Under Graduate Teaching And Research Using Project-Oriented Approach with Matlab Environment

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Abstract : The role of universities cannot be overestimated in the training process of students of under-graduate and post-graduate studies that would eventually shape the world's technological and scientific progress. The past decade has seen many changes in the expectations of students in the field of education. For the students of under-graduate courses the goal has shifted to obtaining theoretical and practical knowledge in their chosen specialization. Some choose to continue their education for a career in post-graduation and then pursue research; others opt to elevate their professional competency, teamwork and leadership skills. Despite different learning expectations, instruction in universities continues to be based on traditional pedagogical methods, such as "face-to-face" studies, or "E-learning" training and communication, which are overwhelmingly teacher-led.

The purpose of this paper is to search for new methods of education that would permit gaining real and practical experience harnessed by seeking examples relevant to the curriculum outside the classroom that also enhance the professional competency of a graduate student, thus evolving into a more student-centric type of learning.

The main emphasis of this paper is the demonstration of the use of software packages and programs to solve problems in Mathematics, Physics and Engineering as a part of enhancing the comprehension of the student's learning curve. The formulation and analysis of complex problem solving techniques such as comprehensive grades of the students in a class in various subjects and application of differential equations has been taken as an example using the fundamental "if"…"Else" statement from MATLAB as an example. The paper consists of the introduction to scientific problem and its complete numerical solution along with a graphical analysis using one of the fourth generation programming languages i.e., MATLAB. The emphasis is on programming rather than problem solving.

Key words: Matlab, if-else statement, Numerical methods, Graphical Analysis, Student's Grades, Differential Equations.

Introduction

In recent years, demands from industrial employers on their professional workers have changed dramatically.

This is readily explained by the fact that the students are currently graduating with good knowledge in fundamental theoretical concepts and computer literacy, but they lack application of the subject in practice, and they do not possess strong teamwork and communication skills.

Many publications evidence that students and employers alike, are calling for significant changes in the delivery of under-graduate education. The critical issues that are reflected in these requests are summarized here (Mills,2003).

Under-graduate curricula are too focused on theoretical concepts in mathematics and Sciences without much practical application being taught. Sufficient integration methodology relating to these topics to industrial practices is not provided. And all the Programs are too content-driven. Current programs do not provide sufficient practical experience to the students. And they also lack communication skills and teamwork experience as such. The faculty too typically lack practical experience, hence they are not able to adequately relate theory to practice or provide practical experience. Therefore, it may be concluded that the existing teaching and learning strategies in under-graduate curricula are outdated. They need to be supplemented with more student-centric ones.

There exist many ways of resolving this problem, from the radical – redesigning of the under-graduate curricula – to the introduction of project based or project-oriented leaning modules in the framework of traditional curricula.

The article seeks examples from basic mathematical concepts of under-graduate curriculum such as 'students grading' and a 'basic solution of a differential equation' as sources of the project and their complete numerical solution along with a graphical analysis using one of the fourth generation programming languages

i.e., MATLAB has been sought. The emphasis on the student was more on conceptual understanding through the application of the project oriented method of problem solving rather than meagrely learning the concept conventionally hearing in the classroom.

The main emphasis of this paper is the demonstration of the use of software packages and programs to solve problems in under-graduate Mathematics course as a part of enhancing the comprehension of the student's learning curve.

The formulation and analysis of complex problem solving techniques such as comprehensive grades of the students in a class in various subjects and application of differential equations were given to the students as the conceptual tools for implementation of the "Project Oriented Learning Method" and use was made of the fundamental "if"…"Else" statement from MATLAB environment.

Problem-based learning (PBL) in under-graduate education

This learning method has been utilized successfully in the classroom. Generally, this is done through "class-room problems" that consist of completing exercises and assignments, or open-end problems, likewise within a particular course. All commence with the identification of the path to elucidating the given problem, which is itself selected by the course context.

Progress in resolving the problem depends solely on the level of knowledge (of the subject) attained by the student. Courses containing "open-end" problems, afford students opportunities to choose autonomously the route to the solution.

There are many examples of successful, optimal usage of PBL as a main component of engineering and under-graduate programs of varying levels. However, there are certain limitations to PBL, explained below (Perrenet,2000,PP.345-358) that discourage recommending PBL as an overall strategy for engineering and undergraduate education:

1. Problems that students encountered during their course cannot always be applied to real-life tasks, which they will certainly counter in their future careers;
2. Much of under-graduate curriculum has a hierarchical knowledge structure. Many topics must be learned in a certain order, because missing essential parts will result in failure to learn later concepts. The problem will be hard for a student to correct, because they probably cannot fully compensate for missed topics, by using only PBL.

It seems therefore that problem-based learning may be a partial answer for resolving the critical issues of engineering and under-graduate education, primarily to demonstrate the applicability of certain concepts in the early stages of an engineering curriculum. However, other active learning, student-centred methods are more appropriate and acceptable for engineering under-graduate education, and these form the basis of project-oriented learning.

Project-oriented learning(POL) in under-graduate education

The term "project" is universally used in under-graduation as a "unit of work". Almost every task undertaken in the academic pursuit by an under-graduate student will be a project. Project-oriented learning may be defined alternately by different education disciplines and levels, which makes it familiar to most students. The advantages of using POL, in comparison with PBL, is listed here (Perrenet,2000,PP.345-358), and involves the following:

1. Project tasks are closer to professional reality;
2. Project work is directed more **to the application of knowledge**, while PBL is more directed to the acquisition of knowledge;
3. POL is usually accompanied by subject courses (e.g. math, physics, software, &c), whereas PBL is not.
4. Management of time and resources by the students as well as task and role differentiation is very important in POL.
5. Independence of action is greater in project work, than in PBL.

POL may be applied either in particular courses, or through the entire curriculum.

According to Heitmann (Heitmann,1996,PP.121-131) POL involves the use of small projects within specific courses, which is usually combined with traditional, "face-to-face" methods, within a given course.

POL focuses on application and integration of previously acquired knowledge. The students work in small groups where teachers serve as advisors. The beneficial adaptation of the above approach, in several universities suggests its viability, and allows us to formulate recommendations for continuing progress towards the intended project-oriented curriculum, which revolve around continued training for both staff and students, in the skills needed to make learning effective, such as problem-solving, teamwork, as well as continued education for staff in implementation and assessment methodologies.
An overview of the literature did not evoke any examples of the aforementioned recommendations. Therefore, we find it necessary to offer our own approach, which is based on the development of our learning unit (module) in the context of POL. We designed the pedagogical aspects the of course based on this collaborative didactic technique (Martín, 2002,PP.17-29).

Definition and development of the problem

The main characteristics of the Differential Equations(DEs) course incorporated with the POL implementation is presented below:

I. General objectives.

The students must learn the basic concepts of DEs, firstly, through the conventional lectures. Throughout the course, the students understand, build and adapt POL method to enhance their comprehension which makes the learning of the basic concepts a must in order to implement it through a program. They have to assimilate, integrate and apply all these concepts. The desired abilities to develop in the course are: Self-motivation, Analytical capability, team work, honesty, leadership, self-directed learning, creativity, and the capacity to identify and solve problems.

II. ***Course contents.***

This basic DE Course syllabus for the students matches with the DE curriculum of the Under-graduate syllabus of the Universities in the Kingdom of Saudi Arabia

III. ***Learning Activities.***

In the first part of the course, the basic concepts of DE are covered in weekly lectures. During this period, the students learn and practice the basic concepts. During mid-way of the program, students form teams and start building and implementing the program using MATLAB Environment. Concurrently, advanced topics for syllabus completionare covered in the classroom as per schedule. In the last stage, the students incorporate these techniques in their understanding of the advanced topics and thus achieve their goals successfully.

IV: ***Course Project.***

The main focus of the course project was to design and build the application of loops and "if…else" statement in MATLAB. Students grade evaluation has been taken as a prelude example to the actual application to the course related problem of solution of ODEs.

V. ***Assessment process.***

A self-assessment method has been conducted through group discussions and presentations by each group and then the best program and its output have been included in this article.

Project Oriented Learning (POL) in the context

A learning-unit is a building-block of a course. Here, we define a learning-unit as a real-world example, an explanatory feature of a course, designed to test knowledge gained in the classroom. It serves as a real- life project, scaled to the course's topics and form. POL is one of several active learning methods, devised during last decade as a product of research at the under-graduate level. POL considers that student teams will work on a single guiding thread, or project, for an entire course (Espinosa,2004).
Implementation of the POL technique in the current curriculum involved in organizing the Student into teams, and play roles while delegating work amongst themselves, and while delivering feedback to their teams (Noguez,2004,PP.83-88). Overall success in these terms is not easily measurable. Since most of the learning process will take place outside the realm of the classroom, learning has to be assumed whenever there is evidence of its existence through visible actions (Espinosa,2004). Besides, it is hard to prove that students are motivated to learn when the instructor applies POL to their classroom activities. As stated by Johnson

(Johnson,2000,P.39)"… changing to a cooperative style is not simple. There is a big difference between putting students into groups to learn… and structuring your teaching so students learn cooperatively...".
The POL technique provided the following advantages as evidenced by Noguez *et al* :

a) It allows the students to learn problems solving techniques using relevant knowledge independently of the discipline source.
Example: Here we present an example from Ordinary Differential Equations(ODE) which was solved in the classroom using the conventional 'Euler's method'. The same problem has been given to different teams of students for solving with POL method using MATLAB/SIMULINK Environment

Euler's analytical methods for solving ODEs are presented before moving on to numerical methods. [http://mathworld.wolfram.com]

The first-order ordinary differential equation is given as

$$\frac{dy}{dx} = F(x, y), \tag{1}$$

if F(x,y)can be expressed using separation of variables as

$$F(x, y) = X(x)\,Y(y), \tag{2}$$

then the equation can be expressed as

$$\frac{dy}{Y(y)} = X(x)\,dx \tag{3}$$

and the equation can be solved by integrating both sides to obtain

$$\int \frac{dy}{Y(y)} = \int X(x)\,dx. \tag{4}$$

Any first-order ODE of the below form can be solved by finding an integrating factor $\mu = \mu(x)$ such that

$$\frac{dy}{dx} + p(x)\,y = q(x) \tag{5}$$

And this condition enables an explicit way to determine the appropriate μ for arbitrary $p$and q. To accomplish this, take

$$p(x) = \frac{1}{\mu}\frac{d\mu}{dx} \tag{6}$$

in the above equation, from which we recover the original equation ($\diamond$), as required, in the form

$$\frac{1}{y}\frac{dy}{dx} + p(x) = \frac{q(x)}{y}. \tag{7}$$

But we can integrate both sides of (9) to obtain

$$\int p(x)\,dx = \int \frac{d\mu}{\mu} = \ln\mu + c \tag{8}$$

$$\mu = e^{\int p(x)\,dx}, \tag{9}$$

Now integrating both sides of ($\diamond$) gives

$$\mu y = \int \mu\, q(x)\,dx + c \tag{10}$$

(with μnow a known function), which can be solved for y to obtain

$$y = \frac{\int \mu\, q(x)\,dx + c}{\mu} = \frac{\int e^{\int^x p(x')\,dx'}\, q(x)\,dx + c}{e^{\int^x p(x')\,dx'}}, \tag{11}$$

where c is an arbitrary constant of integration.
Initially the above theoretical concept leading to the n^{th} - order linear ODE with constant coefficients has been explained to the students and they were also equipped with the relevant method for obtaining the solution using MATLAB .

b) As a prelude to this project the students have first been given an assignment outside the curriculum to learn the usage of the 'if-else' statement in MATLAB environment

Prelude Problem: Generate a program using " if, else and elseif statements" to obtain the output for the grade of the students in an examination given the marks scored as the input.

Student Marks	**0-59**	**60-69**	**70-79**	**80-89**	**90-100**
Student Grade	**E**	**D**	**C**	**B**	**A**

Mat lab coding of student marks and Grading using if-else statement :

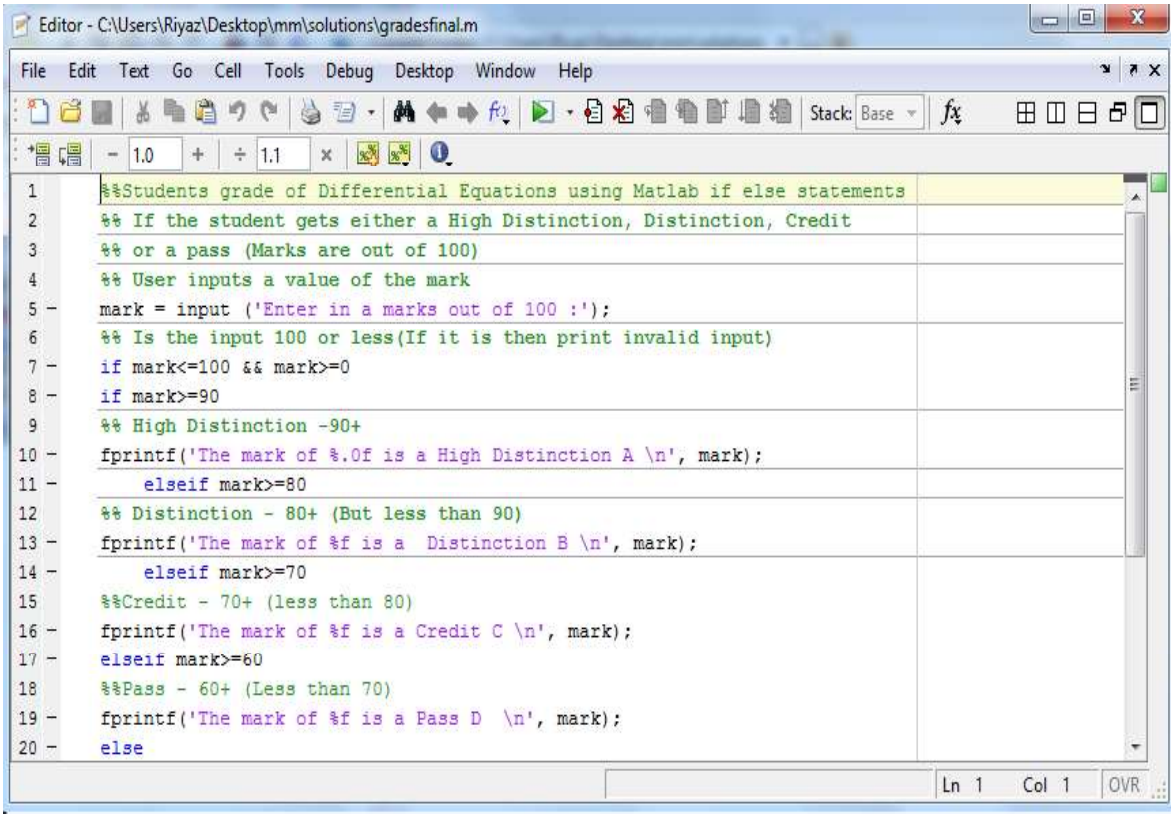

Figure 1: Matlab coding for Students Marks and Grading

Results in Differential Equations :

>> gradesfinal

Enter in a marks out of 100 :83

The mark of 83.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :66

The mark of 66.000000 is a Pass D

>> gradesfinal

Enter in a marks out of 100 :96

The mark of 96 is a High Distinction A

>> gradesfinal

Enter in a marks out of 100 :85

The mark of 85.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :80

The mark of 80.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :80

The mark of 80.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :80

The mark of 80.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :71

The mark of 71.000000 is a Credit C

>> gradesfinal

Enter in a marks out of 100 :80

The mark of 80.000000 is a Distinction B

>> gradesfinal

Enter in a marks out of 100 :120

Not a valid input marks must be between 0-100 :>>

After the successful completion of this project by the students to begin with, different work groups of students have been assigned the problem from the curriculum and a space was provided for presentation of their project and its solution through a group discussion and presentation by each group self-evaluation.

c) The program and solution of the ODE after the self-evaluation process that was unanimously accepted by all the groups of students is presented below.

First Order Equations: $\frac{dy}{dx}(x) = xy$

Code:

```
>>y = dsolve('Dy = y*x','x')
>>y = dsolve(eqn1,'y(1)=1','x')
>>x = linspace(0,1,20);
>>z = eval(vectorize(y));
```



```
>>plot(x,z)
```

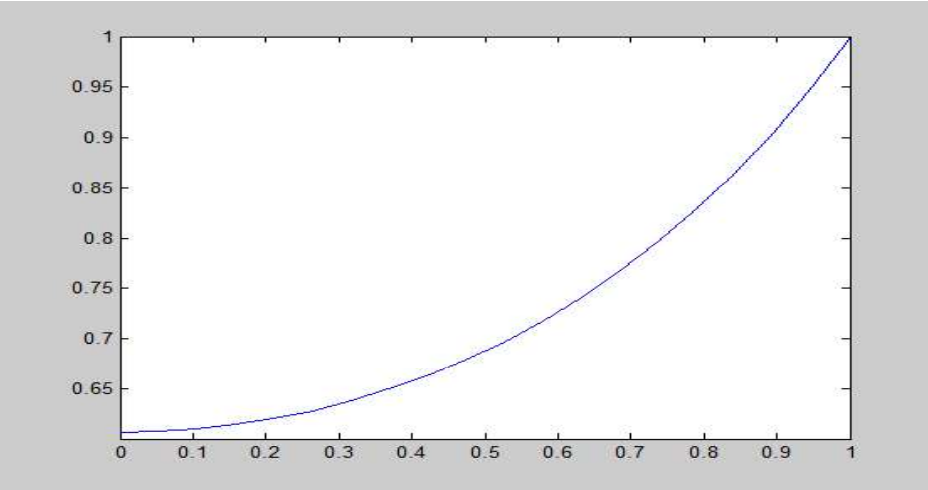

Figure 2: Plot of First Order Differential Equation

Second and Higher Order Equations:

$$\frac{d^2y}{dx^2}(x)+8y(x)+2y(x)=\cos(x) \qquad y(0)=0,\frac{dy}{dx}(0)=1$$

Code:

```
eqn2 = 'D2y + 8*Dy + 2*y = cos(x)';
inits2 = 'y(0)=0, Dy(0)=1';
y=dsolve(eqn2,inits2,'x')
z = eval(vectorize(y));
plot(x,z)
```

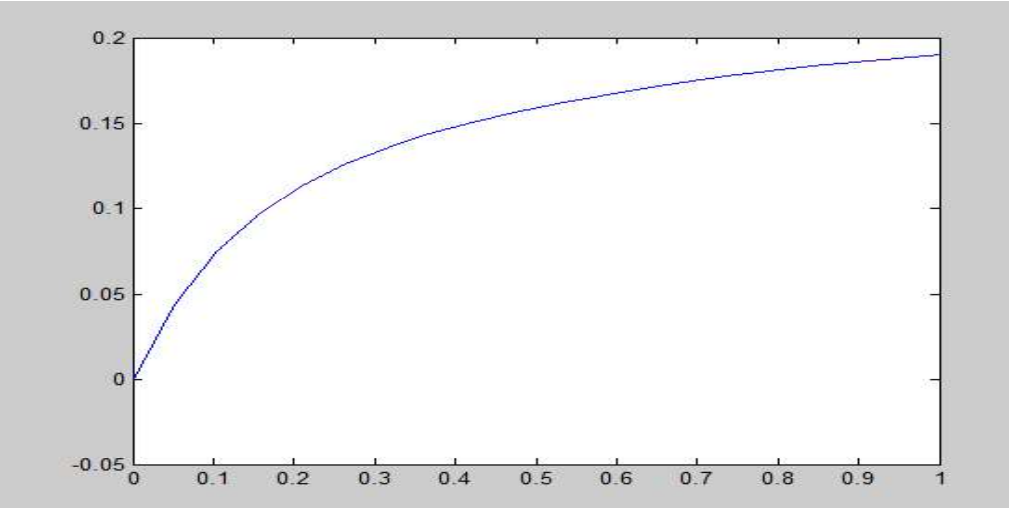

Figure 3: Plot for Second Order Differential Equation

Discussion

The activity was focused on exploring and working for the solution of the above problem leading to the n^{th} - order linear ODE with constant coefficients with an unknown solution.
Activities have been designed in such a way that they can involve several areas of the same discipline or the interaction of different disciplines.
POL method considers in the design the application of interdisciplinary knowledge so the students can appreciate the relationship between different disciplines in the development of a particular project.
The project assignment promotes the search of open solutions so students are free to create new knowledge.

Conclusions

Analysis of the results confirms that using real-world research or practical examples, in the framework of under-graduate courses, that are based on a project-oriented learning approach, may increase not only learning satisfaction for the students, but also boost their motivation at the entry level for the learners to continue their future studies. This could be further developed by the usage of "open-course" technology, which allows more effective, easily-changeable , up to date learning programs.

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