A TOOL FOR REAL-TIME ILLUSTRATION OF BASIC CONCEPTS IN AN ECONOMICS COURSE

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Abstract

This paper presents an interactive software program that is used as a tool to introduce important economic concepts to students in a user-friendly environment. This software is specially developed for educational purposes, and generates multiple polynomials of *n*-degree, i.e., linear, quadratic, cubic, and higher order curves. By changing variable values, real-time manipulation of the curves can be applied, illustrating different behaviours and meanings of these concepts. The student can observe behaviours of economic relationships changing in real-time. This software can be used as a supplement to in-class teaching for illustrating practical examples of the theoretical economic concepts.

Keywords: education, pedagogical teaching tools, visual learning, economics concepts

Introduction

Graphs are the most efficient method for displaying information in a simple manner. The use of this form of representation helps viewers to understand and interpret the information more easily and efficiently, which otherwise could be a very difficult and tedious process.

Economics is a social science that attempts to understand how dependent variables, such as quantity demanded, quantity supplied, total revenue, total cost, consumption, money supply, etc., are influenced by other independent variables. Since economies are dynamic and constantly changing, economists must take snapshots of economic data at specified points in time and compare them to other fixed-time data sets to understand trends and relationships. To understand the relationships between these variables, economists use graphs to visually interpret and explain complex ideas.

In education, whether this is at university level or at high-school level, important concepts in economics courses are mostly demonstrated using graphs. No matter what these concepts are, it is easier and more efficient to provide to students an intuitive understanding of the theory through practical examples illustrated on a graph. This approach is, in effect, similar to viewing a picture in a textbook. A better alternative is for the educator to demonstrate real-time animated graphs, since a picture is worth a thousand words but a moving picture (animation) is worth a thousand static ones.

When an educator has a tool to demonstrate real-time applications, students find it much easier to understand the theoretical concepts. A number of researchers have also developed such tools (Diamond, 2009; Holian, 2011; Leet, 2003; Oskar, Mercier, Gulag, Burdick, & Brown, 2011).

This paper presents a software programme developed to display basic graphs used in an Economics class to demonstrate theoretical concepts. The software was designed based on the experience and requirements of the lecturers in the Department of Economics at the University of Nicosia, who are using it in their in-class sessions to interactively demonstrate to students certain trends of business and economic factors. Also a set of *Default Graphs,* which are more often used in teaching economics, have been created in order to be available with a single button click. Graphs can also be saved as picture files so that can be included in a presentation.

Graphs in Economics

A graph of data points helps economists to illustrate the movements and trends over specific timeframes. Data written on paper is hard to translate into understandable bits of information. However, when economists put information on a graph, it is easy to identify the trend. For example, a data set of gas prices over time could be plotted on a graph to quickly see when prices were increasing or decreasing, whether this happens regularly over a fixed period of time and many other observations that can result in a number of conclusions that play a major role in decision making. Hey (2005) supported teaching using graphs but resented the use of math. In a study, Cohn, Cohn, Balch, and Bradley (2004) found that half the students having problems with graphs also do worse in the exams. However, 70 per cent of the students find graphs useful. Moreover, Ballard and Johnson (2004) found a positive relationship between student mathematical ability and performance in principles of economics classes.

Graphs in economics can show the relationship between two variables. For example, a classical economics graph would be the average cost of a product on one axis and the amount produced on the other axis. This graph would illustrate the cost of production at different levels of output. This graph could help a company determine their pricing policy for profit maximization.

Another classical example of using graphs in economics is to determine equilibrium. For example, the standard supply and demand graph results in an x-shape. The point at which the supply and demand lines intersect is the equilibrium, where the quantity supplied and demanded of a specific good are equal as illustrated in Figure 1.

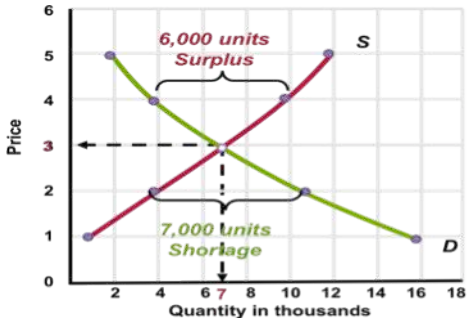


Figure 1. Demand and supply.

Economic graphs can also help illustrate what happens when there is a shift or change in variables. For example, if supply for a product is stable but demand suddenly increases due to specific factors, the demand line on the graph will shift as shown in Figure 2. From this we can predict that the price of the good will rise.

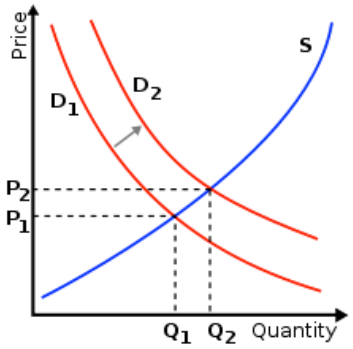


Figure 2. Increase in demand.

The software described in this paper has been developed to provide the educator with the right tools in order to be able to draw economic graphs within a user-friendly environment. The educator can change a number of parameters to modify plotted curves so that students can observe economic concepts in real-time.

The rest of this paper discusses a few aspects of the software development phase and then describes how a user can plot multiple curves on a graph and the effects of altering the values of a number of parameters.

Software Implementation

The software application was implemented using the .Net Framework, the Visual Basic 2010 Express programming language, and the MS Chart Controls for .NetFramework. The *Microsoft Chart Controls* are an encompassing set of charts for WinForms and ASP.NET applications. The Chart Controls suite offers a wide array of chart types and charting features and offers all of the standard chart types – line charts, bar charts, pie charts, and so forth – as well as more specialized ones, like pyramid and bubble charts. It also offers a comprehensive set of charting features, including support for multiple series, customizable legends, trend lines, and labels. And the Chart Controls API makes it easy to sort, search, filter, group, and export the chart data. The programmer needs to specify the data source, set the properties and bind the chart data manually. They provide the foundations for building interactivity for an application manually since the interactivity they offer by default is minimal.

MS Chart Controls have been used to display the graphs. The software's interface is shown in Figure 3 that displays the graph of the function:

$$y = \frac{-((x-5)^2 - 20)}{2}$$

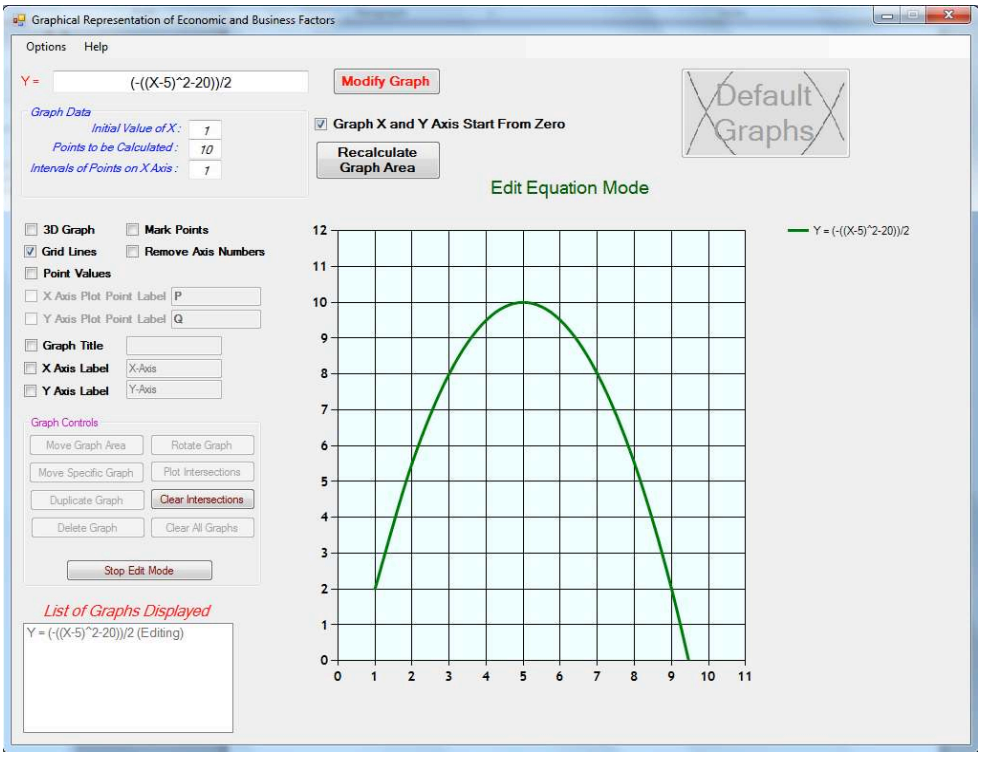


Figure 3 The software's interface.

Equation Input

To display a curve, the user can either select a predefined one or insert a function in the *equation input-box*, along with the initial x-value, the points to be calculated, and the x-interval distance as shown in Figure 4. Accepted values are any numbers, together with any of the following symbols: + * - / ( ) ^ X, where X denotes the variable. The user can also modify a curve after it has been created and plotted, and the graph will change accordingly.

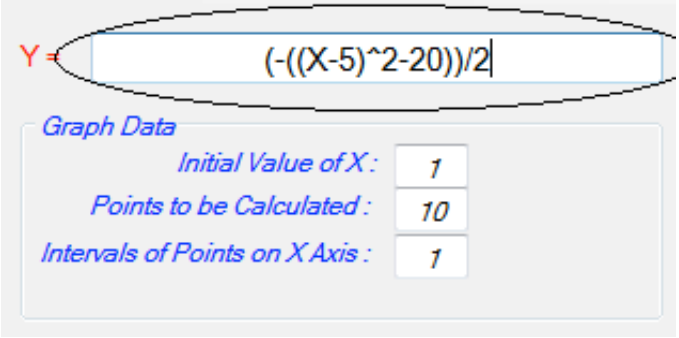


Figure 4. Equation input-box.

Display Control Panel

Many curves can be plotted on the same graph simultaneously. A list of all plotted curves is displayed on the right hand side of the display window, and with the same colour as the curve they represent. This is illustrated in Figure 5.

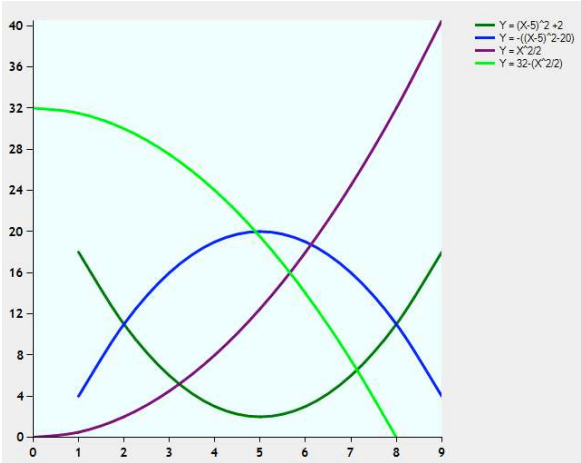


Figure 5. Multiple curves.

The software provides the user with a *display control panel*, shown in Figure 6, which controls the appearance of the graph. For example, a graph can be displayed with or without: title, axis-labels, axis-numbers, or grid lines (Figures 5 and 7). It can also have a 3D effect as in Figure 7(b). A curve can also be displayed with or without labelling its calculated points as in Figure 7(a).

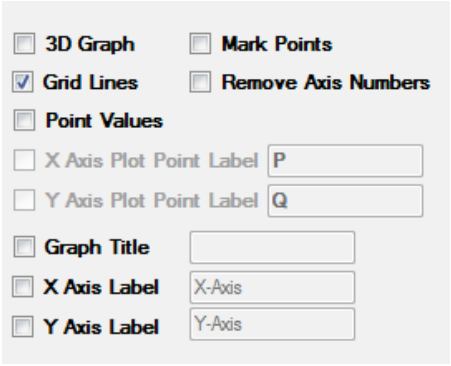
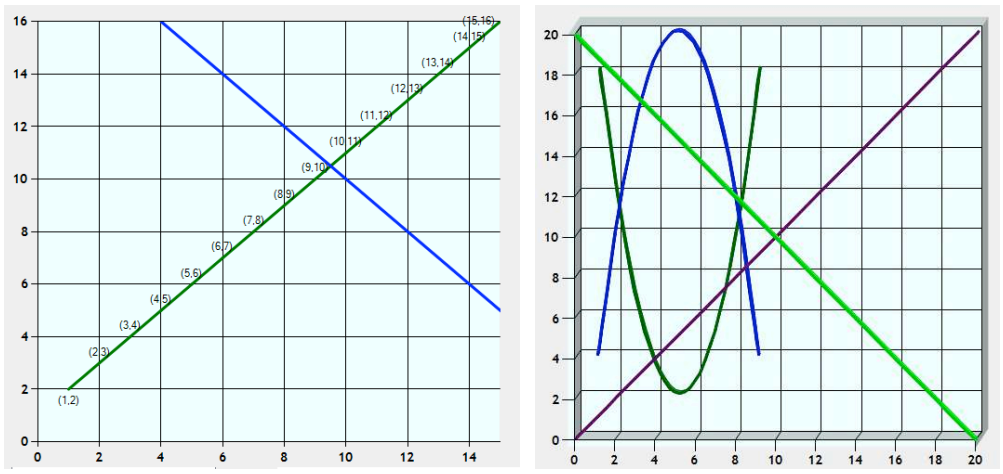


Figure 6. The display control panel.



a b

Figure 7. Displaying graphs.

Graph Control Panel

After plotting the first curve, the *graph control panel* shown in Figure 8 becomes visible and provides the user with a number interactive manipulation of the curves.

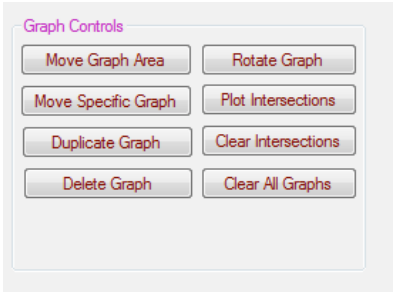


Figure 8. Graph control panel.

Move Graph Area. After pressing the *Move Graph Area* button the user can alter the coordinates of the display window by dragging the mouse on the graph display area, thus affecting all plotted curves as illustrated in Figure 9.

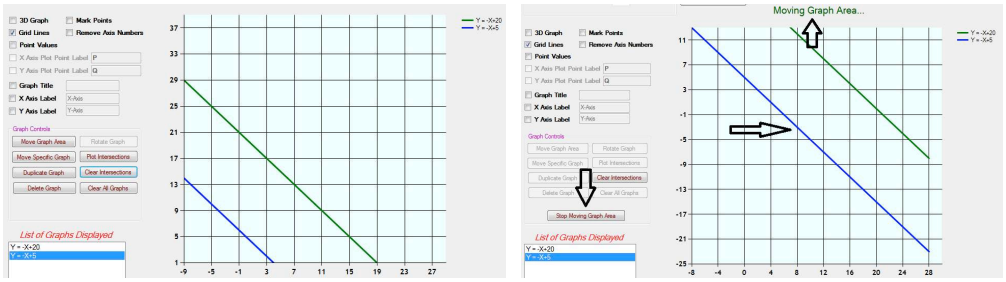


Figure 9. Changing the display window.

Move Specific Graph. This option enables the user to move a specific curve. By clicking the *Move Specific Graph* button, the user can translate the selected curve on the

xy-axis as shown in Figure 10. The selection of the curve to be moved is done in the *List of Graphs Displayed* list-box as shown in Figure 11. The selected curve has the label *Moving* next to its function formula.

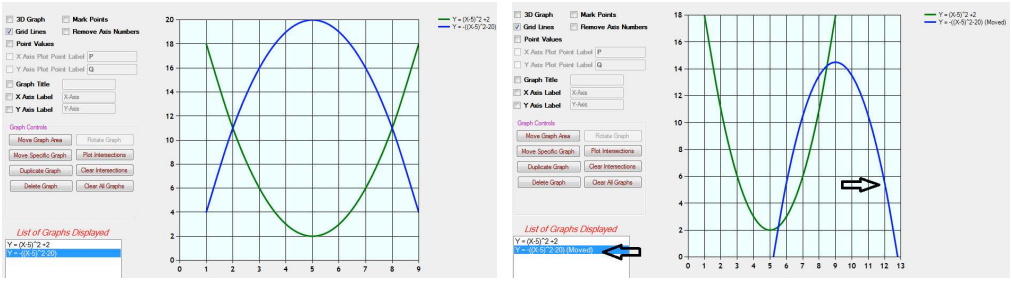


Figure 10. Moving a specific curve.

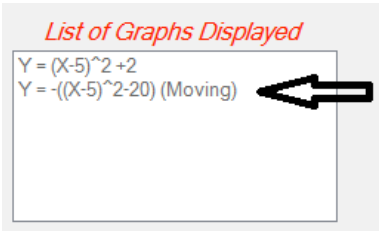


Figure 11. The list of graphs displayed.

Duplicate Graph. This option allows the user to duplicate a curve and place it on another position on the graph. For example, an educator could duplicate the demand curve and place it on another position in order to get the new equilibrium.

Plot Intersections. By clicking the *Plot Intersections* button the user can insert curve intersection lines as shown in Figure 12.

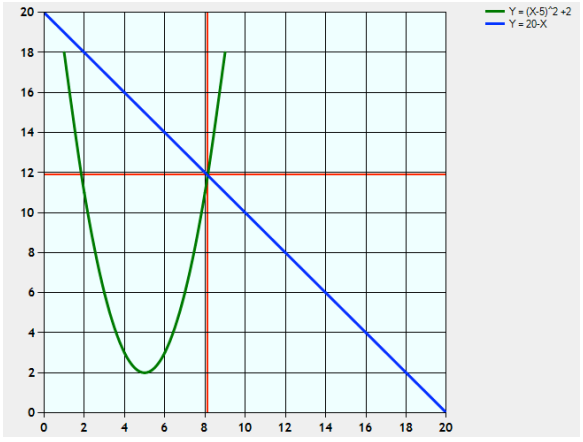


Figure 12. Curve intersection.

By inserting an intersection the two check-boxes *X Axis Plot Point Label* and *Y Axis Plot Point Label* become enabled, and the user can input labels to be displayed on the graph as illustrated in Figure 13.

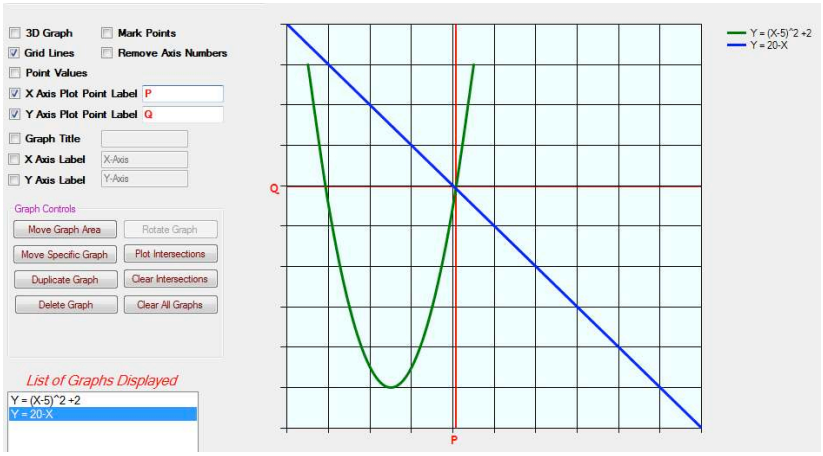


Figure 13. Intersection with labels.

By clicking on the *Clear Intersections* button, the intersection is deleted, and the options of *X* and *Y Axis Plot Point Label* are disabled.

Delete Graph. The user can delete a curve by selecting it from the *List of Graphs Displayed*, and press the Delete Graph button.

Clear All Graphs. This option allows the user to remove all curves at once.

Rotate Graph. When the *3D Graph* option-button is checked, the button *Rotate Graph* becomes enabled. By clicking it the user can rotate the *Display Window* as shown in Figure 14.

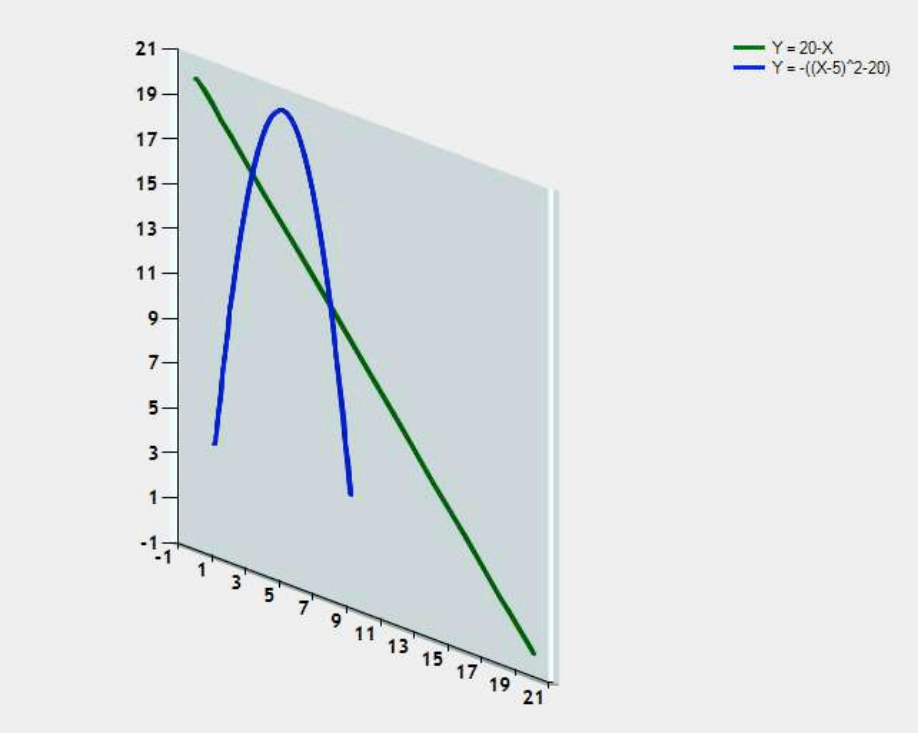


Figure 14. Graph area rotation.

Zooming. By clicking on the *Graph Area* and by rolling the mouse wheel, the user can zoom in and out of the *Graph Area*. This functionality is useful when there is a need to focus on a specific position in a graph, or get the whole picture of all the graphs plotted.

Default Graphs

Since this application was designed to be used by educators in order to present economic theoretical concepts, a number of predefined curves, commonly used in economics to present these concepts, have been included. When the user clicks the *Default Graphs* button, a new window appears with the predefined curves as shown in Figure 15 and the user can select the graph to be plotted.

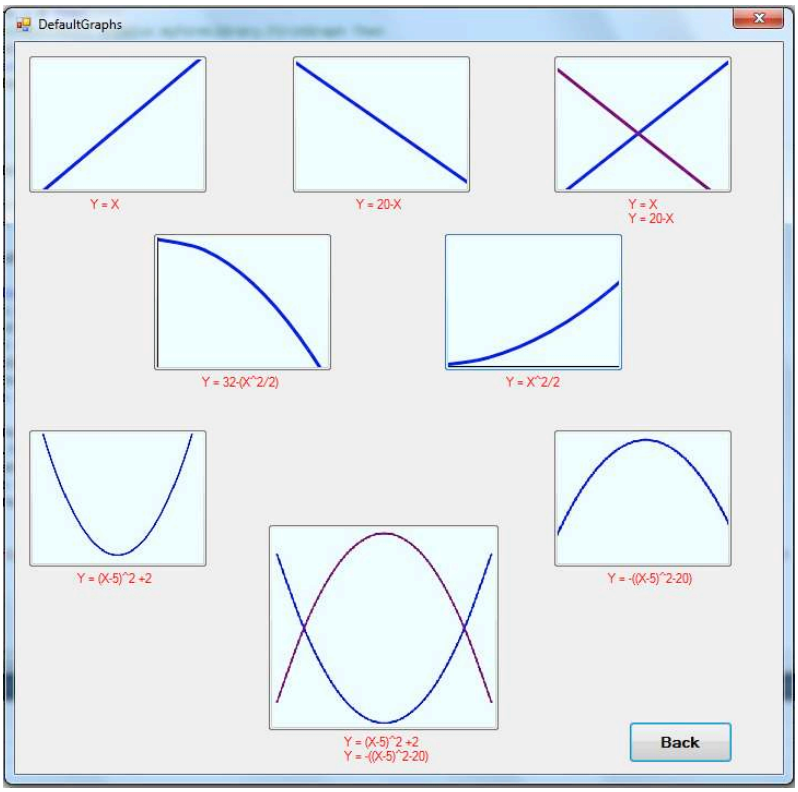


Figure 15. Default graphs.

Using the Software for In-class Teaching

The software has been used as a teaching tool in Economics during the past two semesters. This preliminary qualitative research gives us good reasons to believe that the software program has led to an increase in student understanding especially after noticing a marked improvement in overall grades and favourable comments in course student evaluations at the end of each semester. However, the authors acknowledge the need for a quantitative study regarding the impact of the software on students and lecturers using it.

In the software design process special attention was given at certain course learning outcomes such as:

- Apply graphical analysis on economic issues.
- Identify how equilibrium price is determined in a free market through the interaction of supply and demand.
- Demonstrate the concepts of demand and supply analysis relevant to the business environment.
- Analyze market examples and applications to simulate realistic business experience.

- Analyze the aggregate demand – aggregate supply model, the concept of the multiplier and the business cycle.
- Explain how foreign exchange is determined.

The quantitative survey and the design of the questionnaire aim at examining the extent to which the above learning outcomes are met.

Conclusion

Business and economics textbooks are full of graphs that give students a representation of mathematical concepts. Graphs are visual representation of numerical systems and equations. In addition, graphs play an important role in the modelling and understanding of simple or complex economic systems. However, many students struggle with the basics of graphing.

The software program described in this paper aims at familiarizing students with plotting x-y data on a graph, transforming equations into graphs, describing the resulting relationships (positive, negative or independent), as well as interpreting graphs. The software can successfully create curves such as demand, supply, total, average and marginal product, total, average and marginal cost, total and marginal revenue, profit, slope of linear or non-linear relationships and many others.

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