Yuri Medvedev, Irina Nikolaeva, Ekaterina Davletyarova

Applying information technologies while studying “Numerical Methods and Computer Simulation” section of the “Computer Science and ICT” Middle School Program

Edukacja - Technika - Informatyka 5/2, 413-418

2014

Yuri MEDVEDEV, Irina NIKOLAEVA, Ekaterina DAVLETYAROVA
Vladimir State University Alexander G. and Nicholas G. Stoletovs, Russia

Applying information technologies while studying “Numerical Methods and Computer Simulation” section of the “Computer Science and ICT” Middle School Program

The main objectives of the study of the subject “Computer Science and ICT” in secondary educational institutions are shaping the students’ information system approach to the analysis of the world, the formation of skills of information and communication technologies for solving life problems, the formation of skills to carry out a computational experiment for the discovery of new properties of the object. The solution to these problems is subject to the introduction of the section “Numerical Methods and Computer Simulation” in the training material content line “Modeling and formalization” on basic and core stages of the continuous study of computer science.

The objective of the proposed section is to build a systematic form of a students’ concept of the approximate (numerical) methods for solving practical problems, computer simulation methods, sources of errors and methods for assessing the accuracy of results.

On the examples of solving practical problems students participate in all steps of a computer simulation study from modeled domain formulation of the problem and to interpret the results obtained through computer simulation. Currently, there are effective PC software packages for numerical problem solution. However, understanding the feasibility of implementing theoretical ideas in a software product is an integral part of school education.

Let us outline some specific tasks in this section:

1. Students’ general development and worldview cultivation. Course content and the methods of implementation of this content perform a developmental function. The students are to continue using the computer simulation as a cognitive method.
2. Promoting professional orientation for students. Implementation of this course helps to identify those students who are inclined to research activities, computational experiment, project work.
3. Developing and professionalizing computer skills. The students are to implement the numerical solution algorithm on the computer, to display the results in a clear, accessible way; to carry out a quantitative simulation of a numerical solution, using the selected software, which contributes to the

more complete study of computer software capabilities, and when assessing the accuracy – the computer's capabilities as a calculator.

Program section “Numerical Methods and Computer Simulation”, a summary of those proposed in section [Nikolaeva 2005]. We are now developing separate methods of presenting the individual topics of the program section. For example, methods for studying the topics “Approximate methods for solving equations with one variable” and “Approximate methods for calculating the areas of curvilinear trapezoids” were tested at the basic stage of the continuous study of Computer Science.

Let us consider some examples of ICT use while studying “Approximate methods for solving equations with one variable”.

Example 1. Consider the separation of real roots of the equation $x - \cos x = 0$ graphically.

A. We present this equation to the form g (x) = h (x), we have $x = \cos x$. Construct a graph matches the functions $y = x$ and $y = \cos x$ (Fig. 1). During the interval [a; b], which is the only root of the equation $x - \cos x = 0$, we take the interval [0.5, 1.5].

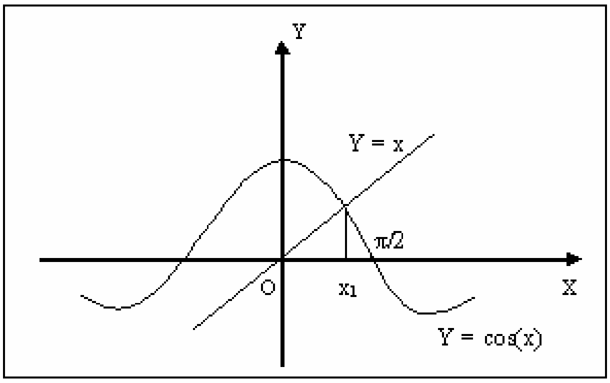

Fig. 1.

B. Verify the correctness of the choice of [0.5, 1.5], in which there is only one real root of the equation $x - \cos x = 0$:

a) Check the continuity of the function $f(x) = x - \cos x$ on the interval [0.5, 1.5]. The function $f(x) = x - \cos x$ is continuous on a numerical interval [0.5, 1.5] (the algebraic sum of continuous functions $y = x$, $y = \cos x$);

b) Verify the monotony of the function $f(x) = x - \cos x$ on the interval [0.5, 1.5]. The function $f(x) = x - \cos x$ is monotonically increasing in this segment, as $f'(x) = 1 + \sin x$; $1 + \sin x > 0$ for all $x \in [0.5, 1.5]$;

c) Check the sign of $f(x) = x - \cos x$ at the ends of the interval [0.5, 1.5], we find the values of the function $f(x) = x - \cos x$ at the end of the test interval:

$$\left.\begin{aligned} f(0.5) &= 0.5 - \cos 0.5 = -0.378 < 0 \\ f(1.5) &= 1.5 - \cos 1.5 = 1.429 > 0 \end{aligned}\right\} \Rightarrow f(0.5)\,f(1.5) < 0$$

The function $f(x) = x - \cos x$ at the ends of the interval [0.5, 1.5] takes values of different signs.

On the interval [0.5, 1.5] is continuous, monotonic and takes on the ends of the interval values of different signs, therefore, within the interval [0.5, 1.5] contains the real root of the equation $x - \cos x = 0$, and this root only.

C. The arguments A and B can be illustrated using the charting function $y = f(x)$ and determine the roots of the equation $f(x) = 0$ via Mathcad system.

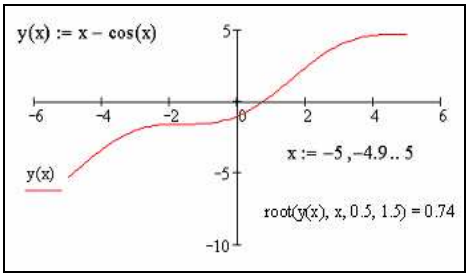

Fig. 2.

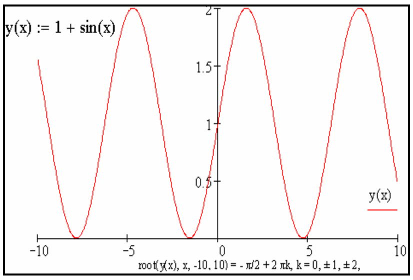

Fig. 3.

a) The graph of $f(x) = x - \cos x$ on the interval [-6, 6] (Fig. 2) can be used for: illustration of continuity of $f(x)$ on this interval; highlight segments monotonicity of $f(x)$; determine the sign of the function $f(x)$ at the ends of the segments monotony; Branch segments within which there is only one real root of the equation $x - \cos x = 0$.

b) Using the graph of the function $\varphi(x) = 1 + \sin x$ (Fig. 3), where $\varphi(x) = f'(x)$, we can determine the intervals of constant sign function $\varphi(x)$, compare these intervals with intervals of monotonicity formula function $f(x)$.

To separate the real roots of the equation $f(x) = 0$, the students are to use computer models programmed in the selected language. They are to carry out a computational experiment, and to conclude that the reliability of the software real root separation depends on the nature of the function $y = f(x)$, as well as on the number of partitions of the study area to determine this function into n parts. Using Mathcad, the students are to confirm the results of computational experiments.

In studying the topic “Approximate methods for solving equations with one variable”, we propose to use MS Excel at the stages of separation and clarification of the real equation root.

Example 2. Clarifying the root of the equation $f(x) = 0$ by bisection of the interval by way of using VBA.

Let us input the results of the left end of the selected segment – *a* in cell A1, and the results of the right end of the selected interval – *b* – in cell B1. Cell D1 will then store the precision value of the root. While the program runs, column A will record the computed values of the left end of the segment – and the column B will record the computed values of the right end of the segment – *b*. Column C will record the calculated values of $c = a + (b - a) / 2$, and the cell E (i) – the approximate value of the root of the equation with accuracy ε (Fig. 4).

	A	B	C	D	E
1	0,5	1,5	1	0,0001	
2	0,5	1	0,75		
3	0,5	0,75	0,625		
4	0,625	0,75	0,6875		
5	0,6875	0,75	0,71875		
6	0,71875	0,75	0,734375		
7	0,734375	0,75	0,742188		
8	0,734375	0,742188	0,738281		
9	0,738281	0,742188	0,740234		
10	0,738281	0,740234	0,739258		
11	0,738281	0,739258	0,73877		
12	0,73877	0,739258	0,739014		
13	0,739014	0,739258	0,739136		
14	0,739014	0,739136			0,739136

Fig. 4.

VBA code to clarify the roots of the equation f (x) = 0 by bisection of the interval

```
Sub Koren_uravneniya ()
  a = InputBox (“Enter the left end of the segment”, “input function”)
  b = InputBox (“Enter the right end of the segment”, “input function”)
  e = InputBox (“Enter the value of precision”, “input function”)
  i = 1: Cells (i, 1) = a: Cells (i, 2) = b: Range (“D1”). Value = e
  Do While Abs (Cells (i, 1) – Cells (i, 2)) > 2 * Range ("D1"). Value
     Cells (i, 3) = Cells (i, 1) + (Cells (i, 2) – Cells (i, 1)) / 2
     If f (Cells (i, 3)) = 0 Then Exit Do
     If f (Cells (i, 1) * Cells (i, 3 )) < 0 Then
          Cells (i + 1, 2) = Cells (i, 3): Cells (i + 1, 1) = Cells (i, 1)
     Else
          Cells (i + 1, 1) = Cells (i, 3): Cells (i + 1, 2) = Cells (i, 2)
     End If
     i = i + 1
  Loop
  If f (Cells (i, 3)) = 0 Then
     Cells (i, 5) = Cells (i, 3)
```

```
  Else
     Cells (i, 5) = Cells (i – 1, 1) + (Cells (i – 1, 2 ) – Cells (i – 1, 1)) / 2
  End If
  MsgBox ("The value of the root" & Cells (i, 5))
  MsgBox ("Accuracy" & Range ("D1"). Value)
End Sub
Function f (x As Single) As Single
  f = x – Cos (x)
End Function
```

As a result of studying the section "Numerical Methods and Computer Simulation" student must learn to support the choice of a numerical method of solving the problem, they also must have a command of an algorithm of the method used. In the study of educational material in this section, students have the opportunity to conduct an experiment using programming systems, spreadsheets, Mathcad mathematical design system and other computer software, select the appropriate options, analyze dependencies, predict outcomes, to conduct a graphical interpretation of the results. This contributes to a deeper understanding of the essence of numerical methods and their practical value and teaches the rational use of software, as well as shows the students new ways of solving problems.

Literature

Davletyarova E.P. (2011), *Information Technology in Mathematics* (*workshop*) / E.P. Davletyarova, I.A. Gordeeva, A.V. Shutov, Y.A. Medvedev. – Vladimir: VGGU, 104 c.

Davletyarova E.P. (2005), *Software package Microsoft Office (practical classes on "Computer", part 2). Spreadsheet MS Excel* / E.P. Davletyarova, Y.A. Medvedev. – Vladimir: SGMP, 53 c.

Nikolaeva I.V. (2005), *Numerical methods and computer simulation* / I.V. Nikolaeva. – Vladimir: SGMP, 62 c.

Abstract

The article describes the experience of using information technologies in the study section "Numerical Methods and Computer Simulation" in the subject "Informatics and ICT" primary school. The aims and objectives of the study material in this section on basic and core stages of continuous study of computer science. Consider some examples of the use of information technology in the study of educational material theme "Approximate methods for solving equations with one variable". To illustrate the results of the research function $y = f(x)$ for solving the equation $f(x) = 0$, and examples of opportunities for Mathcad charting and determine the roots of the equation. Considered VBA code refinement root of the equation $f(x) = 0$ by bisection of the interval for the table processor MS Excel. The article summarized the results of testing some educational material section “Numerical Methods and Computer Simulation” in the schools of the city of Vladimir. In the study of educational material in this section, students have the opportunity to conduct an experiment using a computer programming systems, spreadsheets, mathematical computer-aided design Mathcad and other computer software, select the appropriate options, analyze dependencies, predict outcomes, to conduct a graphical interpretation of the results. This contributes to a deeper understanding of the essence of numerical methods and their practical value, focuses on the clever use of computer software applications, and enriches the students’ new ways of solving problems.

Key words: numerical methods, computer models, computer experiment, the Information Technology, Department of the real roots of the equation with one variable, continuity, monotony, accurate root of the equation.