

A FRAMEWORK PROPOSAL FOR ENGINEERING EDUCATION THROUGH THE DEVELOPMENT OF PROJECTS THAT SUPPORT PERFORMING ARTS

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Abstract – An important characteristic of the technological devices that support performing arts is that they involve a strong component of creativity and initiative. Due to this nature, work in this type of projects becomes well-suited for engineering education, since it promotes motivation and the development of both technical and non-technical skills.

In this paper we present a flexible framework, consisting in structure and methodology proposals, for an engineering education program that aims to design, build and operate projects that support performing arts. The proposed framework is still under evaluation, but has already shown interesting results in terms of improvement of motivation and skills.

Keywords: Engineering education, performing arts, framework, motivation, project-based learning

1. INTRODUCTION

The combination of performing arts and technology has evolved from conventional audio amplification and support systems to advanced sound and video processing techniques to complex and interactive displays. Therefore, an important characteristic of the technological devices and techniques designed to support performing arts is that they not only require a significant amount of technical knowledge and skill from the engineers that develop them, but also involve a strong component of creativity and initiative.

Then, due to this nature, work in this type of projects becomes well-suited for engineering education, since it promotes both the improvement of technical abilities and the development of key non-technical skills that sometimes are not emphasized as much in formal curricula, especially if it is not skill-based.[1] In this paper we present a framework for an engineering education program that aims to design, build and operate projects that support performing arts.

Section 2 presents the proposal of the framework, which includes the environment in which it was developed, the premise, objectives and characteristics that define it, the

structure and methodology that conform it, and the techniques proposed to evaluate its performance. In Section 3 we present the instance of the framework we used to evaluate it and the evaluation results. Section 4 consists in the main conclusions of the work so far.

2. FRAMEWORK PROPOSAL

2.1 Environment

The framework proposal has been developed and evaluated in The Department of Electrical Engineering of the University of Costa Rica, with undergraduate students from the Bachelor and Licentiate in Electrical Engineering programs¹. Although this is a very specific environment, the framework design proposal is intended to be compatible with different engineering programs and students.

One important thing to note is that the curriculum of our Licentiate program is currently content-based. Even though the initiative to develop a skill-based program has been promoted, no formal changes have been made yet. The proposal of this framework intends to collaborate with this initiative, in which our Department is especially interested.

2.2 Premise, objectives and characteristics

The proposed framework is based on one specific premise: the development of projects that support performing arts can enhance engineering education. Therefore, the framework's objectives, design approach and fundamental characteristics revolve around this main concept. Also, this means that the framework is aimed towards a specific group of students: those who have some level of motivation to work on projects related to performing arts.

¹Licentiate (or *Licenciatura*) is an academic degree between Bachelor and Master used in some latin-american countries. The Licentiate in Electrical Engineering program of the University of Costa Rica consists in the Bachelor in Electrical Engineering program, one additional year of courses and a Final Graduation Work, and is accredited as substantially equivalent by the Canadian Engineering Accreditation Board (CEAB).

Considering this, we defined two main objectives for the framework:

- Increase motivation to learn engineering;
- Develop technical and non-technical engineering skills.

The motivation to learn can be enhanced considering the nature of the framework: by working on a project that will be presented (or used for a presentation) in front of an audience, a student's motivation and dedication gets improved. If he becomes aware that he is able to develop such projects with relative success, his confidence will increase significantly and, with it, his attitude towards learning engineering.[2]

The development of technical and non-technical skills can be achieved through the project-based learning dynamics of the proposed framework. For a given project and depending on its characteristics, different sets of technical skills like electronics circuit design or automatic control systems implementation can be improved. Therefore, the set of technical skills developed by the proposed framework can have a wide range. The non-technical skills to be enhanced, however, can be more clearly identified. Creativity, initiative and self-criticism are the skills intended to be exercised most, but other abilities like communication, collaboration and time management may also be developed, depending on the format used for a project.

The framework objectives are intended to be achieved by one core activity: the development of open design projects. This activity, in itself, is already an asset for a formal engineering education program, since most of the time the projects developed during the program are bound to courses and, thus, to their assigned contents and skills.

We identify, then, three main characteristics of the framework proposal:

- It has a strong project-based learning core, in which students design, build and operate projects that support performing arts;
- It is highly flexible, thus providing the possibility to have different numbers of students, professors and projects involved, as well as to address students from different levels of an engineering program;
- It is complementary, and therefore does not aim to cover the complete range of contents and skills defined for an engineering program; on the contrary, it aims to develop technical contents and skills on which a given student shows stronger motivation.

Based on the mentioned premise, objectives and characteristics, the framework proposal consists in a structure to define the different project possibilities and a methodology to develop the projects, as well as some activities for its performance evaluation.

2.3 Structure

The proposed structure for the framework consists in a set of blocks that make up a modular system designed to support performing arts. Each block, or *module*, may be used to define a project to be developed, so that the projects are clear in terms of starting point and goals. This has two important effects:

- It facilitates the project definition process, which is normally the most complicated for an engineering student;
- It provides defined interfaces to couple the different projects, making them compatible with each other and easier to include in a performing arts presentation.

Furthermore, a project may involve several modules, but it must comprise them completely in order to maintain the previously mentioned effects.

The proposed structure consists in five different module types, and several possibilities for the nature of each module. The proposed modules types and their correspondent variations are shown in Table 1. Of course, different variations may be proposed for each module, and even new module types may be added if considered appropriate.

Table 1: Module types and their variations.

Module type	Variations
Interface (input) device	Human interface Sensor interface (non-human input)
Synthesis device	Audio synthesis Video synthesis Data synthesis
Processing device	Audio processing Video processing Data processing
Mixing device	Audio mixing Video mixing Data mixing
Output device	Audio output Video output Light output Electrical output Mechanical output

The information exchange formats between different modules must also be well defined. A simple data protocol with defined instructions may be used to transmit information from an interface device to a synthesis, processor, mixing

or output device, such as MIDI for audio or DMX for lights. The audio and video information may be analog signals or digital data streams.

This definition of modules and information exchange formats allows many different projects of many different kinds to be proposed. For example, a project could consist in developing a new instrument, programming a reactive animation, building a dancing robot, or implementing a wireless audio relay. In the same way, an input interface device could be an infra-red depth camera or a fruit bowl, a processing device could be an analog distortion pedal or a digital video processing board, and an output device could be a remote controlled blimp or a LED screen.

2.4 Methodology

The methodology proposed for the framework consists in a cyclic project development process, in which several professors and several students are involved. In this process, a student or group of students develop an open design project guided by a professor or a group of professors during working sessions. This way, a high flexibility may be achieved.

A student may work on his own on a simple, specific module under the guidance of a single professor, or he may be part of a team that develops a comprehensive project that involves different modules and professors with different areas of expertise. In the former, the student will exercise only very specific skills, but does not have to dedicate a large amount of time to his project. Even though the impact of implementing the framework this way is not very strong, it would be compatible with crowded engineering programs. In the latter, the student will develop a wider range of skills (including groupwork-related skills), but would have to dedicate more time to his project. Implementing the framework this way would increase its effect as it involves the development of more complex tasks, but would be less compatible with stronger course grids. Furthermore, a student hierarchy is also possible in which the more advanced students can act as 'leaders' of projects or modules, and the less advanced students collaborate with simple parts of the project.

The project development process involves five phases:

- Definition;
- Design;
- Implementation;
- Testing;
- Presentation;

In the project definition phase, the student and professor decide on an idea to implement a module or group of modules. Students propose, either individually or in groups, an idea for a project, and the professor discusses with them its difficulty and outreach. Together they define a project plan according to the abilities, learning styles and interests of

the students, so that they can successfully carry out the design, implementation and testing phases. If a student does not have an idea of his own, he can either join an existing project or start a new one based on an idea from another student or a professor.

The design, implementation and testing phases are developed by the students with some level of guidance from the professors involved. A professor can guide a project by simply approving or disapproving the students' work or as a source of ideas, concepts and other technical resources that the students may require. The amount of guidance provided would depend on the technical abilities of the students involved: the less advanced students receive more guidance, while the more advanced students receive almost none. This wide spectrum of guidance available contributes to the flexibility of the framework and helps encourage motivation and a satisfying project progress.

The testing of the project includes trying it in a performing arts presentation rehearsal (as a part of the proposed structure). If some features must be modified or added, a revision of project is performed and the design, implementation and testing phases are repeated. Once a project has been tested and approved for performance, it is included in the next performing arts presentation. For this framework, then, the related performing arts group must be open to modify their presentation to adapt to the development of new projects. Conversely, project ideas might arise from needs or intentions identified by the performing arts group.

The cyclic nature of the methodology proposed for the framework consists in a repeated revision of the different projects after each presentation, so that the projects can be in constant development. When a project has been presented, it might be left as an asset for the performing arts group or retaken as a new project with an upgrade or modification idea. For example, a Tesla coil could be developed in a first cycle as a light output device, and in a second cycle it could be modified to sound according to some input, turning it into an audio output device.

Then, a full project cycle consists in the development of a project from the definition to the presentation phases, and should take some time between six months and one year, depending on the project. Figure 1 shows an instance of the methodology proposed for the framework.

All the project development phases would be carried out during work sessions defined to be compatible schedule-wise with the formal engineering program. In these sessions, the students work on their projects in a common environment, while the professors are available to provide guidance to different projects but addressing all the students that attend the session. These common working sessions allow to share knowledge and experiences among the different projects, promoting interest in areas that are different to those related to an assigned project.

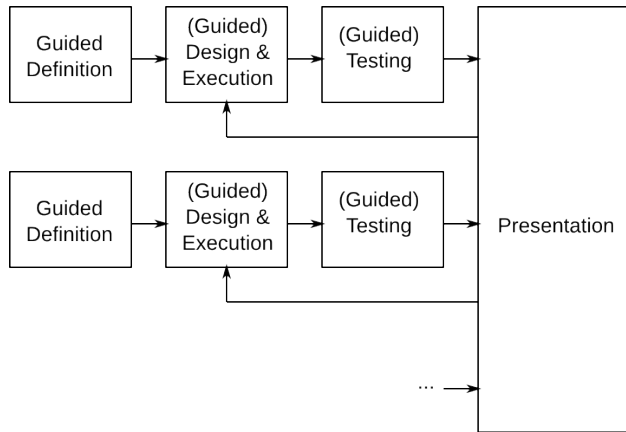


Figure 1: Instance of the proposed methodology for the framework.

2.5 Performance evaluation

The evaluation of the performance of the proposed framework is related directly to its objectives. Therefore, the increase in motivation and the development of technical and non-technical skills are the parameters to measure.

For the motivation, self-perception is the proposed parameter, although other methods to evaluate it may be used. Self-perception of motivation is a relatively reliable indicator, and is easy to measure by means of a questionnaire.

To evaluate the development of technical skills, three methods are proposed:

- Self-perception;
- ‘Conventional’ evaluation methods;
- Comparison with regular students.

Self-perception of the development of technical skills is easy to measure, but not very reliable. ‘Conventional’ evaluation methods, such as written or oral tests are possible, but we consider that a significant part of the motivation of the students to participate comes from the difference in the methodology from regular courses, and therefore discourage the use of ‘conventional’ evaluation methods. Short, oral evaluations are encouraged, as they are less likely to be found in regular courses. Finally, comparing the performance of students that follow the framework to that of regular students might not be very reliable, since it becomes hard to define an adequate control group if the participation in the framework is not very high and the participants in the program are already a specific group.

3. FRAMEWORK EVALUATION

3.1 Instance

The proposed framework was evaluated with a group of sixteen students from the Electrical Engineering Bachelor program of the Department of Electrical Engineering of the

University of Costa Rica. The framework was instanced as an extracurricular program since October 2014, in which students could join voluntarily. The performing arts group was, in this case, an amateur group formed by some of the participant students. Presentations were arranged in local technology-related events as well as in-house presentations. From October 2014 to February 2015, six projects have been started, two have completed a cycle and three presentations were carried out. Five professors have been involved in the development of the framework, and there has been one weekly working session of three hours.

The performance evaluation techniques used so far have been limited to self-perception. A questionnaire was handed to the students in February, in which they had to indicate the perceived improvement in motivation, technical skills and non-technical skills, as one of three possibilities: none, slight or significant.

3.2 Results

The numerical results of the performance evaluation of this instance of the framework are shown in Table 2. These numbers, although bound to self-perception, show promising results for the three objectives.

Table 2: Numerical results of the performance evaluation of the instanced framework.

Improvement Objective	None	Slight	Significant
Motivation	2	9	5
Tech. skills	0	6	10
Non-tech. skills	0	11	5

Besides the numerical results, two important additional observations were obtained:

- During the work sessions, students showed to be interested in the work of other students involved in different projects. Students exchanged knowledge and perceptions irrespectively of the project they had assigned, and when one student asked for assistance from a professor many of them payed attention to the explanation, even if the subject was not related to their project.
- During the presentations, students had to perform quick repairs on their projects and improvise solutions to unexpected problems. Although this activity was not intentional, it helped them face situations that might arise when installing a project for presentation.

4. CONCLUSIONS AND FURTHER WORK

We have presented a framework proposal for an engineering education program based on the development of projects that support performing arts. This framework, based on the premise that these kind of projects have strong educational value, consists in a modular structure and a cyclic methodology, as well as in specific performance evaluation techniques.

After four months of development of an instance of the framework, we have observed that students perceive an improvement in their motivation, technical abilities and non-technical skills. The proposed framework must be further studied, but it has shown to provide a highly-customized complementary teaching resource that facilitates the open design project development in undergraduate engineering programs.

Further work should focus on the further development of the framework instance, an increase in the number of students and projects involved and a deeper evaluation.

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