Project-Oriented Approach with a Matlab/Simulink Environment for Engineering Teaching and Research

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THE MAIN AIM OF THE WORK

The purpose of this paper is to search for new learning methods in engineering education that would permit gaining real and practical experience that could be harnessed outside the classroom and would also elevate a graduate's professional competency, by using modern technology. This evolves into a more student-centric type of learning.

To this end, we utilize a project-oriented learning approach, in the framework of a classical engineering course, which incorporates our proposed learning module, based on the Matlab/Simulink software environment that can be used for any level of education from BA to Ph.D students alike.

WHY IS SEARCHING FOR NEW METHODS FOR GAINING PRACTICAL EXPERIENCE IN ENGINEERING EDUCATION SO IMPORTANT?

Many industrial employers say that today's engineers are graduating with good knowledge in fundamental engineering and computer literacy, but they don't know how to apply this in practice, and don't have strong teamwork and communication skills.

Many publications evidence that students and employers alike, are calling for significant changes in the delivery of engineering education. The critical issues that are reflected in these requests are:

Engineering curricula are too focused on engineering science and technical courses, without providing for sufficient integration and relating of, these topics to industrial practice. Programs are too content-driven.

Current programs do not provide sufficient design experience for students.

Graduates lack communication skills and teamwork experience.

Existing faculty typically lack practical experience, hence they are not able to adequately relate theory to practice.

There exist many ways of resolving this problem, from the radical – redesigning the engineering curricula – to the introduction, ad hoc, of problem- or project-oriented models in the framework of traditional curricula. Let us briefly analyze these.

A BRIEF BACKGROUND OF PROBLEM-BASED (PBL) AND PROJECT-ORIENTED (POL) LEARNING MODELS

1. Problem-based learning (PBL) in engineering education

This learning method has been utilized successfully since the 1970s. Generally, this is done through “class-room problems” that consist of completing exercises and assignments, or open-end problems, likewise within a particular course.
There are many examples of successful, optimal usage of PBL as a main component of engineering programs of varying levels. However, there are certain limitations to PBL that discourage recommending PBL as an overall strategy for engineering education:

Problems that students encountered during their course cannot always be applied to real-life tasks, which they will certainly counter in their future careers.

Much of engineering 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 education, primarily to demonstrate the applicability of certain concepts in the early stages of an engineering curriculum. However, other active learning, student-centered methods are more appropriate and acceptable for engineering education, and these form the basis of project-oriented learning.

2. Project-oriented learning (POL) in engineering

The term “project” is universally used in engineering as a “unit of work”. Almost every task undertaken in professional practice by an engineer will be a project.
Project-oriented learning may be defined alternately by different education disciplines and levels, for instance, it is widespread on the K12 level, which makes it familiar to most students.
The advantageousness of using POL, in comparison with PBL, is listed here:

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

POL may be applied either in particular courses, and involves the use of small projects within specific courses, which is usually combined with traditional, “face-to-face” methods.
POL focuses on application and integration of previously acquired knowledge. The students work in groups where teachers serve as advisors. Our recommendations for future progress towards the intended project-oriented curriculum, consists of continued training for both staff and students, in the skills needed to make learning effective, such as problem-solving, teamwork, etc.
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.

OUR APPROACH

A learning-unit is a building-block of a course. We define a learning-unit as a real-world example, an explanatory feature of a course, designed to test previously gained knowledge. It serves as a real-life project, scaled to the course's topics and form; it also allows a student to expand his teamwork skills.

In order to illustrate our offered method, let us view a specific example:
A group of MS.c and Ph.D students from our environmental engineering department, most of whom have had a hiatus between their current studies and their B.A education. (Figure 1).

Fig.1 Engineers working in a Lab on a project

They have been working on a research project, searching for new methods to reduce emissions of pollutants and exhaust fumes from diesel engines. In this setting, apart from the theoretical background, an experimental set-up was formed that had a diesel engine, an electric generator, a spectrometric analyzer, &c.

In accordance with the researched physical process (alluded to above), and based on a mathematical foundation, a GUI (Graphical User Interface) in Matlab was formed, as shown in Figure. 2. With the help of this interface, without resorting to actuation or measurements, the students were able to simulate the effects altering input parameters had on the end result (the concentration of exhaust particles).

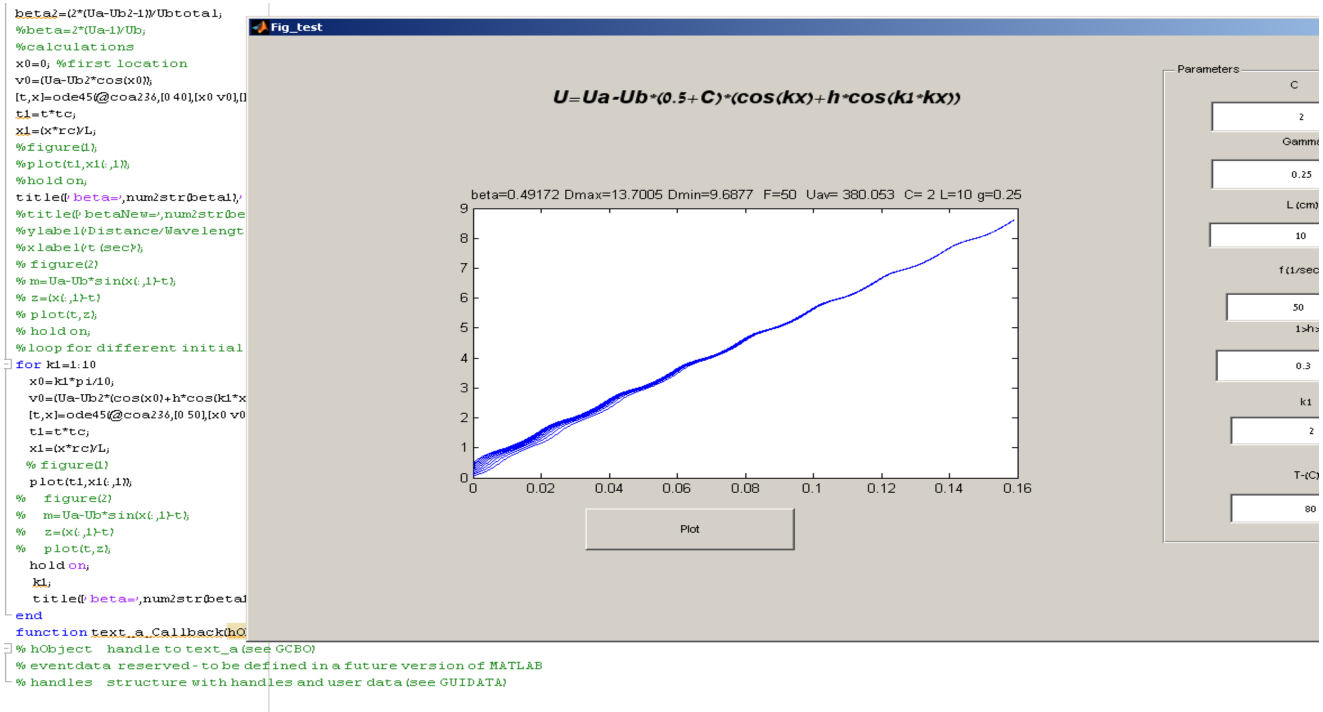


Figure.**2 A GUI prepared by Post-degree students**

This group of students also serves as TAs (teaching assistants) for entry level students. As a demonstration, let us take the "Control of Air Pollution" course (obligatory for BA students, offered in the same department). Previously, this course had been taught using traditional face-to-face techniques and drills.

After learning the topic, "Influence of modern vehicles on air pollution", the students were tasked with constructing a project that would explore this issue in a diesel engine, without any experimental measurements (we substituted the drill offered in this topic of the course).

The students were informed that the assessment of the project would be based on the implementation of previously mastered knowledge from the “Matlab/Simulink software environment for engineers” course.
For the purposes of their work, they used the “SimDriveLine” pack, made available through the “Simulink” environment mentioned above.
The students were asked to change input data (speed, power, energy, etc), to experiment with correlating their tweaking with the resultant pollution concentration (presented in Figure 2).

The dialog box for such a procedure is detailed in Figure 3.

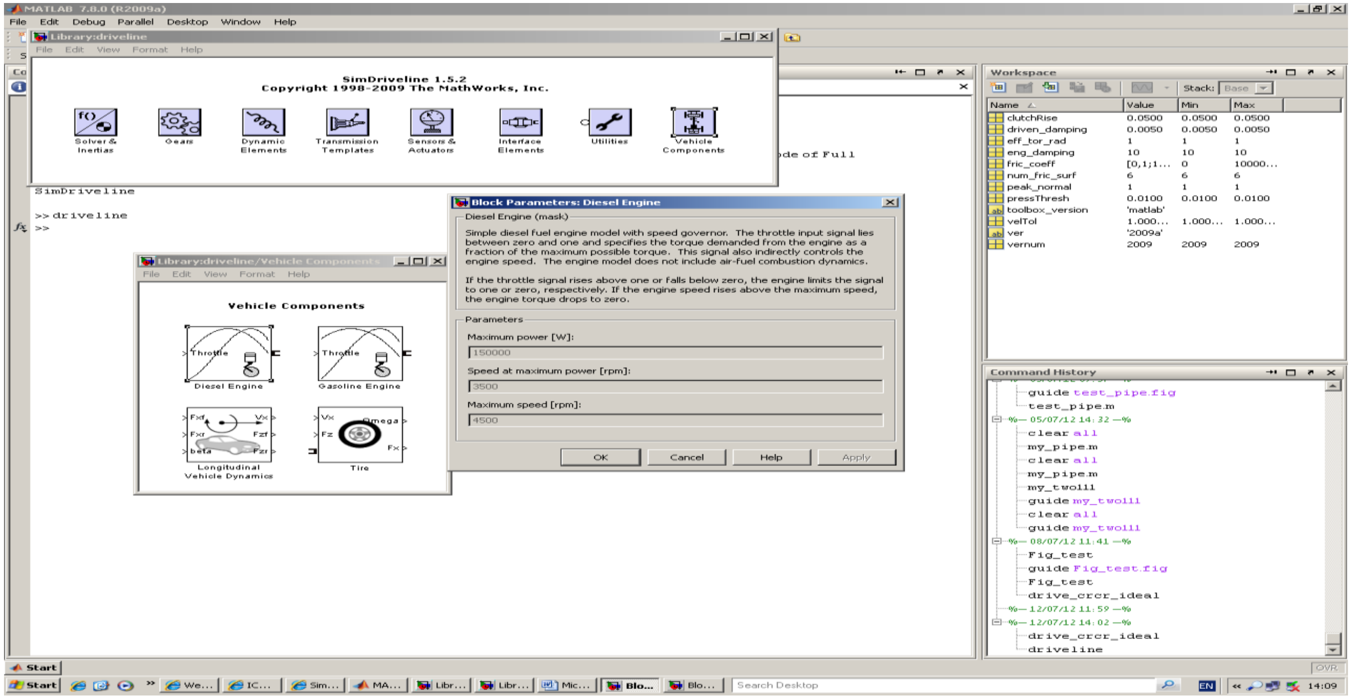


Fig.3.The dialog box for input parameters

In the scope of this work, the BA and post-graduate students work as a team, wherein the latter served as scientific advisors (who explain for the students the physical implications of the changes they have made).

As we have observed, the fact that most post-graduates students returned after a pronounced gap to academia, left them without sufficient training in Matlab/Simulinks environments. Thus, the utilization of the same learning unit for students of different levels, allowed:

- BA students to acquire experience in working with a real, live scientific project; the theoretical foundation of which, they received during their regular coursework.
- For post-degree students, to gain skills which they had not had previously.
- And for both, to work as a real engineering team, where the younger members are apprenticed in actual engineering task, and the experienced ones gain valuable training in teamwork and leadership.

RESULTS

Let us consider the effect of our method, with the help of the output from an annual survey conducted by our student's association. The students were polled on a series of statements posed to them, and were requested to rate their agreement with the query on a scale of 1 to 5 (5 denoted the highest concurrence, 1 being the least acceptance). The results, shown in Table 1, are tabulated by contrasting two identical questionnaires: one done in 2009 (before the introduction of our method) and in 2012 (after the using our approach).

	"I find the subject interesting"		"The drill was beneficial		"I obtained knowledge, skills, and understanding"	
[redacted]	2009	2012	2009	2012	2009	2012
Average score	3.5	4.1	3.0	4.1	3.8	4.4
Percentage of students, awarding the maximum score	23.3%	38.4%	16%	48%	20%	57%
Standard deviation	1.1	1.1	1.3	1.2	0.8	0.9

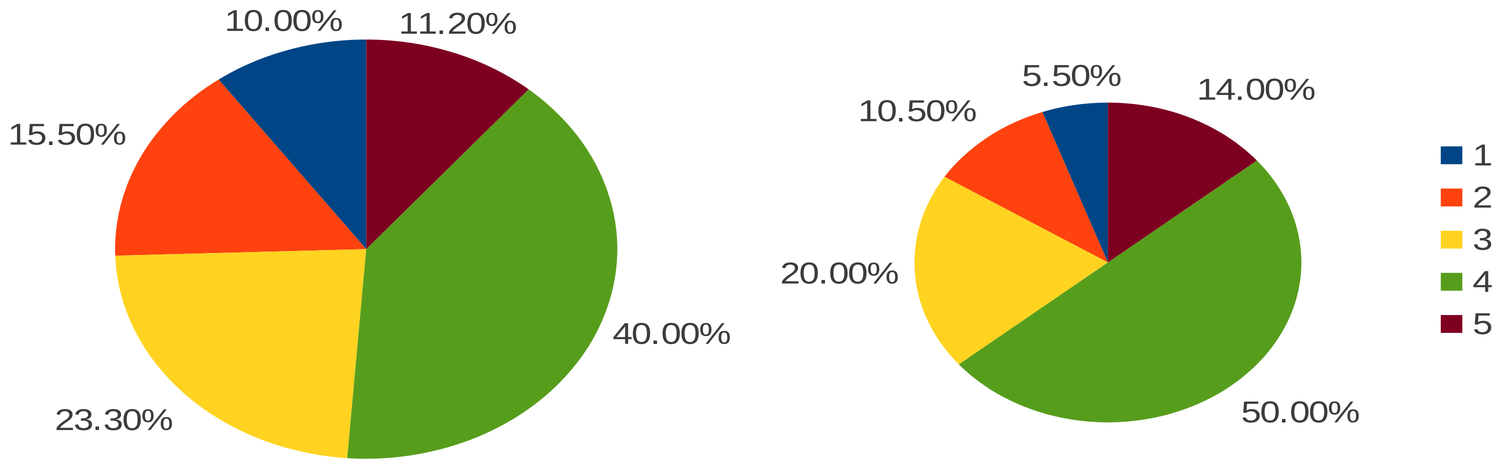
Table 1. Results of our survey

A separate poll was conducted in 2012, for students taught using our methodology. The students were asked to rate two queries, by the degree of their agreement with them, on a scale from 1 to 5, where 1 denotes complete disagreement, and 5 marks full concurrence. We posited two statements:

a) *This method has helped me to learn the course material,*

b) *I wish more courses be taught using this method*.

The results are depicted in Figure 4 and show that most students are satisfied with our approach.



a b

Fig 4. Charts depicting the results of our Questionnaire

CONCLUSIONS

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