
The Role of the Computer in Learning Mathematics Through Numerical Methods

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Abstract: The paper exploits the results of an experimental, formative-ameliorative research conducted by 30 3rd-year students from the Department of Mathematics, *Vasile Alecsandri* University of Bacău, during their teaching practice at the *Ștefan cel Mare* National Pedagogical College from Bacău, involving 150 students from 6 11th-grade classes with a real specialization profile. The research was based on the following hypothesis: if we use numerical methods to solve linear equations systems and to the graphical representation of functions in the instructive-educational process, then we shall enhance the efficiency of these activities and increase the students' performance by enhancing intrinsic motivation. In order to achieve the objectives, there were presented various techniques for solving linear equations systems and for the graphical representation of functions through numerical methods, followed by the application of sets of tests on the different methods for solving mathematical problems integrated in the various moments of the lesson, either in teaching new content or in consolidating and checking it. The paper highlights the role and values of computer use in learning Mathematics, in the informative as well as formative-educational sense, in agreement with the taught objectives and contents, based on the tendencies of updating and upgrading the school activity, and enhancing its role in preparing students for life. The research objectives were: - knowledge of the students' (initial) training level as a basis for implementing the experiment; - presentation of the theory on numerical methods; - evaluating the contribution of the methods for solving linear equations systems and the graphical representation of functions through numerical methods to the enhancement of school performance; - recording progress following the application of the progress factor, respectively the various methods for solving linear equations systems and the graphical representation of functions through numerical methods.

Keywords: Computer, Learning Mathematics, Formative-Ameliorative Research, Numerical Methods

1. Introduction

The algorithm for solving linear equations systems can also be computer programmed. This method relies on serially reducing unknowns, the system evolving into other equivalent systems, whose number of equations diminishes step-by-step; this method is called Gaussian elimination or row reduction.

For the gradual processing of the system, there are applied the following elementary transformations that generate equivalent systems: - swapping two rows (equations); - reordering the unknowns; - multiplying a row by a non-zero number; - adding a multiple of one row to another row. (Frumușanu G., 2008),

By applying these operations, there is generated one of the

situations: - the final system is triangular, its solution being unique (compatible determined); - the final system is trapezoidal, with several solutions (compatible non-determined); - the final system contains a contradiction, with no solutions (incompatible).

Practically, applying the Gaussian method consists in covering the following steps: - writing the extended matrix of the system (namely, the system's matrix, to which we annex the column of free terms); - applying elementary transformations to this matrix, until it takes a triangular or trapezoidal form; - analysing the linear system to which this extended matrix belongs; - if there occurs a contradiction within this system, then the system is incompatible; - if there occurs no contradiction, then the system is compatible or compatible non-determined, according to whether it is


```

FUNCTION Max(i,j:Integer):Integer;
BEGIN
...IF (i>j) THEN Max:=i
...ELSE Max:=j
END;
PROCEDURE WriteMat(VAR a:Mat);
{Show system coefficients}
VAR
...i,j,n1,n2 : Integer;
BEGIN
...n1:=8; n2:=5; WriteLn;
...WriteLn(System coefficients:');
FOR i:=1 TO n DO
...BEGIN
.....FOR j:=1 TO n DO
.....IF ((p(i,j)>=1) AND (p(i,j)<=3*d+1))THEN
.....Write(a[i,p(i,j)]:n1:n2)
.....ELSE Write(0.0:n1:n2);
.....WriteLn
.....END;
...WriteLn
END;
PROCEDURE Wait;
VAR
...c:Char;
BEGIN
...WriteLn;WriteLn('Press a Key !');
...REPEAT c:=ReadKey UNTIL (c<>'')
END;
PROCEDURE GaussElim(n,d:Integer;VAR a:Mat;VAR
b:Vec;VAR flg:Boolean);
VAR
...i,j,k,ipvt : Integer;
...temp : UserType;
...apvt : UserType;
BEGIN
...flg:=False;
...FOR i:=1 TO n-1 DO
...BEGIN
.....apvt:=0;ipvt:=i;
.....FOR j:=i TO Min(i+d,n) DO
.....IF (apvt<Abs(a[j,p(j,i)])) THEN
.....BEGIN
.....apvt:=Abs(a[j,p(j,i)]);ipvt:=j
.....END;
.....IF (apvt=0) THEN
.....BEGIN flg:=True; Exit END;
.....IF (ipvt<>i) THEN
.....BEGIN
.....FOR k:=i TO Min(i+2*d,n) DO
.....BEGIN
.....temp:=a[i,p(i,k)];
.....a[i,p(i,k)]:=a[ipvt,p(ipvt,k)];
.....a[ipvt,p(ipvt,k)]:=temp
.....END;
.....temp:=b[i];b[i]:=b[ipvt];
.....b[ipvt]:=temp

```

```

.....END;
.....FOR j:=i+1 TO Min(i+d,n) DO
.....BEGIN
.....IF (a[j,p(j,i)]<>0) THEN
.....BEGIN
.....temp:=-a[j,p(j,i)]/a[i,p(i,i)];
.....FOR k:=i+1 TO Min(i+2*d,n) DO
.....a[j,p(j,k)]:=a[j,p(j,k)]+temp*a[i,p(i,k)];
.....b[j]:=b[j]+temp*b[i];
.....a[j,p(j,i)]:=0
.....END
.....END
.....END;
...IF (a[n,p(n,n)]=0) THEN BEGIN flg:=True; Exit END;
...b[n]:=b[n]/a[n,p(n,n)];
...FOR i:=n-1 DOWNT0 1 DO
...BEGIN
.....temp:=b[i];
.....FOR k:=i+1 TO Min(i+2*d,n) DO
.....temp:=temp-a[i,p(i,k)]*b[k];
.....b[i]:=temp/a[i,p(i,i)]
...END
END;
BEGIN {Main Prog}
...ClrScr;
...flg:=False;
...Write('n=');ReadLn(n); {Number of equations}
...Write('d=');ReadLn(d); {Number of diagonals}
...Date2(a,b);
...IF (n<50) THEN WriteMat(a);
...WriteLn; WriteLn('Free terms');
...ScrieSol(b);
...Wait;
...GaussElim(n,d,a,b,flg);
...Write(#7);
...WriteLn; WriteLn('System solution:');
...WriteSol(b);
...Wait
END {Test_Gauss_Elimin Column.

```

4.1. Application Examples of Applying Numerical Methods to Solve the Equation System

Solve the equation system:

$$\begin{aligned}
0.39419 \cdot x_1 + 0.25212 \cdot x_2 &= 0.64631 \\
0.95007 \cdot x_1 + 0.71412 \cdot x_2 + 0.72213 \cdot x_3 &= 2.38632 \\
0.68713 \cdot x_2 + 0.57916 \cdot x_3 + 0.76899 \cdot x_4 &= 2.03528 \\
0.98697 \cdot x_3 + 0.80641 \cdot x_4 + 0.02246 \cdot x_5 &= 1.81585 \\
0.83403 \cdot x_4 + 0.22243 \cdot x_5 &= 1.05646
\end{aligned}$$

The result of running the program:

```

n=5
d=1
System coefficients:
0.39419 0.25212 0.00000 0.00000 0.00000
0.95007 0.71412 0.72213 0.00000 0.00000
0.00000 0.68713 0.57916 0.76899 0.00000
0.00000 0.00000 0.98697 0.80641 0.02246
0.00000 0.00000 0.00000 0.83403 0.22243

```

Free terms:

0.64631 2.38632 2.03528 1.81585 1.05646

System solution:

1.00000 1.00000 1.00000 1.00000 1.00000

4.2. Examples of Applying Numerical Methods to Graphical Representations

Likewise, these programs particular to numerical methods may be applied to graphical representations. We shall further present a program that enables the graphical representation of every function, the scaling of the graph being performed automatically. *The axes of coordinates are traced only when they enter the display window.* We have chosen to illustrate the graphical representation of functions $(x) = \sin x + \sin 3x$, $x \in [-1, 2]$, $f(x) = \frac{1}{1+x^2}$, $x \in [-2, 2]$. (Postolică, V.; Nechita, E.; Lupu, C., 2014)

The source program:

```
PROGRAM Graphical representation;
USES Crt, Graph;
CONST
  ...nmax=640; { Number of points }
TYPE
  ...Vec = ARRAY[1..nmax] OF Real;
  ...St4 = STRING[4];
VAR
  ...xp, yp : Vec;
  ...n, brx, bry : Integer;
  ...xmin, xmax : Real;
  ...ch : Char;
  ...fld : Boolean;
PROCEDURE Date;
VAR
  ...x, dx : Real;
  ...i : Integer;
  ...c1 : Char;
FUNCTION f(x:Real):Real;
BEGIN
  ...f:=Sin(x)+Sin(3*x)
  ...{f:=1/(1+Sqr(x))}
END;
BEGIN
  ...c1:='x';
  ...REPEAT
    .....ClrScr;
    .....WriteLn('1...Number of points: ', n);
    .....WriteLn('2...xmin : ', xmin:6:3);
    .....WriteLn('3...xmax : ', xmax:6:3);
    .....WriteLn('4...brx : ', brx);
    .....WriteLn('5...bry : ', bry);
    .....WriteLn('0...Exit');
    .....REPEAT c1:=ReadKey UNTIL (c1 IN ['0'..'5']);
    .....CASE c1 OF
      ..... '1' : BEGIN
        .....WriteLn('Number of points: '); ReadLn(n);
        .....END;
      ..... '2' : BEGIN
        .....WriteLn('xmin: '); ReadLn(xmin)
```

```
.....END;
..... '3' : BEGIN
.....WriteLn('xmax: '); ReadLn(xmax);
.....END;
..... '4' : BEGIN
.....WriteLn('brx: '); ReadLn(brx);
.....END;
..... '5' : BEGIN
.....WriteLn('bry: '); ReadLn(bry);
.....END;
..... '0' : BEGIN
.....dx:=(xmax-xmin)/n;
.....FOR i:=1 TO n DO
.....BEGIN
.....x:=xmin+(i-1)*dx;
.....xp[i]:=x; yp[i]:=f(x);
.....END
.....END
...END
...UNTIL c1='0'
END;
PROCEDURE Wait;
VAR
  ...cc:Char;
BEGIN
  ...REPEAT cc:=ReadKey UNTIL cc<>''
END;
PROCEDURE GrInit;
VAR
  ...Gd, Gm : Integer;
BEGIN
  ...Gd:=Detect;
  ...InitGraph(Gd, Gm, 'c:\BP\BGI'); IF GraphResult=grOK
  THEN Exit;
  ...Halt(1)
END;
PROCEDURE GetSize;
VAR
  ...i:Integer;
BEGIN
  ...maxa:=a[1]; mina:=maxa; maxb:=b[1]; minb:=maxb;
  ...FOR i:=2 TO n DO
  ...BEGIN
    .....IF maxa<a[i] THEN maxa:=a[i];
    .....IF maxb<b[i] THEN maxb:=b[i];
    .....IF mina>a[i] THEN mina:=a[i];
    .....IF minb>b[i] THEN minb:=b[i]
  ...END;
  ...sx:=(GetMaxX-2*brx)/(maxa-mina);
  ...sy:=(GetMaxY-2*bry)/(maxb-minb);
  ...stpx:=Int(Ln(maxa)/Ln(10)-1);
  ...stpx:=Exp(stpx*Ln(10));
  ...stpy:=Int(Ln(maxb)/Ln(10)-1);
  ...stpy:=Exp(stpy*Ln(10))
  END;
  BEGIN
  ...GrInit; mx:=GetMaxX; my:=GetMaxY; GetSize;
```

```

...IF (minb*maxb<=0) THEN
...BEGIN
.....MoveTo(0,Yplot(0)); LineTo(mx,Yplot(0));
.....LineTo(mx-8,Yplot(0)+8);
.....MoveTo(mx,Yplot(0));
.....LineTo(mx-8,Yplot(0)-8);
.....OutTextXY(mx-8,Yplot(0)+10,tctx);
.....xx:=stpx;
.....WHILE Xplot(xx)<=mx-10 DO
.....BEGIN
.....MoveTo(Xplot(xx),Yplot(0)-4);
.....LineTo(Xplot(xx),Yplot(0)+4);
.....xx:=xx+stpx
.....END;
.....xx:=-stpx;
.....WHILE Xplot(xx)>=10 DO
.....BEGIN
.....MoveTo(Xplot(xx),Yplot(0)-4);
.....LineTo(Xplot(xx),Yplot(0)+4);
.....xx:=xx-stpx
.....END
.....END;
...IF (mina*maxa<=0) THEN
...BEGIN
.....MoveTo(Xplot(0),my); LineTo(Xplot(0),0);
.....MoveTo(Xplot(0),0); LineTo(Xplot(0)+8,8);
.....MoveTo(Xplot(0),0); LineTo(Xplot(0)-8,8);
.....OutTextXY(Xplot(0)+10,0,tctx);
.....OutTextXY(Xplot(0)-10,Yplot(0)+8,'0');
.....yy:=stpy;
.....WHILE Yplot(yy)>=10 DO
.....BEGIN
.....MoveTo(Xplot(0)-4,Yplot(yy));
.....LineTo(Xplot(0)+4,Yplot(yy));
.....yy:=yy+stpy
.....END;
.....yy:=-stpy;
.....WHILE Yplot(yy)<=-10 DO
.....BEGIN
.....MoveTo(Xplot(0)-4,Yplot(yy));
.....LineTo(Xplot(0)+4,Yplot(yy));
.....yy:=yy-stpy
.....END
.....END;
...xp0:=Xplot(a[1]); yp0:=Yplot(b[1]);
...FOR i:=2 TO n DO
...BEGIN
.....MoveTo(xp0,yp0); xp1:=Xplot(a[i]); yp1:=Yplot(b[i]);
.....LineTo(xp1,yp1); xp0:=xp1; yp0:=yp1
.....END;
...Wait;
...CloseGraph
END;
BEGIN {Main Prog}
...fld := False;
...brx := 20;
...bry := 20;

```

```

...n := 200;
...xmin := -1;
...xmax := 2;
...REPEAT
.....ClrScr;
.....WriteLn('1...Initial data');
.....IF fld THEN
.....BEGIN
.....WriteLn('2...Function graphic')
.....END;
.....WriteLn('0..Exit');
.....REPEAT ch:=ReadKey UNTIL (ch IN ['0'..'2']);
.....CASE ch OF
.....'1' : BEGIN
.....Date;fld:=True
.....END;
.....'2' : IF fld THEN Graf(xp,yp,n,brx,bry,'x','y');
.....'0' : Exit
.....END
...UNTIL False
END {Graphic Representation}.

```

The results of running the program are shown in the figures below (Lupu C., 2015).

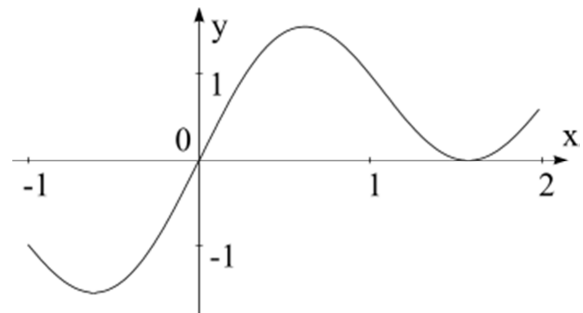


Figure 1. The graphical representation of the function: $f(x)=\sin x + \sin 3x$, $x \in [-1, 2]$.

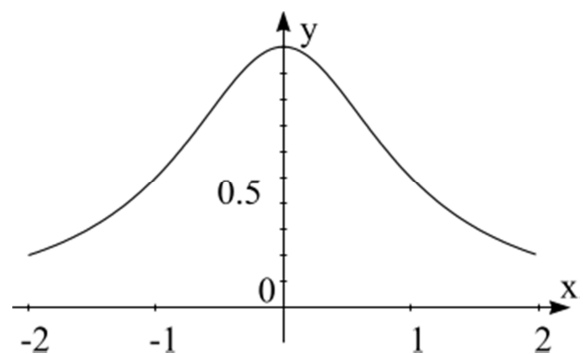


Figure 2. The graphical representation of the function: $f(x) = \frac{1}{1+x^2}$, $x \in [-2, 2]$.

5. Research Methodology

5.1. Research Methods and Techniques

The research was of an experimental type, using the test method. Other research methods and techniques used were: - Pedagogical observation; - The communication; - Analysis of

school documents and student work products; - The interview;
- Statistical techniques for data processing.

5.2. Research Description

The paper highlights the role and values of computer use in learning Mathematics, in the informative as well as formative-educational sense, in agreement with the taught objectives and contents, based on the tendencies of updating and upgrading the school activity, and enhancing its role in preparing the student for life.

5.3. Sample Description

The paper exploits the results of an experimental, formative-ameliorative research conducted by 30 3rd-year students from the Department of Mathematics, *Vasile Alecsandri* University of Bacău, during their teaching practice at the *Ștefan cel Mare* National Pedagogical College from Bacău, involving 150 students from 11th-grade classes with a real specialization profile.

5.4. Research Objectives

The research objectives were: - knowledge of the students' (initial) training level as a basis for implementing the experiment; - presentation of the theory on numerical methods; - evaluating the contribution of the methods for solving linear equations systems and the graphical representation of functions through numerical methods to the enhancement of school performance; - recording progress following the application of the progress factor, respectively the various methods for solving linear equations systems and the graphical representation of functions through numerical methods.

5.5. Research Hypothesis

The research was based on the following hypothesis: if we use numerical methods to solve linear equations systems and to the graphical representation of functions in the instructive-educational process, then we shall enhance the efficiency of these activities and increase the students' performance by enhancing intrinsic motivation.

5.6. Research Variables

The research hypothesis generates two research variables: - the independent variable, introduced through the numerical methods for solving systems and the graphical representation of functions; - the dependent variable related to enhancing the motivation for acquiring mathematical notions and school progress.

5.7. Research Stages

The research was conducted February 5th – May 30th, during the 2nd term of the 2014-2015 school year. The paper exploits the results of an experimental, formative-ameliorative research conducted by 30 3rd-year students from the Department of Mathematics, *Vasile Alecsandri* University of

Bacău, during their teaching practice at the *Ștefan cel Mare* National Pedagogical College from Bacău, involving 150 students from 6 11th-grade classes with a real specialization profile. The research was based on the following hypothesis: if we use numerical methods to solve linear equations systems and to the graphical representation of functions in the instructive-educational process. The paper highlights the role and values of computer use in learning Mathematics, in the informative as well as formative-educational sense, in agreement with the taught objectives and contents, based on the tendencies of updating and upgrading the school activity, and enhancing its role in preparing students for life.

6. The Results and Their Interpretation

Through the experiment carried out on an initial test with second year Math undergraduates of "Vasile Alecsandri" University of Bacău, it was proved that the teaching and the development of skills and abilities for assessment in high school are possible if we use various evaluation methods and procedures. This information was very useful in planning the following activities, taking into account the specificities of each student. Motivation for team learning consists (without the students being aware) of exciting activities, attractive, intuitive special materials, worksheets and modern teaching methods.

In terms of the second year students of the Faculty of Mathematics, it was found that through impact assessment, observed learning and assessment records, there was active participation on the part of the students, increasing the degree of intellectual effort, interest and curiosity with regard to mathematics.

This data was recorded in an observation grid. At the same time, the experiment results confirm the hypothesis that if we use various techniques for teaching-learning-assessment in all lesson stages, the teaching of mathematics in school will be more efficient, and the results of the pupils will improve.

In terms of the second year students of the Faculty of Mathematics, it was found that through impact assessment, observed learning and assessment records, there was active participation on the part of the students, increasing the degree of intellectual effort, interest and curiosity with regard to mathematics.

Analysing the results obtained by the students in the initial and final evaluation tests, there may be diagnosed a relevant progress in terms of problem-solving competences and skills, calculus abilities as well as correct use of mathematical concepts. Of the 15 students who got initial marks below 5, 10 succeeded in getting marks above 5 in the final test, applied at the end of the term. The raise in the number of students who obtained the marks 7, 8, 9 and 10 is relevant and may be followed in the table and frequency polygons below.

Table 1. Comparative analysis of the results obtained in the initial and final evaluation.

Nota	4	5	6	7	8	9	10
Test initial	30	20	34	20	24	12	10
Test final	8	10	20	33	35	24	20

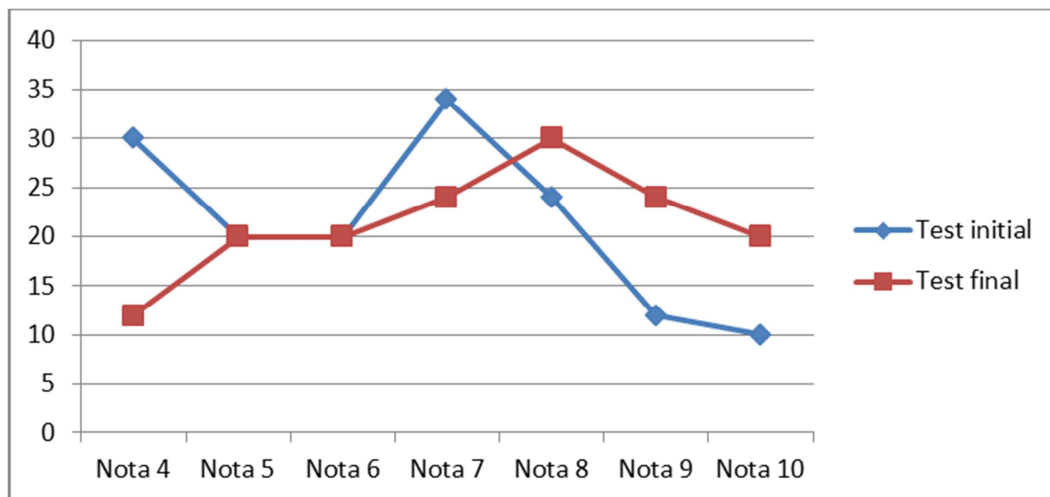


Figure 3. Comparative frequency polygon: the initial and final test results.

This comparative frequency polygon showing the results in the initial and final test highlights the fact that although the number of students who got 5 in the final test is much smaller than the number of students who got this mark in the initial test, the number of students who got marks above 8 increased significantly compared to the initial test to 20 marks of 10.

7. Conclusions

The progress of the school results is obvious, both at the individual and class level, an aspect reflected in the frequency of the marks obtained and the general means of the class, calculated at the two stages of the research: pre-experimental and post-experimental.

Regarding the initial evaluation, the mean of the class results were 6.42, an average that corresponds to below standard performances. In the final evaluation, the class average was 7.52, showing a relevant increase of 1,10 points. It is worth mentioning that a first progress was observed as of the stage of applying the experimental factor, the mean of the marks obtained by students in the formative evaluation being 6,85.

In the final evaluation test, 74% of the students obtained marks at least equal to 7, and 22 of the 30 students who got marks below 5 in the initial test succeeded in obtaining marks above 5 in the final test. The comparative analysis reveals the relevant growth of the students' results at Mathematics, which validates the hypothesis of the experimental research. Besides the progress recorded at the level of the school results, it is also worth mentioning the progress on the motivational level, there being a greater number of active students, interested in the school activity, at the expense of the passive and disinterested ones.

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