Developing Interactive Course Material for Volterra Integral Equations of Second Kind

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***Abstract*—the main purpose of this paper is to propose a developed interactive course material which is contained course materials, solution methods with examples and interactive environment for Volterra Integral Equations (VIEs) of Second Kind. It is possible to learn what VIE of Second Kind is, to make practice with interactive part of the material and, also how a VIE can be converted to an equivalent Initial Value Problem (IVP).**

***Keywords*—Interactive Application; Maple; Volterra Integral Equations of Second Kind; Interactive Course Material; Developing Interactive Course**

I. INTRODUCTION

Interactive learning actively attracts the students in struggle with the material. It reinvigorates the classroom for both students and faculty. Lectures are changed into debates, and students and teachers become partners in the journey of knowledge acquisition.

One approach to interactive learning, sometimes referred to as the "flipped classroom," is an holistic methodology that employs both online and classroom strategies to boost student engagement and mastery of content.

Differential Equations are among the most important tools used in producing models in the physical sciences, biological sciences, and engineering [1].Especially, Ordinary Differential Equations are playing an ever more important role in the physical, biological sciences and some other social sciences as well. Furthermore, ODEs are encountered in numerous applications in many fields including mechanics, potential theory, geophysics, electricity and magnetism, kinetic, biology, mechanics, optimization, optimal control systems, communication, mathematical economics, population genetics, mathematical problems of equilibrium, and heat transfer problems. In this paper, II-Order Ordinary Homogeneous and Nonhomogeneous Differential Equations are considered.

II. MOTIVATION

The definition of Differential equations and II-Order Ordinary constant coefficient differential equations are defined entirely in the literature [2]-[10].

There are some methods to obtain exact and approximate solutions of II-Order Ordinary constant coefficient differential equations, such as The Method of Undetermined Coefficients or Guessing Method [2], The Method of Variations of Parameters [3], Finite Difference Method [4]-[7]. In this work the application of these methods will be considered.

III. USING MAPLE

Computer algebraic systems (CASs) have become an essential tool in making the teaching and learning process become more meaningful (Ittigson and Zewe, 2003). This idea has been extended by various researchers through studies that evaluate the benefit of using certain elements of CAS during the classroom process, especially for teaching mathematics. The CAS was introduced to the world of education in 1970 (Godarzi, Aminifar, and Bakhshalizadeh, 2009). Nowadays, there are several commonly used CASs in mathematics classrooms, such as Maple, Mathematica, Mathlab, and Mathcad.

In recent years a remarkable number of interactive tools have been created to display mathematics over the internet using any browser. Two most known software are web Mathematica (see [8, 9] and MapleNet see [10]). Educators engaging in the use of the internet in teaching Mathematics are using interactive tools to present and discover mathematical concept.

Virtualizing differential equation concepts enhance the ability of the student to comprehend the dynamic of the three dimensional mathematical concept. We have created an application with Maplets that contains 2-D and 3-D graphics for the concept covered in the ordinary differential equations course by keeping this philosophy in mind.

Computer algebra systems (CAS) like Maple and others are changing the way we study, teach and apply mathematics. Each of those systems combines extensive collection of mathematical functionalities, a graphical and computational environment, a programming language and many other features in one software package, making it possible to perform sophisticated mathematical computations with a single or a sequence of commands. Nowadays, Maple and Matlab are probably the two most successful CAS, along with Matlab that is mainly built for efficient numerical computations.

Maple is a product of Maple Soft, one of the leading providers of software tools for mathematical, engineering and scientific computing. It consists of rich and user-friendly interfaces along with a large collection of functionalities for

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manipulating mathematical expressions and numbers. Moreover, Maple comes with a simple programming language that is capable of being used to implement developed algorithms for scientific computing. It is a perfect platform for introducing scientific computing, basic programming, mathematical experimentation and simulation.

A Maplet consists of one or more windows which interact with the user by means of buttons, checkboxes, text fields, and other standard graphical controls. Maple is a powerful problem-solving environment capable of doing quite advanced mathematics, but the price of this power is considerable complexity. With a Maplet, this complexity can be retained but restrained: a simple menu interface, tailored to a specific task or problem [8].

The Maplets packages of Maple allow designing graphics interfaces with the capability to interact with the mathematical kernel. With this tool we have developed a Maplet application of II-Order ODEs with constant coefficient. The Maplets are generated basically using Maple code and then displayed over the web as JSP application thorough MapleNet. The use of Maple thorough MapleNet gives the user with access to the internet using any browser the interactive capabilities of the animations.

The advantage of using interactive tools such as the Maplets is that it takes away the somehow complicated code to investigate the concept. The Maplet as well as other similar applications allow the user to enter minimum information. The main goal of the application is for the user to experiment and discover mathematical concept, develop the perception and make conjectures.

IV. Interactive Course Material for Volterra Integral Equations of Second Kind

Figure 1 is the main display of the interactive course material for VIE. Here the topic is gathered under five subtitles which are Introduction, Classification, and Applications of the Solution methods for VIEs of second kind, Interactive Application, and Converting VIEs to an IVP. This is actually a pull down menu. User can see detailed information about the title when pull down each title.

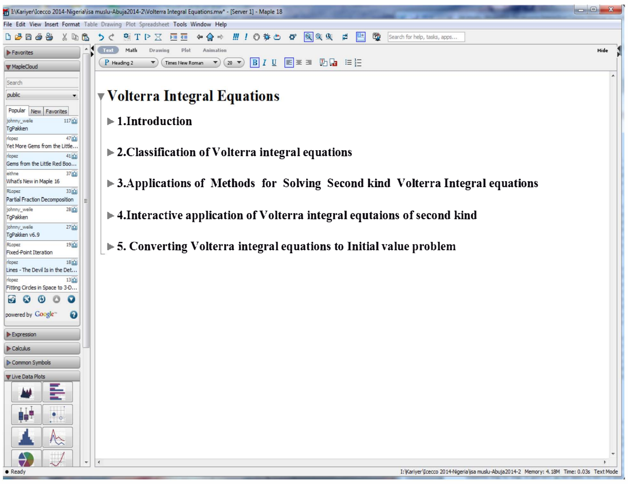

Fig. 1.Main display

Figure 2 is the pull down form of the main display. Here the details of the each of subtitles like definition of VIE, classification of VIEs, solution methods, interactive application, and a converter VIE to an IVP can be seen. Here the detailed information is given with examples.

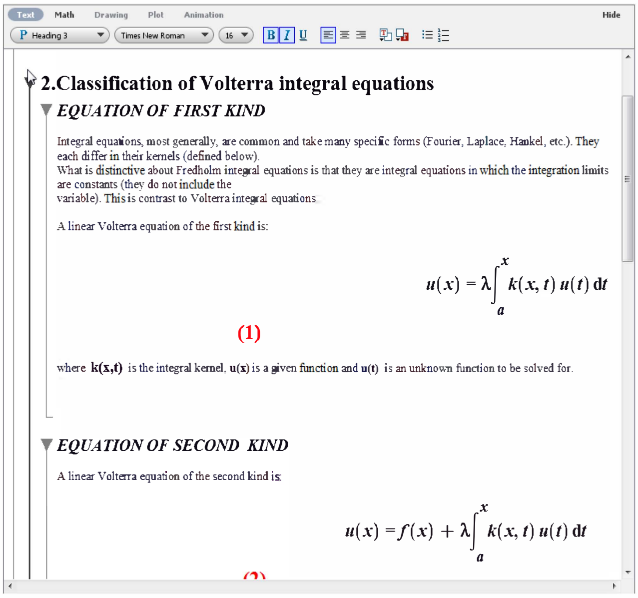

Fig. 2 .Pull down form of main display

Figure 3 is converting part of a VIE to an equivalent IVP. The explanation of the converting a VIE to an IVP is given with examples at the beginning and then the interactive converter is given at the end. So, it is possible to learn how a VIE can be converted to an equivalent IVP with examples and then to make practice with interactive converter.

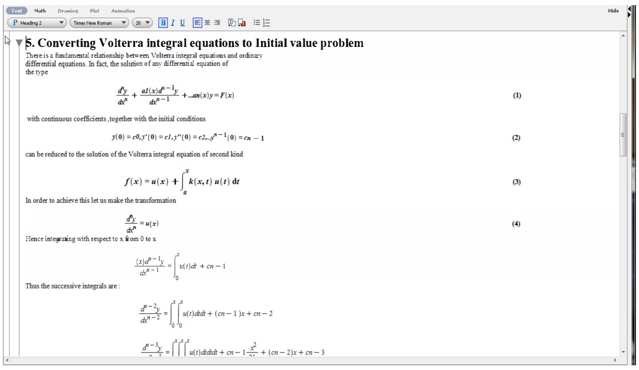

Fig. 3 .Converting a VIE to an IVP

Figure 4 is the guide for interactive part of the material for the user to make user's work as soon as uncomplicated. Here some information is given about used buttons, the equations which is used, and so on.

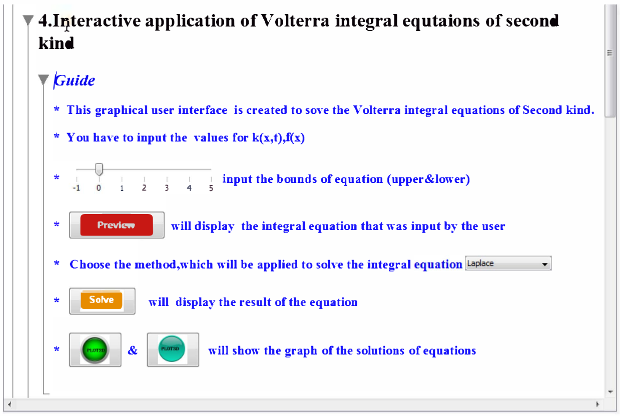

Fig. 4 .Guide about interactive part for user

Figure 5 is one of the interactive parts of the material. There are some panels for instance a panel to enter the kernel of the VIE, a panel to choose bounds, a panel to plot the equation, a panel to choose solution method, panels to see 2-D and 3-D plots of the solutions. Here user can enter own functions f and kernel K, enter the lower and upper bounds, choose one of the solution methods from the pull down menu, plot the function in 2-D and 3-D graphics. Here there are given four of the solution methods for VIEs of second kind which are Laplace method, Eigen function method, Neumann method, and converting to an equivalent differential equation method. Here of course all entries are in Maple syntax and it is possible to see entering's in mathematical notation thorough the Preview button. So, here user can control if it the integral equation is entered correctly or not. User also can control the bounds of the graphics.

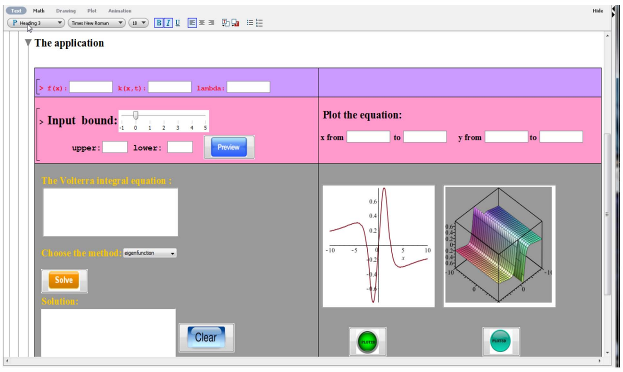

Fig. 5 .Interactive application part of VIE

Figure 6 is the interactive converter of a VIE of second kind to an equivalent IVP. There are also some panels to enter function f(x), kernel function K(x, t), lambda, lower and upper bounds, convert buttons, initial conditions and so on. It can be reduced a VIE of second kind to an IVP by this interactive part. User can make practice over and over. Here it can be entered integral equations by taking care of Maple syntaxes and then convert to an equivalent differential equation and finally find the initial conditions for differential equation.

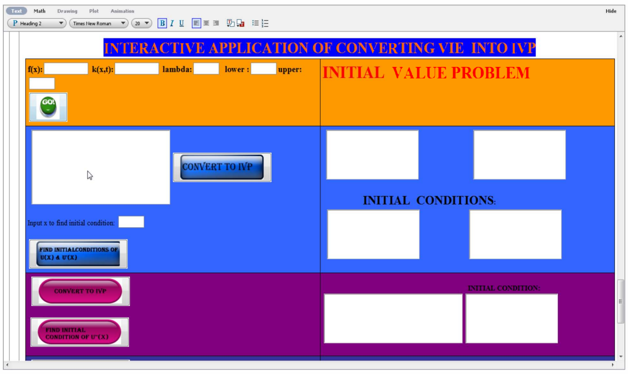

Fig. 6 .Interactive converter of VIE to a IVP

V. CONCLUSION

Nowadays, integral equations have attracted for most of the last years and their theory is well developed. Digital computers have greatly changed the philosophy of mathematics as applied to engineering. Many applied problems that cannot be solved explicitly by analytical methods can be solved easily by digital computers. This computing equipment makes it relatively easy to execute extended numerical calculations, to generate graphical displays of a very high quality, and, in many cases to carry out complex symbolic manipulations.

The combinations of the interactive course materials, as part of the lectures carries to the classroom the dynamic of three dimensional mathematical objects to create a more active way of teaching differential equations. The interfaces provide the instructor and student with simulations bringing integral and differential equations concept alive. The interactive course materials enable the user to control his/her self-studies and by help of the graphics user can improve his/her understanding of mathematical concepts.

And finally, an interactive course material can be very exciting, enjoyable and attractive for the all students, engineers, researchers and who is interested in. Interactive course materials have to be developed for other interesting topics of mathematics.

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We welcome any question, comments, and suggestions for improvement of this interactive course material.

REFERENCES

[1] M. Tenenbaum, H. Pollard, Ordinary Differential Equations: en elementary textbook for students of Mathematics, Engineering and the Sciences, Dover, 1985

[2] K.E.Atkinson, W.Han, D.E.Stewart, Numerical Solution of Ordinary Differential Equations, Wiley, New Jersey,2009

[3] W. E. Boyce, R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems 8th Edition. Wiley Interscience., 1965

[4] J. D. Lambert, Numerical Methods for Ordinary Differential Systems, John Wiley & Sons, Chichester, 1991

[5] E. Hairer, S. P. and G. Wanner, Solving ordinary differential equations I: Nonstiff problems, second edition, Springer Verlag, Berlin, 1993

[6] A. Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, 1996.

[7] H.M. Andia, Numerical methods for scientists and engineers, 2nd ed, Birkhauser Verlag, Basel-Boston-Berlin, 2002

[8] J. Flores, Multivariable Calculus Project http://www.usd.edu/~jflores

[9] K. Stroyan, Interactive Multivariable Calculus, http://itsnt711.iowa.uiowa.edu:8080/webMathematica/iMultiCal

[10] Stephen Forrest, Maplets: A Customizable Interface to Maple, Maplesoft

http://www.cargo.wlu.ca/e-ECCAD2004/Maplets.pdf

[11] R. E. Klima, N. P. Sigmon, Cryptology: Classical and Modern With Maplets,CRC Press, USA, 2012

[12] P. Kinshuk, J. Michael., Multiple Perspectives on Problem Solving and Learning in the Digital Age, Springer, London, 2011