of integers saved in the array a



Fig.19 Web application “algds” - Solve the given algorithm (i.e. determine the value of the variable s)

The Web application “algds” enables students to improve their knowledge in an enjoyable way. Each students answer is analyzed and the correct answer appears if student was wrong. There is no explanation of why the student’s answer was false however they can follow step by step the whole algorithm using the program “Algorithms” (see the section 4.2).

6 Virtual learning environment

As we have mentioned at the beginning of this paper the top applications of multimedia are represented by virtual reality. At our university the professional virtual WebCT learning environment has been used.

Let us briefly summarize how can virtual learning environment, containing above mentioned multimedia applications, used as a compliment to a subject influence the optimization of students’ study habits. (see [11])

- Students have all electronic study materials assigned to the appropriate subject available altogether in one environment together with needed information.
- Students greatly appreciate accessibility to self-tests with automatic checking and to multimedia study materials visualizing the explained matter.
- The relevant study material is accessible whenever and wherever. In this way also students staying abroad within the framework of students exchange for several months are able to follow the subject.
- Students interested in the area explained within a subject can find additional material in the WebCT environment, and sources and information outside the immediate framework of the subject. Discussions on “a level” with their teacher can start. This is also one of the ways in which the teacher can train his potential thesis writers.
- In many subjects, the inevitable outcome of creating common projects is teamwork. Virtual study environments are inherently well-suited to this. Students can communicate with the teacher and each other, and discussions are accessible to members of the team only.
- Students find also very useful the possibility to find all the information about important dates (written credit tests, examination etc.) and evaluation of their work within the subject in one environment.

Moreover, at the Faculty of Informatics and Management of the University of Hradec Králové, there are also part-time students in combined study-programs in addition to full-time students. This is because a huge number of people are interested in continuous study. Students who had not had the chance to study at a university immediately after they had finished their high school studies or those who had to interrupt their study for various reasons are later searching for a chance to further their education, often while coping with a tiring job. Distance-learning at a university is a great opportunity for such students to combine their occupation and studies.

“In a non-synchronous e-learning environment, owing to the lack of instruction and guidance by a real teacher, learners must take the initiative to learn.”[12] “Hypermedia teaching applications may use additional learning procedures as guided navigation, hierarchical contents presentation, sequenced deterministic presentations, and other deterministic procedures.”[13] “Web pages related to distance learning should help students to find necessary information about the course, to learn material and to introduce them to the theme of the course. Web pages designed in the appropriate way should initiate thinking, discussion and active participation during the distance learning process.”[14]

The WebCT environment used at our faculty is an immense contribution insofar as it is a highly effective resource, making a remote, distance study-program possible.

6 Conclusion

„Recent years as computer technology progresses fast, personal computers and the Internet are closely linked to human life. As someone puts, information technology is like the air we breathe, surrounding us. Technology has indeed greatly influenced our education as well in the process. From the early stages of computer aiding teaching, to the present, education combined with information technology into learning, this technology has become an efficient tool for teaching as a teacher and learning as a student.“[15]

In our paper we discussed what multimedia can add to the enhancing of teaching and to the optimization of students' study habits. We have shown how important and effective can be role of multimedia study materials as a complement of lectures on one hand and as important support of students' self preparation on the other hand. We also

mentioned how multimedia programs can save the time of both, teachers and students, when preparing the other study materials.

Let us emphasized again that visual presentations prepared with the aid of modern information and communication technology help to understand better explained matters and implementation of them into the lectures makes them interesting, illustrative and understandable, and their location within the virtual study environment enables the students to get, to complete, to test and to deepen their knowledge and increase their imagination.

Students admire quality multimedia applications prepared by their colleagues. These materials inspire them, and we are pleased to see an increased interest, not only in the subject matter, but also in the level of cooperation through the preparation of other multimedia material.

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