**ΕΤΠΕ**

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΝΩΣΗ
ΤΕΧΝΟΛΟΓΙΩΝ ΠΛΗΡΟΦΟΡΙΑΣ
& ΕΠΙΚΟΙΝΩΝΙΩΝ ΣΤΗΝ ΕΚΠΑΙΔΕΥΣΗ

**3ο Συνέδριο ΕΤΠΕ
«Οι ΤΠΕ στην
Εκπαίδευση»**

**Ρόδος**

26 - 29 Σεπτεμβρίου 2002

ISSN: 2529-0916

**Teaching Linear Functions in Junior High School with the use of Computers**

*Athanasios S. Kyriazis, Konstantinos E. Korres*

# Teaching Linear Functions in Junior High School with the use of Computers

Athanasios S. Kyriazis [a], Konstantinos E. Korres [b]

[a] Assoc. Professor, Department of Statistics and Insurance Sciences, The University of Piraeus
akyriaz@math.uoa.gr
[b] MPhil in Didactics of Mathematics, Department of Mathematics, The University of Athens
kkorres@math.uoa.gr

## ABSTRACT

*In this paper we propose the use of computer software programs in the teaching–learning process of Junior High School Mathematics. In particular we propose the use of Mathematica® in the teaching of linear functions for the third grade of Junior High School. We present a plan of an experimental course of teaching linear functions with the corresponding programs in Mathematica®. Moreover we present the results of a case–study concerning the teaching of the course to a group of junior high school students during the schooling year 2000–2001. This paper studies the evaluation of the use of the program in the teaching–learning process by the students that participated in the study and the change in their level of understanding after the completion of the experimental course.*

**KEYWORDS***: Computers; Constructivism; Discovery Learning; Improving classroom teaching; Media in Education; Mathematics; Software; Teaching/learning strategies*

## INTRODUCTION

The goals of Mathematics' Secondary Education, and especially Junior High School Education, have been well documented (Toumasis, 1994). Traditional, purely theoretical, teaching of Mathematics has not succeeded in fulfilling in a satisfactory extent these goals mainly because it uses means and methods (narration, presentation on the board, lack of practical verification of results obtained etc) that barely provoke the interest and draw the attention of students.

The subject of functions and the special difficulties students have in the understanding of the function concept have been thoroughly studied (Markovits, Eylon & Bruckheimer, 1988 and Toumasis, 1994). The subject of linear functions being associated with many applications and everyday situations and the geometric interpretation of solving a 2×2 system, is one of the most important subjects in Junior High School Mathematics. Unfortunately, traditional teaching "forces" students to a mechanic, learning "by heart" of some algebraic techniques, and fails to "convince" them on the necessity and prepare them for dealing with subjects that concern the geometric representation and properties of linear functions.

In this paper we propose the introduction and appropriate use of computer software programs in the teaching–learning process of linear functions for the third grade of Junior High School. We present a plan of an experimental course, in which the computer software Mathematica® is used, that follows the traditional purely theoretical program of teaching. Moreover we present the results of a case–study of the teaching of the experimental course to a group of junior high school students, during the schooling year 2000–2001. Our aim here is to study the evaluation of the use of the program in the teaching–learning process by the students that participated in the study and the change in their level of understanding after the completion of the experimental course.

## A THEORETICAL FRAMEWORK

We propose the use of Guided Discovery Learning with the use of Computers (Kyriazis & Korres, to appear) in the teaching of linear functions in Junior High School. This approach is based on the ideas of J. Bruner for Discovery Learning (Bruner, 1960 and 1966), the contemporary ideas of Constructivism (Sinclair, 1987 and Steffe & al., 1988) and the emancipatory paradigm of Computer Aided Learning (CAL) (Kyriazis & Bakoyiannis, 1995).

In guided discovery learning the teacher provides his students with an environment in which they can accomplish results for which they did not possess a formed algorithm, via a process of exploration and experimentation, without having those results posed or explained to them. The teacher uses questions, discussion and various activities in order to guide his students to construct the desirable result. The teaching–learning process consists of (Kyriazis & Korres, to appear):

1. Definition of the problematic situation.
2. Gathering of data, elaboration, organization and analysis of data.
3. Formation and formulation of a conjecture.
4. Checking of the conjecture.
5. Formation and formulation of a conclusion.
6. Investigation and discussion of the conclusion.

The computer software programs of the emancipatory paradigm of CAL can be used effectively as accommodating tools. They can be used in the exploration and experimentation with the learning material and the formation, checking and investigation of the students' conjectures and hypotheses. They can accommodate the teacher and the students in plotting complex graphs and in making difficult, complex calculations. Also they can be used for the visualization of geometric quantities and concepts that are difficult or impossible to be understood otherwise.

Mathematica® and Maple® are programs that do not presuppose efficient programming skills, yet have a function–based structure, and can be used effectively in guided discovery learning with computers (Kyriazis & Korres, to appear, Torrence & Torrence, 1999 and Wolfram, 1996).

## THE METHODOLOGY OF RESEARCH

The research was designed for students of the third grade of Junior High School and concerns the study and the evaluation of the use of the computer software Mathematica® in the teaching of linear functions, in a resuming–reviewing course that follows the traditional program of teaching.

One experimental course, with duration two didactic hours, was designed and the corresponding programs of Mathematica® were prepared. In this paper we present the results of a case–study of the teaching of the experimental course in two Junior High Schools, one public in East Attiki and one private in West Attiki, during the schooling year 2000–2001. A total of 64 students of the third grade attended the course, which we regard as one group, since our aim here is not to compare the students of the two schools. The regular teachers of the students taught the experimental course. The teachers were trained in the use of the program and were operating on the computer during the course; the screens of the program were projected with the use of a video–projector.

Two questionnaires were developed and were answered by the students, the first before and the second after the experimental course. The first questionnaire aimed in the evaluation of the knowledge and skills that were acquired by the students during the traditional program of instruction. The second questionnaire aimed in the evaluation of the improvement of those knowledge and skills after the experimental course and the evaluation of the use of the program in the teaching–learning process.

The data that was gathered by the encoding of the questionnaires was analyzed with the statistical programs SPSS® and Statgraphics®. The methods used in the statistical analysis are tests of hypotheses ($X^2$ – Testing for homogeneity, $X^2$ – Testing for independency, Kolmogorov–

Smirnov and Mann-Whitney) and regression analysis (simple linear model and general linear model) (Kyriazis & Korres, to appear). We must note that safe conclusions and general results regarding the effectiveness of the experimental course and the evaluation of the use of the program cannot be accomplished.

## TEACHING LINEAR FUNCTIONS WITH THE USE OF MATHEMATICA®

We have developed certain functions in Mathematica® concerning the formation of the table of values and its representation on a cartesian system of coordinates. These functions are:

---

**TableValues[f_, {a_, b_, step_}] :=**
  **TableForm[Table[{x, f[x]}, {x, a, b, step}], TableHeadings –> {None, {"x", "f(x)"}},**
  **TableAlignments –>Right, TableDirections –> Row]**

---

**PlotTable[f_, {a_, b_, step_}, {color_, join_}] :=**
 **ListPlot[Table[{x, f[x]}, {x, a, b, step}],**
  **PlotStyle –> {If[join == True, Thickness[0.015], AbsolutePointSize[4]], color},**
  **PlotJoined –> If[join == True, True, False], AspectRatio –> Automatic,**
  **Ticks –> {Range[a, b, 1], Range[Min[Table[ f[x], {x, a, b}]], Max[Table[ f[x], {x, a, b}]], 1],**
  **DefaultFont –>{"Times", 16}]**

---

The command TableValues[f, {a, b, step}] creates the table of values of f for x = a (step) b. The command PlotTable[f, {a, b, step}, {color, join}] represents the table of values on a cartesian system of coordinates. By selecting smaller steps the points plotted dense so as a continuous plot of the function is created. We can select the color of the points or lines plotted by setting Hue[c], c∈[0, 1] in the color option and whether the points will be joined by setting True or False in the join option. In order for any command to be executed we must press SHIFT and ENTER, with the cursor be in the line we have typed the command.

For example, we can define the linear function f(x) = 2 x, create its table of values and represent the table of values on a cartesian system of coordinates as follows (see figure 1 and figure 2):

| x | - 4 | - 3 | - 2 | - 1 | 0 | 1 | 2 | 3 | 4 |
|---|-----|-----|-----|-----|---|---|---|---|---|
| f(x) | - 8 | - 6 | - 4 | - 2 | 0 | 2 | 4 | 6 | 8 |

**f[x_]:= 2 * x**
**TableValues[ f, {– 4, 4, 1}]**

*Figure 1:* Table of Values of f(x) = 2 x, for x = – 4 (1) 4



**p1 = PlotTable[ f, {– 4, 4, 1},**
  **{Hue[1], False}]**

**p2 = PlotTable[ f, {– 4, 4, 1},**
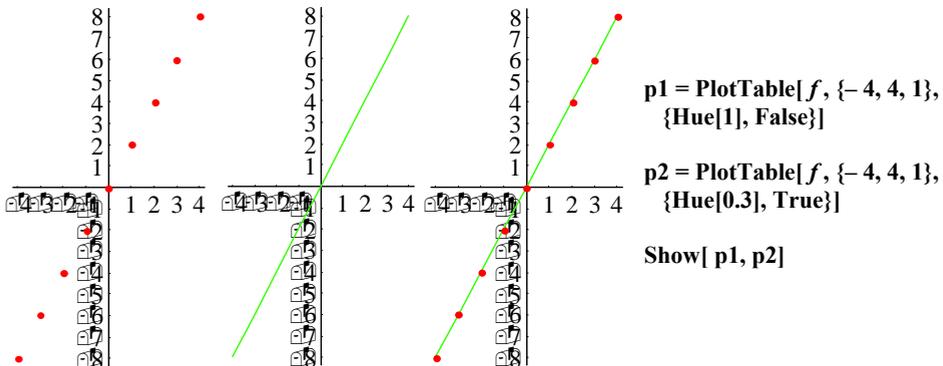  **{Hue[0.3], True}]**

**Show[ p1, p2]**

257

**Figure 2:** Representation of the table of values of f(x) = 2 x, for x = – 4 (1) 4

We can study the change in the plot of a function respectively to the change in the parameters with the use of the program. In particular we can plot multiple plots of functions in the same graph, using different colors or shades of gray for each function. For example we can plot the linear functions f(x) = a x, for a = – 4 (2) 4, as follows (see figure 3):
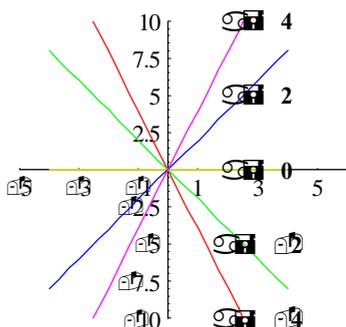


```
Plot[
Table[ a * x, {a, – 4, 4, 2}] // Evaluate, {x, – 4, 4},
  Ticks –> {Range[–5, 5, 2], Automatic},
  PlotRange –> {{– 5, 6}, {– 10, 10}},
  PlotStyle –> {Hue[1], Hue[0.3], Hue[0.1], Hue[0.7],
   Hue[0.8]},
  AspectRatio –> 1,  DefaultFont –> {"Times", 16},
  Epilog –> Table[ Text[ FontForm[ TableForm[
   {{"α =", a}}, TableSpacing –> {1}],
   {"Times–Bold", 18}], {3, 2.5*a}],
  {a, – 4, 4, 2}] ]
```

**Figure 3:** Change in the graph of f(x) = a x, for a = - 4 (2) 4

We can also plot the graph of a function for different values of the parameters as an animation with the use of the command Do[expression that contains a parameter, {parameter, a, b, step}]. The following command creates the plot of f(x) = – 2 x + b, for b = – 5 (1) 5 step by step (see figure 4). We can observe the plot as an animation by selecting the graphs having being plotted and by selecting the command **Cell → AnimateSelectedGraphics** from the menu of commands.
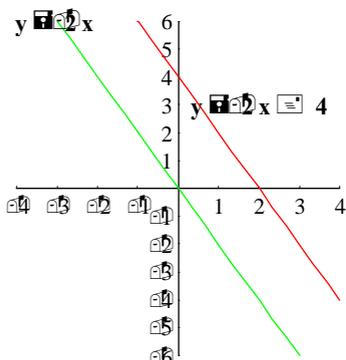


```
Do[ Plot[ {– 2 * x + b, – 2 * x }] // Evaluate, {x, – 4, 4},
  Ticks –> {Range[–4, 4, 1], Range[–6, 6, 1]},
  PlotRange –> {{– 4, 4}, {– 6, 6}},
  PlotStyle –> {Hue[1], Hue[0.3]},
  AspectRatio –> 1, DefaultFont –> {"Times", 16},
  Epilog –> { Text[ FontForm[ TableForm[ If[b < 0,
   {{" y = – 2 x –", Abs[b]}}, {{" y = – 2 x +", b}}] ],
   {"Times–Bold", 18}], {2, – 1 + b}],
  Text[ FontForm[ TableForm[ {{" y = – 2 x " }} ],
   {"Times–Bold", 18}], { – 3, 6}] }],
  {b, – 5, 5, 1}]
```

**Figure 4:** Representation of the change in the graph of f(x) = – 2 x + b, for b = – 5 (1) 5

The following problem was given to the students that participated in the study. Its solving came as a result of a collaborative attempt using the program in making complex plots. The problem concerns the minimization of expenses for a journey from Athens to Patra, having as alternatives taking a taxi or a bus. The tariffs and the expenses per kilometer were given to the students who constructed the functions of expenses taxi(x) = 25 x + 250 and bus(x) = 15 x + 1850, with some guidance from the teacher. The students were asked to plot these functions in their papers and the teacher presented the corresponding plots with the use of the program (see figure 5).
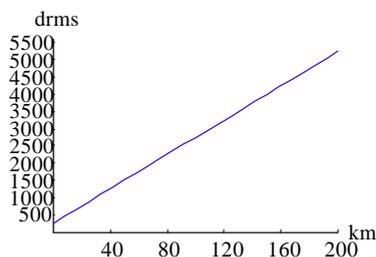
```
taxi[x_]:= 25 * x + 250
t1 = Plot[ taxi[ x ] // Evaluate, {x, 0, 200},
 PlotStyle –> {Hue[0.7], Thickness[0.0035]},
 Ticks –> {Range[ 0, 200, 40], Range[ 0, 5500, 500]},
 PlotRange –> {{ 0, 200}, { 0, 5600}},
 AxesLabel –> {"km", "drms"} ]
```
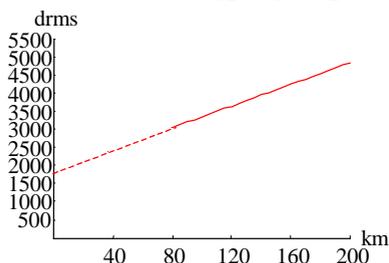
```
bus[x_]:= 15 * x + 1850
t2 = Show[ Plot[ bus[ x ] // Evaluate, {x, 0, 80},
  PlotStyle –> {Hue[1], Dashing[{0.015}],
  Thickness[0.0035]} ],
 Plot[ bus[ x ] // Evaluate, {x, 80, 200},
  PlotStyle –> {Hue[1], Thickness[0.0035]} ],
  Ticks –> {Range[ 0, 200, 40], Range[ 0, 5500, 500]},
  PlotRange –> {{ 0, 200}, { 0, 5500}},
  AxesLabel –> {"km", "drms"} ]
```

**Figure 5:** Graphs of taxi(x) = 25 x + 250, x ∈ [0, 200] and bus(x) = 15 x + 1850 x, ∈ [80, 200]

The students were asked to decide which of the two transportation means has smaller expenses. Also to what distance the use of the taxi has smaller expenses than the use of the bus which leads to solving the 2×2 system of the two functions. The teacher can guide his students to conclude about which transportation means has smaller expenses for different towns between Athens and Patra, by observing at the plot of the two functions (see figure 6).
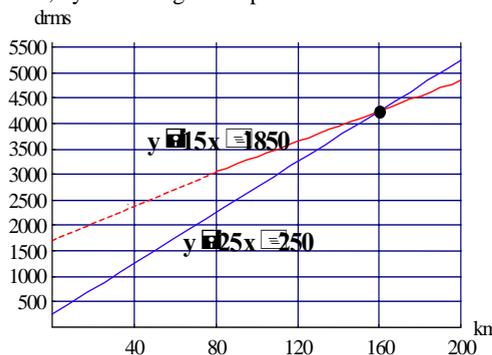


```
Show[ t1, t2,
  GridLines –> {{40, 80, 120, 160, 200},
    {500, 1000,1500, 2000, 2500, 3000, 3500,
    4000, 4500, 5000, 5500}},
  Epilog –> {{ Text[ FontForm[
   TableForm[ {{" y = 25 x + 250}}],
   {"Times–Bold", 16}], { 97, 1700}],
  Text[ FontForm[
   TableForm[{{" y = 15 x + 1850" }}],
   {"Times–Bold", 16}], { 80, 3700}] },
   {AbsolutePointSize[8], Point[{160,
   taxi[160]}] }} ]
```

**Figure 6:** Representation of the solution of the 2×2 system of taxi(x) and bus(x)

## THE STUDENTS THAT PARTICIPATED IN THE RESEARCH

The students that participated were 64, with mean age 14,53 years and std. deviation 0,50 years. As for the gender 31,1 % of the 95,3 % that answered were males and 68,9 % were females.

The whole of students made use of computers at School and the whole of students that answered the corresponding question (a total of 95,3 %) made use of computers at home.

90,6 % of the students stated they find the use of computers interesting. Males and females seem to be homogenous, with males presenting a slightly higher percentage of positive answers than

females (Males: 100 %, Females: 85,7 %); we cannot formulate a safe conclusion about their homogeneity though ($X^2$–Homogeneity, $X^2$ = 3,010, P– value = 0,083, Df = 1) (see Table 1).

The students had experience in the use of computers, since 81,3 % had been using computers for more than 3 years. Males and females were not homogenous ($X^2$–Homogeneity, $X^2$ = 6,758, P–value = 0,009, Df = 1); the whole of males had been using computers more than 3 years, compared to 71,4 % of females (see Table 1). The students used computers mainly for games (51,5 %), word processing (37,5 %) or other use (34,4 %), mainly Internet.

***Table 1***: Evaluation of the students' interest and previous experience in the use of Computers

|  |  | **Males** | **Females** | **Total** |
|---|---|---|---|---|
| 1. Do you find the use of computers interesting? | **Yes** | 100% | 85,7 % | 90,6 % |
|  | **No** | 0 | 14,3 % | 9,4 % |
| 2. For how long have you been using computers? | **More than 3 years** | 100 % | 71,4 % | 81,3 % |
|  | **1 to 3 years** | 0 % | 0 % | 0 % |
|  | **Less than 1 year** | 0 % | 28,6 % | 18,8 % |

## EVALUATION OF THE USE OF MATHEMATICA® IN THE TEACHING–LEARNING PROCESS

The whole of students stated that the use of the program provoked their interest for the lesson; indeed 71,9 % in a great extent. Males and females were homogenous ($X^2$–Homogeneity, $X^2$ = 2,497, P–value = 0,114, Df = 1) (see Table 2). The students' interest for the lesson was independent to their interest ($X^2$–Independency, $X^2$ = 2,591, P–value = 0,107, Df = 1) and their experience in the use of computers ($X^2$– Independency, $X^2$ = 2,068, P–value = 0,356, Df = 2).

95,4 % of the students stated that the possibilities of the program provoked their interest for Mathematics as a science; 45,9 % of them in a great extent. Males and females presented differences ($X^2$–Homogeneity, $X^2$ = 7,143, P–value = 0,028, Df = 2); males presented a percentage of negative answers (15,8 %) while females did not, but a slightly higher percentage at the greater extent of positive answers (see Table 2). The students' interest for Mathematics was independent to their interest in the use of computers ($X^2$–Independency, $X^2$ = 0,373, P–value = 0,830, Df = 2). We cannot formulate a safe conclusion about the independence of the students' experience in computers' use and their interest for mathematics ($X^2$– Independency, $X^2$ = 6,010, P–value = 0,050, Df = 4). Students with greater experience in computers (more than 3 years) though, presented a higher percentage in the greater extent of interest for Mathematics (More than 3 years: 57,7 %, Less than 1 year: 25 %).

86 % of the students stated that the use of the program enabled their active participation in the lesson, 54,5 % of them in a great extent. Males and females were homogenous concerning their active participation ($X^2$–Homogeneity, $X^2$ = 3,646, P–value = 0,162, Df = 2) (see Table 2).

60,9 % of the students stated that the use of the program enabled their self–action, 38,5 % of them in a great extent. Males and females were not homogenous ($X^2$–Homogeneity, $X^2$ = 9,337, P–value = 0,009, Df = 2); females presented higher percentages both in positive answers and at the greater extent of positive answers (see Table 2).

***Table 2:*** Evaluation of the use of the program in the teaching-learning process

|  |  | **Males** | **Females** | **Total** |
|---|---|---|---|---|
| 1. Did the use of the program provoke your interest for the lesson? | **Yes, in a great extent** | 84,2 % | 64,3 % | 71,9 % |
|  | **Yes, in some extent** | 15,8 % | 35,7 % | 28,1 % |
|  | **No** | 0 % | 0 % | 0 % |
| 2. Did the use of the program provoke your interest for | **Yes, in a great extent** | 47,4 % | 50 % | 51,6 % |
|  | **Yes, in some extent** | 36,8 % | 50 % | 43,8 % |

| Mathematics as a science? | No | 15,8 % | 0 % | 4,7 % |
| 3. Did the use of the program allow your active participation in the lesson? | **Yes, in a great extent** | 47,4 % | 50 % | 46,9 % |
| | **Yes, in some extent** | 52,6 % | 35,7 % | 39,1 % |
| | **No** | 0 % | 14,3 % | 14,1 % |
| 4. Did the use of the program allow your self-action, exploration and experimentation? | **Yes, in a great extent** | 0 % | 35,7 % | 23,4 % |
| | **Yes, in some extent** | 47,4 % | 35,7 % | 37,5 % |
| | **No** | 52,6 % | 28,6 % | 39,1 % |

90,2 % of the students stated that they would like the program to be used in the lesson of Mathematics, 70,9 % of them in every subject. Males and females were homogenous ($X^2$–Homogeneity, $X^2$ = 3,806, P–value = 0,149, Df = 2) (see Table 3). The students' attitude was independent to their interest in the use of computers ($X^2$–Independency, $X^2$ = 3,754, P–value = 0,153, Df = 2). On the contrary it was dependent to their experience in the use of computers ($X^2$–Independency, $X^2$ = 28,872, P–value < 0,001, Df = 2). Students with greater experience presented a higher percentage both at positive and at absolute positive answers (More than 3 years: 100 % and 67,3 %, Less than 1 year: 50 % and 50 % respectively).

58,6 % of the students stated that they would like to use the program themselves in the lesson of Mathematics. Males and females were not homogenous ($X^2$–Homogeneity, $X^2$ = 6,167, P–value = 0,013, Df = 2); males presented a higher percentage of positive answers than females (see Table 3). The students' attitude towards using the program themselves and their interest in the use of computers seem to be dependent ($X^2$–Independency, $X^2$ = 4,724, P–value = 0,030, Df = 1); the whole of students who were not interested in the use of computers (9,4 %) would like to use the program themselves in the lesson. The students' attitude was independent to their experience in the use of computers ($X^2$– Independency, $X^2$ = 0,464, P–value = 0,496, Df = 1).

*Table 3:* Attitude of the students towards the potential use of the program

| | | **Males** | **Females** | **Total** |
| --- | --- | --- | --- | --- |
| 1. Would you like the program to be used in the lesson of Mathematics? | **Yes** | 63,2 % | 61,5 % | 63,9 % |
| | **Yes, in some subjects** | 36,8 % | 23,1 % | 26,2 % |
| | **No** | 0 % | 15,4 % | 9,8 % |
| 2. Would you like to use the program yourself in the lesson? | **Yes** | 84,2 % | 50 % | 58,6 % |
| | **No** | 15,8 % | 50 % | 41,4 % |

## EVALUATION OF THE CHANGE IN THE LEVEL OF UNDERSTANDING OF STUDENTS

The two tests given to the students aimed in the evaluation of their competence to deal with subjects related with the geometric properties of linear functions. In particular the students were asked: a) to conclude about the sign of the parameters a and b of the linear function y = a x + b, by observing at the graph of the function, b) to correspond a number of equations of linear functions to a number of graphs that are given, c) to find the equation of a linear function from its graph, d) to plot the graph of a linear function from its equation and e) to correspond a number of given values for the parameters a and b to given graphs. The tests were ranked with grades from 1 to 5 (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent).

At the pre–test the students ranked from 1 to 4. The mean grade was 2,17 with std. deviation 1,09. The level of understanding of the students was low, as 62,1 % ranked below 2 (poor or fair), indeed 36,2 % ranked 1 (poor) (see Table 4).

Males and females did not present great differences concerning their homogeneity (Kolmogorov–Smirnov, Z = 0,825, P-value = 0,504) and their distribution functions (Mann–

Whitney, U = 351, P–value = 0,736). Males ranked from 1 to 3 with mean grade 2,05 and std. deviation 0,85. Females ranked from 1 to 4 with mean grade 2,26 and std. deviation 1,20.

At the post–test the students ranked from 1 to 5. The mean grade was 3,70 with std. deviation 1,16. The level of understanding of the students changed considerably to high, as 85,9 % ranked above 3 (good to excellent), indeed 32,8 % ranked 5 (excellent) (see Table 4).

Males and females presented differences concerning both their homogeneity (Kolmogorov–Smirnov, Z = 2,271, P–value < 0,001) and their distribution functions (Mann–Whitney, U = 181,5, P–value < 0,001). Males ranked from 2 to 5 with mean grade 3,16 and std. deviation 0,90. Females ranked from 1 to 5 with mean grade 3,93 and std. deviation 1,19. The level of understanding of both males and females was high as 84,2 % of males and 86,6 % of females ranked above 3 (good to excellent). We must note though that 73,3 % of females ranked above 4 (very good or excellent) compared to 15,8 % of males, whose majority (68,4 %) was gathered mainly at 3 (good).

We must note that females presented higher percentages in greater grades than males but also greater variations from the mean grade. The same observation was made in two former studies of the authors, where undergraduate and postgraduate students of the Mathematics Department of the University of Athens (Kyriazis & Korres, to appear) and students of the $2^{nd}$ grade of High School (Kyriazis & Korres, 2001) participated. This result remains to be examined further.

*Table 4:* Evaluation of the Change in the Level of Understanding of Students

|  | Males | | Females | | Total | |
|---|---|---|---|---|---|---|
|  | Pre–Test | Post–Test | Pre–Test | Post–Test | Pre–Test | Post–Test |
| **Poor** | 31,6 % | 0 % | 36,8 % | 6,7 % | 36,2 % | 4,7 % |
| **Fair** | 31,6 % | 15,8 % | 23,7 % | 6,7 % | 25,9 % | 9,4 % |
| **Good** | 36,8 % | 68,4 % | 15,8 % | 13,3 % | 22,4 % | 29,7 % |
| **Very Good** | 0 % | 0 % | 23,7 % | 33,3 % | 15,5 % | 23,4 % |
| **Excellent** | 0 % | 15,8 % | 0 % | 40 % | 0 % | 32,8 % |

The grades of students at the pre–test and the post–test were dependent ($X^2$–Independency, $X^2$ = 21,071, P–value = 0,012, Df = 9). Further analysis showed that the grade of students at the post–test (Y) can be related to their grade at the pre–test (X) with the linear function:

Y = 2,782 + 0,458 X (simple linear model, F = 18,28, Df = 56, P–value < 0,001).

The grade of students at the post–test is an increasing function of their grade at the pre–test. We must note that greater variations between the grades at the post–test and the pre–test are accomplished for lower grades at the pre–test.

The grade of students at the post–test was independent to their interest in the use of computers ($X^2$–Independency, $X^2$ = 5,486, P–value = 0,241, Df = 4) and their experience in the use of computers ($X^2$–Independency, $X^2$ = 3,531, P–value = 0,473, Df = 4).

The grade of students at the post–test (Y) though can be related to their grade at the pre–test (X) and their interest in computers use ($X_1 \in \{0, 1\}$, where 1 = Yes, 0 = No) with the linear function:

Y = 3,568 + 0,471 X – 0,898 $X_1$ (general linear model, F = 12,978, Df = 57, P–value = 0,017).

The grade of students at the post–test (Y) can also be related to their grade at the pre–test (X) and their experience in computers use ($X_2 \in \{1, 2, 3\}$, where 1 = Less than 1 year, 2 = 1 to 3 years, 3 = More than 3 years) with the linear function:

Y = 3,643 + 0,479 X – 0,351 $X_2$ (general linear model, F = 13,319, Df = 57, P–value = 0,013).

We must note that the grade of students at the post–test seems to be a decreasing function of their interest and experience in the use of computers. This observation may be explained by the fact that students with greater experience and interest in computers usually do not pay attention to subjects associated with computers at school since they believe they can handle them more fluently than their co–students. This result remains to be examined further.

## CONCLUSIONS

This paper supports the introduction and use of appropriate computer software programs such as Mathematica® or Maple® in the teaching of linear functions in Junior High School. We regard these programs more suitable and effective to be used especially by the teachers than other subject–specific programs, since the teacher can easily modify the programs presented here or those he constructs himself in order either to design other activities for his lesson, or teach other subjects, as trigonometry, analytic geometry or calculus.

The situation prevailing in Greek schools today does not permit the direct use of these programs on an everyday basis with the students operating on computers. We propose the use of these programs in the context of a resuming–reviewing course, which succeeds the traditional program of teaching and focuses on the negotiation of the geometric quantities of the concepts and subjects that the students have been taught and on solving problems which are associated with everyday situations and relevant mathematical subjects. The programs can be operated by the teacher and the screens of the programs can be projected with the use of a video–projector.

In this paper we present the results of a case–study concerning the teaching of linear functions in Junior High School with the use of Mathematica®. A group of 64 students of two schools, one public in East Attuki and one private in West Attiki, participated in the study, which was realized during the schooling year 2000–2001.

The students that participated made use of computers at School and at home. The majority of them stated they find the use of computers interesting with males presenting a slightly higher percentage of positive answers than females. The students had experience in the use of computers with males having greater experience than females.

The use of the program provoked the whole of students' interest for the lesson and the majority of them in a great extent. Males and females were homogenous. A noteworthy result is that the students' interest for the lesson was independent to their interest and experience in the use of computers.

The possibilities of the program provoked the vast majority of the students' interest for Mathematics as a science (95,4 %). Coming usually in contact with a strict, static, inspired yet untouchable form of Mathematics, the students in most cases lose their interest, rejecting what they cannot handle and deal with. Males and females seem to present differences, as males presented a percentage of negative answers but a slightly higher percentage at the greater extent of positive answers than females. The students' interest for Mathematics was independent to their interest in the use of computers, but seems to be dependent to their experience, as students with greater experience in the use of computers presented a higher percentage in the greater extent of interest for Mathematics as a science.

The use of the program enabled the majority of the student' active participation in the lesson (86 %). Males and females were homogenous. The use of the program enabled the self–action of a lower percentage of students (60,9 %). Females presented higher percentages both in positive answers and at the greater extent of positive answers than males. A noteworthy observation of the teaching of the experimental course was that students that usually did not pay any attention were self–acting, participating actively in the lesson.

The majority of the students (90,2 %) would like the program to be used in the lesson of Mathematics. Males and females were homogenous. The students' attitude was independent to their interest in the use of computers but dependent to their experience in the use of computers, as students with greater experience presented a higher percentage of positive answers.

More than half of the students (58,6 %) would like to use the program themselves in the lesson of Mathematics. Males presented a higher percentage of positive answers than females. The students' attitude towards using the program themselves and their interest in the use of computers

seems to be dependent, as the whole of students who were not interested would like to use the program themselves in the lesson. The students' attitude was independent to their experience in the use of computers.

The change in the students' level of understanding after the completion of the experimental course was obvious. The level of understanding of the students from being low at the pre–test (mean grade 2,17, std. deviation 1,09) changed considerably to high at the post–test (mean grade 3,70, std. deviation 1,16).

At the pre–test males and females did not present great differences concerning their homogeneity and their distribution functions. On the contrary they presented differences at the post–test. Both males' mean grade and std. deviation were lower than females' (mean grade 3,16 to 3,93, std. deviation 0,90 to 1,19). We must note that females accomplished a higher percentage in very good and excellent grades than males, but also greater variations from the mean grade, a result observed in former studies of the authors.

The technological developments of our days have occupied us with powerful, promising tools, tools in the service of both teachers of Informatics and teachers of other domains. These tools can help us improve the quality of our lesson, improving not only the performance of our students in demanding tests, but also "gain" our students' interest and trust in being occupied with the subjects we teach them, based not only to our "word" but on their personal feelings. We must not "convict" our students to the traditional instruction we experienced as students, an instruction related with plain formulations of definitions and theorems, an instruction that "hides" the real magic of Mathematics, that is "discovering" and "doing" Mathematics.

## REFERENCES

Bruner J. (1960). «On Learning Mathematics». *The Mathematics Teacher*, 53, 610–619.

Bruner J. (1966). *Towards a Theory of Instruction.* Belknap Press, Cambridge.

Kyriazis A. & Bakoyiannis S. (1995). *New Technologies in Education* (in Greek)*.* University of Athens.

Kyriazis A. & Korres K. (to appear). *Pre–service and in–service teacher of Mathematics' training in teaching with the use of Computers.* Proceedings of the 2nd International Conference on the Teaching of Mathematics at the Undergraduate Level.

Kyriazis A. & Korres K. (2001). *Teaching of Plane Curves, in High School, with the use of Computers* (in Greek)*.* Proceedings of the 18th Conference of Mathematics Education of the Hellenic Mathematical Society, 309–319.

Kyriazis A. & Korres K. (to appear). *A Teaching Approach of Plane and Space Curves with the use of Computers.*

Kyriazis A. & Korres K. (to appear). *Studying Plane and Space Curves with the use of Computers.*

Markovits Z., Eylon B. & Bruckheimer M. (1988). Difficulties students have with the function concept. In A. Coxford & A. Shulte (eds), *The Ideas of Algebra*, K12, 43–60. Reston, VA: N.C.T.M.

Sinclair H. (1987). *Constructivism and the psychology of mathematics*. Proceedings of the Eleventh Annual Psychology of Mathematics Education Conference.

Steffe L, Cobb P. & Von Glasersfeld E. (1988). *Construction of arithmetical meaning and strategies*. Springer–Verlag, New York.

Torrence Br. & Torrence E. (1999). *The Students Introduction to Mathematica*, Cambridge University Press.

Toumasis Ch. (1994). *Contemporary Didactics of Mathematics* (in Greek). Gutenberg, Athens.

Wolfram St. (1996). *The Mathematica Book*, 3rd Edition. Cambridge University Press.