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Perspectives of Business and Entrepreneurship Development in Digital Transformation of Corporate Business

Maple Application in Economic Disciplines

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Abstract

Purpose of the article Efforts to use the Internet to make everyday activities as easy as possible is a current trend. The same applies to education, with teaching being gradually more and more supported by programs, applications and internet documents. The same goes for teaching of subjects in the field of mathematics and economics and their applications.

Methodology/methods One way to bring mathematics closer to students and encourage their creativity is the use of tools provided by ICT technologies. The use of ICT in teaching of mathematical and economic subjects has now come to the centre of attention of educators teaching these subjects. Engagement of computers and all ICT technologies in the teaching process may be of various quality and form. We can perceive the computer as a tool the educator uses to prepare their teaching aids, as well as the environment where the whole class works on solving a particular problem.

Scientific aim The aim is the use of Maple for solving differential equations, difference equations, functional differential equations and their economic applications.

Findings Incorporation of mathematical software (Maple, Matlab, Mathematica, etc.) can simplify work with functions created from real data for students. Students can get new motivation for work when they see that mathematics is not only a theoretical science but it can also be used as a tool in many fields. Studies show that students using Maple handle the curriculum content much better than those who learn in the traditional way. Improvement is obvious in all students regardless of initial knowledge level.

Conclusions By suitable and active incorporation of Maple into teaching a much larger amount of examples can be discussed since a number of routine calculations are eliminated. Maple allows students to model various economic situations and see immediately how these changes of external conditions affect the output. Many tasks stimulate critical mathematical thinking since it forces outcome estimates or checks and, last but not least, there are graphical outputs.

Keywords: Maple, mathematical software, ICT, teaching

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Introduction

Maple is a computer environment developed at the University of Waterloo in Canada to simplify and accelerate calculations in mathematics. Unlike traditional numerical calculation programs, it models mathematical operations with symbolic expressions. Maple enables symbolic and numerical calculations as well as function graphs, programming of custom functions or procedures, saving data in several formats and even export to programming languages. Maple implemented functions cover an extensive area of mathematics from basics of linear algebra, differential and integral count to differential equations, geometry and logic. The work is based on symbolic operations using the advantages of saving numbers in their exact format, therefore Maple gives results with much higher precision than in ordinary numerical calculations with movable decimal point. Maple is used not only for teaching but also for research and development. It is a very complex mathematical system providing various tools for real problem simulation.

There have been a lot of issues in teaching of mathematics at all school levels for many years. The field that was perceived as one of the absolute bases of education for many decades was gradually marginalised. At schools, mathematics is often regarded as unpopular, boring, hard, detached from reality and even useless.

Of course, these problems are reflected in university studies as well. The situation is slightly more favourable in fields immediately related to mathematics, usually attended by students who favour the subject. Problems are emerging in technical programmes where students more often than in the past have difficulties mastering mathematics, although many faculties lowered their requirements compared to the past. The situation is the least favourable in humanities, such as economics, sociology, law, etc. Here one often hears claims that mathematics (statistics, logic, …) is useless, not only from students, but sometimes also from the educators.

Thus the question stands how to prepare mathematics teaching, mostly in fields aimed "for mathematicians, how to bring the subject closer to the students, how to simplify its perception and, most of all, how to show that mathematics can play an important role even in their lives, as a discipline that presents various practically applicable tools and also as a field that cultivates systematic and logical thinking and develops the ability of objective perception of facts and, last but not least, contributes to creative everyday problem-solving. (Dostal, 2016)

One way to bring mathematics closer to students and encourage their creativity is the use of tools provided by ICT technologies. (Jehlička, 2018) Use of ICT in teaching of mathematics has become a subject of interest of educators who teach mathematics.

Engagement of computers and all ICT technologies in the teaching process may be of various quality and form. We can perceive the computer as a tool the educator uses to prepare their teaching aids, as well as the environment where the whole class works on solving a particular mathematical problem.

Incorporation of mathematical software (Maple, Matlab, Mathematica, etc.) can simplify work with functions created from real data for students. Students can get new motivation for work when they see that mathematics is not only a theoretical science but it can also be used as a tool in many fields. Studies show that students using Maple handle the curriculum content much better than those who learn in the traditional way. Improvement is obvious in all students regardless of initial knowledge level. (Ningsih 2018)

## 1 Basic mathematical tools used in teaching economics

The aim of a basic economics course is not to prove using sophisticated mathematical methods how variable X affects the course of variable Y, but for the students become familiar with basic economic terms, be able to explain what its subject of inquiry is and why it is good to study economics in the first place. On the other hand, the use of the mathematical apparatus cannot be avoided in many cases. (Drábeková, 2015) It is completely necessary for basic courses of economics that the student has mastered solving systems of equations with two unknowns and most importantly learned to read graphs. These two skills constitute the absolute basics that are essential for students of basic courses of economics.

Basic courses are usually taught in the bachelor university programmes, advanced courses in master programmes. Students' ability to use mathematics as a tool for solving economic models is not sufficient, although the students consider the study of mathematics and statistics to be important. This is demonstrated by the fact that the students believe practical knowledge of mathematics and statistics to be significant. Problems occur mostly in the use of basic mathematical knowledge and its application to economic problems. Students often suffer from needless bias and fear to combine mathematical and economic knowledge and they tend to give up easily. At the level of basic microeconomics course, students are often challenged by reading a graph depicting any function.

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As for advanced microeconomics courses, students should have mastered mathematical skills of grammar school graduates. These courses are taught mostly in follow-up master programmes. In optimization tasks in particular the use of derivations for finding extremes of utility, production, profit and cost functions is required, as well as for solving tasks measuring demand elasticity in order to deduce conclusions concerning investigated goods and services.

E.g. in optimization tasks, it is important that the students understand and apply Lagrange method of bound extremes. A model example can be the search for the maximum of the utility function bound by the condition of budgetary restriction. To get a better idea of the solution, it is advisable to depict the searched bound maximum graphically.

Example We will work with a particular utility function and the budgetary restriction. By applying Lagrange method of bound extremes, we will calculate the utility maximum. Maximum utility of 250 (full blue line) will be achieved at the point of the utility curve touching the budgetary restriction, i.e. at, see Figure 1. The blue dashed line shows higher and lower utility values. Higher utility (500) may not be achieved with the given budgetary restriction; to the contrary, lower utility (100) is not desirable with regard to the search for utility maximum.
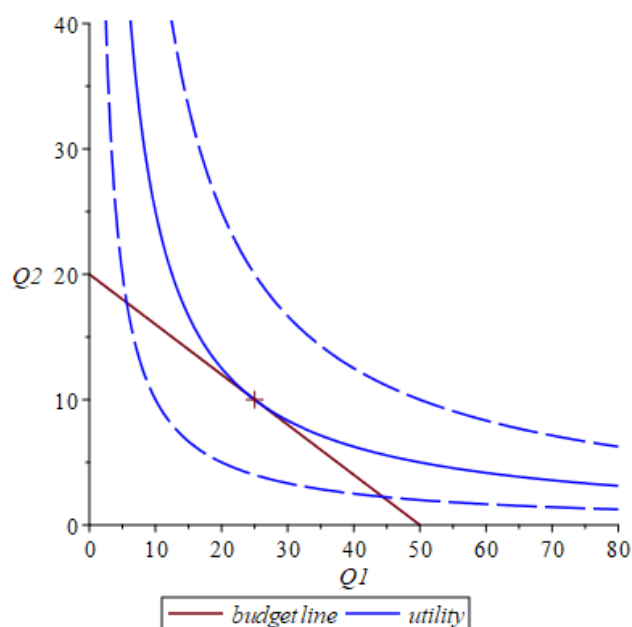
Source: Elaborated in Maple by the author, 2019

Figure 1 Bound maximum

In advanced courses, students also face various types of differential equations, difference equations, functional differential equations and their applications. Mathematical models describing common everyday problems also include the application of this type of equations.

Mathematical models using delay functional differential equations are applied in areas we would not have expected few years ago. For instance, they are used in medicine in describing the process of substance effects on the body or spread of infectious diseases. In ecology, there are models describing populations of a single species as well as models of multi-species population dynamics. In physics the models describe the pantograph movement down the line or nuclear reactor dynamics, among other things. In microeconomics, the models describe price fluctuation and in macroeconomics they apply to the theory of economic cycles.

Maple offers three ways of solving differential equations:

1. Analytical solution with Maple searching for a solution in the form of a single-variable function,
2. Solution using infinite sequences with Maple looking for a solution in the form of an infinite power series,
3. Numerical and the closely related graphical solution.

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All types of solutions in Maple are under one order, the dsolve procedure, which is one of the most useful and frequently used tools for solving differential equations. There is a large number of optional parameters in the dsolve procedure.

The analytical solution is the basic method of solving differential equations in Maple and the program has strong computing tools for this type of solution. Other solution methods are used when the analytical solution fails or when the result may not be expressed "in a nice form". The analytical solution by dsolve procedure is used most frequently of all the methods, therefore this type is preset and no other additional settings of optional parameters are necessary.

Some equations may not be solved analytically but we can solve those using power series.

By numerical solution of ordinary differential equations we mean approximate solution of ordinary differential equations by methods of numerical mathematics. These methods are used in cases when finding an exact analytical solution is difficult in terms of computing or in cases when an analytical solution may not be found. The most common examples include non-linear differential equations, linear differential equations with non-constant coefficients or higher order linear differential equations with constant coefficients.

The graphical solution is closely related to the numerical solution or it is added as visualisation of function graphs obtained in the analytical solution. For these purposes, Maple provides a basic tool for graph depiction – plot procedure, or a special tool for graphical depiction of the numerical solution, the odeplot procedure from the plots library.

Example Euler's method is the basic method for the numerical solution of differential equations. By this method, we will find an approximate solution of the initial task

$$y' = x - y \qquad\qquad y(0) = 1$$

at interval [0;1]. We will use a ten-point power equidistant network. The graphical output is in Figure 2. The numerical solution graph is depicted in red, the analytical solution graph in blue.
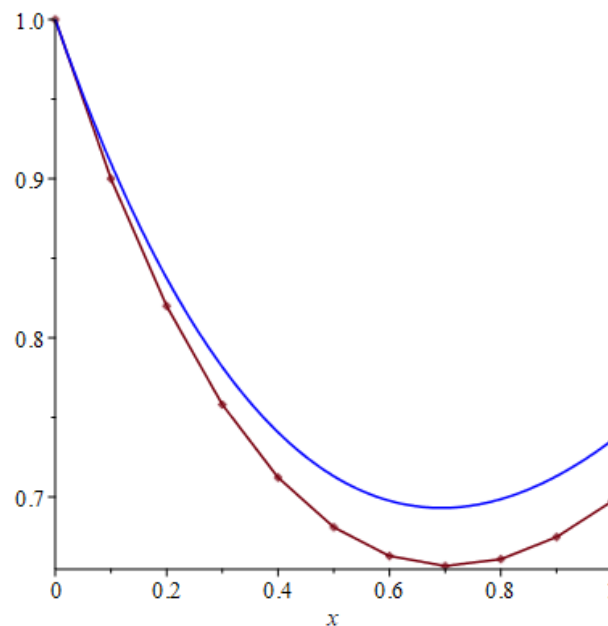
Source: Elaborated in Maple by the author, 2019

Figure 2 Numerical and analytical solution graph

The primary aim of economic subject teaching at universities should be not only to provide knowledge but also to encourage practical application of the knowledge. On the other hand, practice should not underestimate scientific approach; it should require educated, thinking people able to use their knowledge pragmatically, and used to responsibility, independence and creativity as well as efficient work. Economic profile disciplines give students sufficient options for topic selection and compilation of their theses. The use of mathematical disciplines together with knowledge from practically oriented subjects in thesis drafting gives senior students wide range for

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self-realization and together with a number of ICT tools, creates environment for deepening and strengthening the acquired knowledge.

2 Use of ICT

There are three broad categories of the applications of computers in the field of mathematics education: computer assisted instruction (CAI), student (educational) programming and general purpose educational tools such as spreadsheets, databases and computer algebra systems (CAS).

Presently it seems that university professors would benefit from combining information technologies with mathematics to show students the possibilities of using information technologies in mathematics. (Misut, 2015)

ICT technologies can be viewed as

a) Tool for teachers

The simplest way for computer technology to assist mathematics teaching is using the computer as an educator's tool for teaching preparation. At a time when university professors become the editors and often even publishers of their own textbooks, in paper or digital form, as is increasingly the case, the above skills may be regarded as the minimum standard.

b) Demonstration tool

The computer may serve as an illustrative demonstration tool in mathematics teaching, for the teacher to present new findings. A specially equipped classroom is required for computer aided teaching (computer + interactive board or projector), which is often not a standard at universities.

c) Tool for practice

Use of computers as practical tools used by students in mathematics is the most demanding form of teaching in terms of requirements. This is because such classes need to be taught in a fully equipped computer room where each student or a pair of students have their own computer. However, school computer room capacities are of-ten insufficient to meet the educators' requirements and specialized subjects are preferred.

Conclusions for Education

There is a major issue that during the study of mathematics, students often fail to see any practical application of what they are supposed to learn. Thus the bias against mathematics as such mentioned above may originate and economics is then often perceived just as another mathematics-oriented subject. However, economics is a science of human behaviour and mathematics serves for better understanding of the relations between real economic phenomena.

A possible solution may come in the form of certain humanization of mathematics and consistent explaining and reasoning of why the students are required to learn how to solve equations, examine function behaviour, to differentiate or integrate. Students should know that they are not learning something just for the sake of learning, something they will not apply in further study or practice. Of course, the same appeal goes to economics teachers who should consistently explain, demonstrate on examples and point out important connections any-time they try to extend the students' knowledge in the fascinating science of economics. Mathematics may never form a universal model of human behaviour but it definitely is a very suitable science that enriches economics and helps us to understand real economic phenomena, explain them and predict the effects of individual measures, the impact various changes might have on the economic reality, if external conditions shift. Maple allows students to model various economic situations and see immediately how these changes of external conditions affect the output. Not only numerically but also graphically.

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