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

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Abstract

One cannot overestimate the role of universities, in the training process of engineering experts that will eventually shape the world's technological and scientific progress.

The past decade has seen many changes in the expectations of students from their studies. For BA students the goal has shifted to obtaining theoretical and practical knowledge in their chosen specialization. For MA students the object is different: some choose to continue their education for a career in 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 in engineering disciplines that would permit gaining real and practical experience that could be harnessed outside the classroom that would also elevate a graduate's professional competency, as well as his teamwork abilities. 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.

Surveys done annually by our students' association have shown that the usage of our method, correlates with greater learning satisfaction, an increase in self-confidence, and as a general byproduct, a boost in motivation for BA students to continue their studies further.

This method could also help trace talented students and by using "open-

course" technology, we can generate truly global and international education programs.

1. Introduction

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

This is readily explained by the fact 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 summarized here [1]:

- Engineering curricula are too focused on engineering science and technical courses, without providing for sufficient integration and relating of, these topics to industrial practices. Programs are too content-driven.
- Current programs do not provide sufficient design experience for students.
- Graduates lack communication skills and teamwork experience.
- Programs do not account for social, environmental, economic, and legal consideration, which form a major component of modern engineering.
- Existing faculty typically lack practical experience, hence they are not able to adequately relate theory to practice or provide design experience.

Therefore, we may conclude that the existing teaching and learning strategies in engineering are outdated. They need to be supplanted with more student-centric ones.

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.

1.1 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. 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 programs of varying levels. However, there are certain limitations to PBL, explained below [2], that discourage recommending PBL as an overall strategy for engineering 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 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.

1.2 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 [2], 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[3] 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 in Europe and Australia, 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.

2. Our approach

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 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. 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),

Figure.1 Engineers working in a Lab on a project

and based on a mathematical foundation [4], 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).

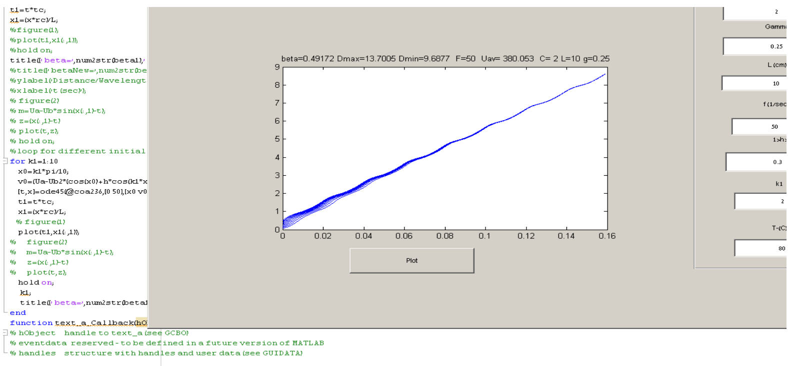

Figure.2 A GUI prepared by Post-degree students

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, with “E-learning” to enhance the course material.

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.

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 “SimDriveLine” pack, made available through the “Matlab/Simulink” course mentioned above; we then substituted the drills offered in the course, for such projects.

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).

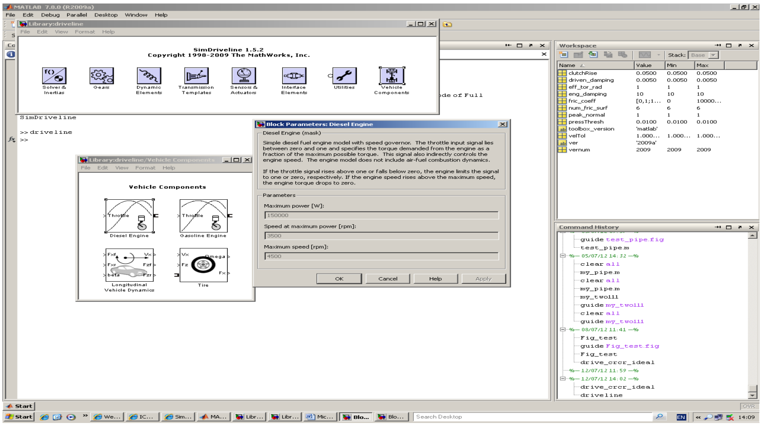

Figure. 3. The dialog box for input parameters

The dialog box for such a procedure is detailed in Fig 3.
In the scope of this work, the BA and post-graduate students work as a team, wherein the latter served as scientific advisors(which elucidate 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.

4. 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).

Table 1. Responses of students to queries, showing data for 2009, and 2012, respectively

	"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

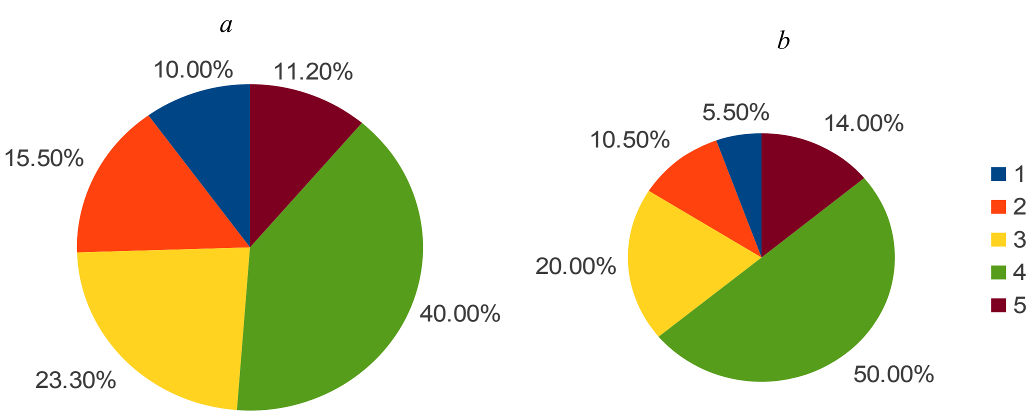

Figure 4. Distribution of students' attitudes to the queries posited

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.

5. 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-course" technology, which allows more effective, easy-changeable , up-today learning programs.

References

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