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Using a Computer Algebra System in Teaching and Learning of Ordinary Differential Equations among Engineering Technology Students

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Abstract

This paper describes how computer algebraic system, Maple can be used to enhance engineering technology students' understanding in learning ordinary differential equations (ODE). These ten undergraduate students of industrial automation and robotics technology are required to enrol in engineering mathematics course as a prerequisite for control system and robotics subject. Though the teaching of engineering mathematics has been conducted in the traditional approach for the past few years the lecturer has introduced Maple as an alternative teaching strategy in engaging the students in the learning of differential equations. The students were interviewed after using Maple for solving their mathematics problems. It was found that these students managed to visualize the solutions of the given mathematics problems. The learning of differential equations has become meaningful in such a way that they have seen the relationship between mathematics and the application in the real world.

Keywords: mathematics, engineering technology, Maple, ordinary differential equations

1. Introduction

Mathematics and Engineering are two important fields that complement each other in various aspects. The common aspect of these two fields focuses on engineering mathematics subject. Most engineering problems are classified as application in mathematics which can be solved using differential equations. It has become a challenge to engineering students to explore the relationship between mathematics and engineering fields. Nowadays, finding the solution to the application problem can be obtained easily with computer algebraic systems. Lawson (1997) defined computer algebraic system as a tool capable of working symbolically as well as numerically. The integration of mathematics in computer algebraic system has made solutions of engineering problems can be simply visualized with the help of special features.

Some common computer algebraic systems like Maple, Mathematica and Matlab have a long list of advantages which have been put forward in making the learning of mathematics more meaningful. By mastering more than one computer algebraic systems, teachers are able to deliver the subject content effectively. In addition, Lua and Yang (1997) reported that Maple helps teachers to be more creative in preparing teaching materials which can be adjusted according to the students and lecturers' need respectively. Integrating Maple in the teaching and learning of mathematics would give benefit to the students in mastering variety of mathematical concept that can be used in their field of study (Lua & Yang 1997).

2. Research Objective

The objectives of this study are to explore students' engagement in learning differential equations using Maple as well as enhance their understanding in solving application problems.

3. Participants of the study

Ten students were selected to participate in this study and the selection was based on their assessment marks which were grouped according to the lowest, average and the highest. Four students scored the lowest marks, three students were from the average and three students scored the highest marks. Only ten students were chosen since there were constraints like the limited number of computers with Maple 13 in the laboratory and the time-tabling problem. However, the researcher has intended to propose to the university that engineering technology students should be given exposure to Maple for all subjects taken including mathematics as well as other engineering subjects.

Most engineering students learn differential equations which include linear, second order

differential equations. The topic has become the prerequisite for them to study the engineering modeling like vibration system and electrical circuit (Lawson 1997). Differential equation is one of the topics learnt in Engineering Mathematics II as well as Laplace Transform and Fourier Series. The high number of failures for this subject has become the justification of the subject teacher to introduce Maple 13 in teaching the topic.

4. Research Methodology

The research was conducted in three mini phases. The first phase was to let the students solve second order ordinary differential equations algebraically during tutorial class. The following question was one of the given problems which were taken from their tutorial. They were asked to solve the given differential equation i.e. $\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 5x = 0$. Next, they were requested to solve for the particular solution of $\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 2x = e^{5t}$ with the given initial condition; $t = 0$, $x = 1$ and $\frac{dx}{dt} = \frac{3}{2}$.

Upon completing the first phase, the students have to attend a briefing on the usage of Maple which was conducted as a special class for them by the lecturer who was also a Maple trainer for the institute. During the second phase, the students were introduced with the Maple 13 interface including the short cut menus and some simple commands that can be used when solving mathematics questions. The students were requested to check the information on the application in engineering in *Maplesoft Application Center* as shown in Figure 1. The idea of this strategy was to give the students an idea on what real life applications can be solved using mathematics as well as Maple.

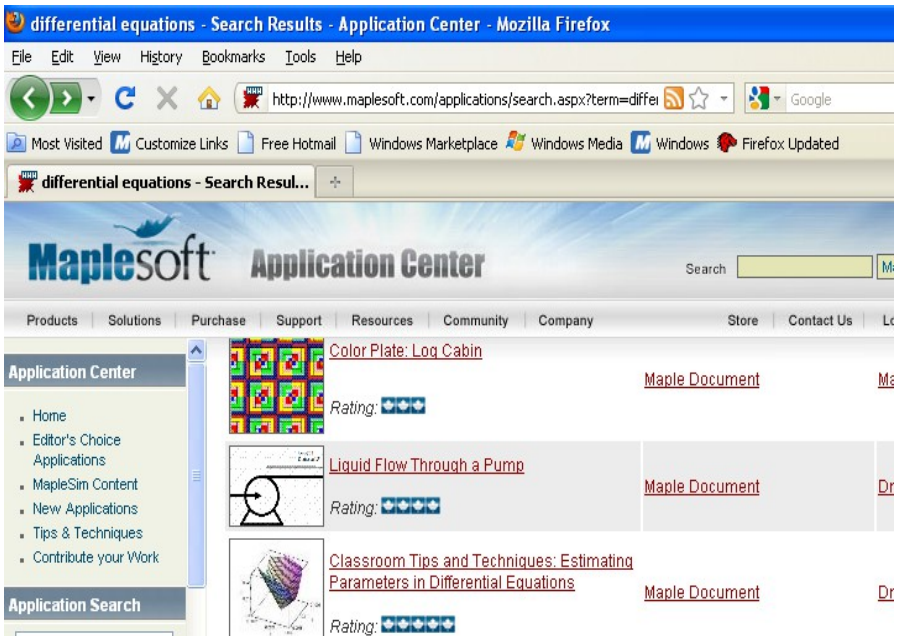

Fig.1. The screenshot on *Maplesoft Application Center*

The last phase was conducted after briefing those students on Maple usage in mathematics and engineering. The teacher started the lesson with the same question of differential equations which were given in the earlier phase. The instruction was given as step by step basis and they were informed to type according to what has been displayed on the screen. They were taught on how to use the short cut menus and simple commands when solving the mathematics problems. Some do's and don'ts in Maple were also informed. Three examples were prepared for them which covered homogeneous and non homogeneous differential equations as well as finding the particular solution using the given initial condition of the question. The questions were adapted from their tutorial questions which were given at the beginning of the semester. The purpose of using these same questions during Maple class was to let the students identify the usefulness of Maple in constructing their mathematical knowledge. The questions were transferred into Maple 13 and they were guided by the teacher in obtaining the answers. The following was the questions used during Maple training.

```
> with(inttrans)
[addtable, fourier, fouriercos, fouriersin, hankel, hilbert, invfourier,
    invhilbert, invlaplace, invmellin, laplace, mellin, savetable]
```

Example 1

```
with(plots):
ode := diff(x(t), t, t) + 6 diff(x(t), t) + 5 x(t) = 0
```

$$\frac{d^2}{dt^2}x(t) + 6\left(\frac{d}{dt}x(t)\right) + 5x(t) = 0$$

$dsolve(ode)$

$$x(t) = \_C1\, e^{-5t} + \_C2\, e^{-t}$$

Example 2

$ode1 := diff(x(t), t, t) + 6\, diff(x(t), t) + 5x(t) = 2$ -

$$\frac{d^2}{dt^2}x(t) + 6\left(\frac{d}{dt}x(t)\right) + 5x(t) = 2 + 3t$$

$dsolve(ode1)$

$$x(t) = e^{-5t}\_C2 + e^{-t}\_C1 - \frac{8}{25} + \frac{3}{5}t$$

Determine the particular solution of ode1 from line (5)

$ics := (x(0) = 0, D(x)(0) = 1)$

$$x(0) = 0, D(x)(0) = 1$$

Example 3

$dsolve(\{ode1, ics\})$

$$x(t) = -\frac{9}{50}e^{-5t} + \frac{1}{2}e^{-t} - \frac{8}{25} + \frac{3}{5}t$$

$plot(rhs(ode1), t = 0..10)$

Fig. 2. The questions that are used during the introduction of Maple 13.

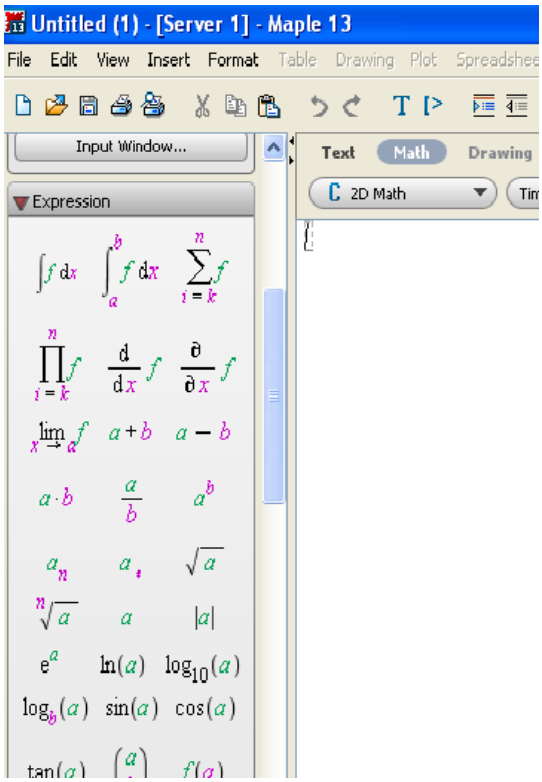

Fig.3. Some commonly used mathematical expression in Maple 13.

5. Results and Discussion

During teacher's observation at the first phase of the study, the average and weak students faced the following problems; a) to write down the auxiliary equation such as $m^2 + 6m + 5 = 0$ and b) to get the roots of the equation hence writing the general solution of the complementary function of the question. They also faced difficulty in distinguishing the term used in differential equations such as homogeneous differential equation, non homogeneous differential equation, complementary function, particular integral and initial value problem (IVP). One of the research participants commented that the said terms are not as important as solving the complete solution of the question.

Some positive comments were gathered from these students when they were introduced by the application in Maple 13 during second phase of the study.

A remark from a good student "I would prefer to use Maple in doing my final year project especially in simulating and sketching graph" Furthermore, the perspective in using Maple is viewed differently by the average and weak students. They seemed to be in favor of the benefit of the software that includes checking their answers, saving their time in solving complicated mathematics problem and having the ability to construct graph for any given function.

However, one of the good students has a different idea relating to students' conceptual understanding. He raised the issue of negligence of the conceptual understanding among weak students which is due to the fact that Maple can be used as the short cut of obtaining answer without going through the normal process of writing the long list of working solutions.

From the teacher's observation, integrating Maple in mathematics teaching holds great potential to attract these students' interest in learning mathematics. Collaborative work among students and teachers would lead to a smoother teaching and learning process (Kovacheva, 2007).

5. Implication and Conclusion

During the implementation of teaching mathematics teachers should be aware that the focus must be on learning mathematics using Maple rather than learning Maple as the end process. Some benefits in using Maple in learning engineering mathematics include the following;

- Students are able to make connection between mathematical ideas and engineering

- They are able to develop and sustain their interest in mathematics

- With animation in Maple, they would appreciate the power and become fascinated in mathematics that would enrich their life (Buchanan 2003).

However, the teachers have to take part in supporting teaching mathematics using Maple and it should be used widely among engineering technology students. Let the students explore all the features in Maple that can be used as the tool which could vary their learning style. Under teacher's guidance, these students would develop the skill to become efficient learners and creative thinkers (Beardon & Way 2003). In order to achieve the efficiency in implementing Maple in the mathematics class, teachers would have to consider introducing students to the selected topic and the presentation of basic Maple commands. When doing practical exercises, teachers have to guide them in doing the analysis of the given problem using Maple on step-by-step basis. The teachers' supervision must consolidate the theoretical taught as well as the students' work (Kovacheva, 2007).

Some limitations in using Maple during mathematics class should be taken into account. The connection between the techniques used and the conceptual understanding among students would not be proper (Galan Garcia et al., 2005). It could lead to undesirable modification to teaching process due to some changes made in mathematics class (Schneider, 1999). Teachers have to ensure that the students know what to do when Maple fails to give them the expected answer (Kovacheva, 2007).

The integration of Maple in teaching and learning of engineering mathematics particularly for topic such as differential equation would enhance students' understanding, increase interest in mathematics and develop their creative thinking. The learning experience become more meaningful for students since Maple creates the opportunity for them to explore, investigate and draws conclusion (Lua & Yang, 1997). It helps teachers to facilitate their teaching process and manages to deepen these students' understanding of a particular topic. Generally, it opens a new direction in making learning mathematics more meaningful in another perspective.

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