

WHAT CAN INDUSTRIAL PARTNERSHIPS BRING IN TO SMALL-GROUP PROJECTS TO TEACH SIGNAL AND IMAGE PROCESSING?

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ABSTRACT

This paper deals with our positive experience about project-based pedagogy with the help of industrial partners to teach signal and image processing. During one semester, students are working in small groups of 6 to 8 students, supervised by two teachers or engineers working in a small or a big company. Various topics are proposed each year such as radar processing, mobile communication system or image processing. The role played by the industrial partners is crucial: they give seminars about program management, they evaluate the technical quality of the projects and the clarity of the oral presentation. An award ceremony is also organized at school during which the activities of the companies are presented. There are also some discussions about the activities of a young engineer and several awards in various categories are given. A cocktail party ends up the day. Anonymous online surveys completed by our students as well as discussions with our partners confirm the relevance of these projects.

Index Terms— Signal and image processing, education, active pedagogy, industrial partnership, projects.

1. INTRODUCTION

In France, the traditional forms of science education at the University or in the “Grandes Ecoles” national educative system is based on lectures, exercises and laboratory sessions. This organization is efficient provided that the students do not skip the lectures. However, they usually expect clarity and relevant examples and are less and less ready to learn conceptual things. New standards and guidelines for science education have emerged for the last years. The way to teach and to learn has changed much. Active learning in classrooms becomes more and more in the trend [1]. Active and cooperative learning (ACL) methods are more and more used [2]: the students sometimes work with others. They can work alone for instance during the first five minutes of each class when readiness assessment tests (RAT) are organized or on their own by using the massive open online courses (MOOCs). In this latter case, the so-called “flipped classrooms”, based on the outside-of-class delivery of video lectures, frees up class

time for discussions and active learning exercises. According to [3], maximum effort must be done into the creation of effective in-class activities. Various other types of ideas are suggested by colleagues to motivate the students [4, 5].

In our engineering school, at the Enseirb-Matmeca (Bordeaux INP)¹ and more particularly in the Telecommunications department which was created 15 years ago, the students learn all about four thematic pillars: signal processing, digital communications, networks, and computer science during three years (from BAC+3 to BAC+5, or equivalently from BsC to MsC). There are various challenges to be addressed in this context.

1. The pedagogic team is composed of people with different fields of expertise. The teachers working in the field of signal and image processing are not working in the same laboratory as their colleagues conducting research in a variety of areas in computer science. Therefore, they do not necessarily have common research projects. The pedagogic team schedules several meetings so that they can exchange and team building events are organized each year to improve communication and develop trusting relationships. The teachers are hence more and more willing to create interdisciplinary by connecting the four pillars of the Telecommunications department. One goal is therefore to create links between the various courses that the students have to follow.
2. After being admitted in our school, some students rapidly focus their attentions on computer science or network due to the practical aspects of these domains whereas others prefer the more theoretical aspects of signal processing or digital communications. This usually depends on their backgrounds and personal tastes. Nevertheless, to get their diploma, the students have to develop their skills in the four domains and to see the links between them. Therefore, new pedagogic approaches had to be found to get them involved in building their skills in every topic.

In addition, a key point is to enable the students to become

¹In France, the system is composed of one hundred universities and of the Grandes Ecoles, which are rather small and highly selective (Admission is after at least two years of higher level education).

more active and to experience cooperative works.

We focused our attention on a project-based pedagogy [6]. More particularly, small-group learning projects were proposed for both 2nd and 3rd-year students. Various topics were presented to the students each year. They covered a wide range of applications from audio and speech processing to mobile communication systems (channel simulator design, etc.). It should be noted that the students had to take advantage of the concepts and the notions they learnt to deliver new software systems, to design new algorithms, etc. If the subject was of interest for a company, this kind of project was very useful as it could be a good starting point to find an internship on this topic. This type of project was very interesting both for the pedagogic team and the students. See [7] for more details. At this time, the projects lasted about 60 hours and corresponded to 5 European Credits Transfer System (ECTS) credits. They were done twice in the degree of our students: during the 2nd and the last 3rd-year.

Despite all the above advantages, we noticed that the students had to mature and to learn more about the daily life they would live in a company after getting their diplomas. Also, we wanted them to be more motivated and more convinced by the relevance of the projects. For this reason, we decided to ask for the support of big industrial companies 5 years ago. We thought that engineers from various big companies could participate in some parts of small-group learning projects. This could be also a very good incentive for the students to work more because people they did not know would give their opinions about their works regularly during the project. In addition, the time allocated to the projects has increased (the students spend up to 100 hours on the projects) and the industrial projects now grant a higher amount of ECTS credits (e.g. up to 9 ECTS credits).

This communication describes our positive experience about these projects and the important role played by the industrial partners.

The remainder of this paper is organized as follows: In the section 2, we give some detailed information about the way the projects and the partnership with the industrial companies is organized and we describe two examples of projects. In section 3, we give some information about the evaluation of the industrial projects based on an anonymous online survey and several testimonies. Finally we conclude and present the future work in section 4.

2. INDUSTRIAL PROJECTS

The layout for the industrial projects is the following one:

1. Small-group selection,
2. Training,
3. Project execution,
4. Special event,
5. Public presentation and report,

6. Awards.

In the remainder of this section, we describe each step of the industrial projects.

2.1. Small-group selection

First of all, different subjects are proposed to the students. These subjects describe the purpose of the project and the objectives to be fulfilled. They are available via a dedicated web-site.

Concerning the way the students are assigned to a group, each student first ranks the subjects in order by preference. Then, they have to demonstrate mental abilities, show their personalities and their motivations and express their goals and person-organization fit during an interview. It looks like a job interview, i.e. a discussion during which the applicant is evaluated for a prospective work in the group. In addition, the selection is based on the marks the student obtained during the previous semesters.

2.2. Training

Just after the beginning of the project, we organize a training session with our industrial partners. This session lasts about half a day and is given by experts working in our partner companies. In these sessions, the principles of project management are explained. These sessions are interactive: at any time, the students can ask questions about how they can apply these principles to their projects.

2.3. Project execution

There are a lot of time slots in the degree schedule reserved to work on the industrial projects. The use of these time slots is left to the will of the group: they can ask for a meeting with the supervisors or use it to work on the project. The students are free to organize their team as they want to work on the project.

2.4. Special event

For the 2nd-year project, after two months, the students have to present their project to the 1st-year students at school. More particularly, they have to explain the purpose of the project, the methods they studied, the results they obtained, what they already achieved, what they still have to do and how they have decided to be organized and to exchange. This is done during a 2-hour forum at school. The students prepare posters, but also some videos, fliers or demos in order to draw the attention of the 1st-year students. This event is hence a good way to initiate some discussions between the students of the 1st and the 2nd years. This can be a good incentive for the 1st-year students as they can have a concrete idea of the kind of tasks their older fellows enforce. Then, a lightning talk session is organized. During this session, a jury of several

project supervisors listen to each group presenting their work in 6 minutes. This presentation is videotaped. The videos are then sent to the groups with some comments and suggestions so that the students can see their mistakes and improve the way to present their projects.

For the 3rd-year project, after three months, each group has to present the current state of their project to the industrial jury by focusing their attention on how they are organized, what is their planning as well as what are the initial and projected costs. They also have to describe the possible threats to the success of their project, and how to address them.

2.5. Public presentation and report

At the end of the projects, the students have to present their projects during an oral defense in English. The jury is composed of all the supervisors of the projects as well as several representatives of our industrial partners. Also, our colleagues who teach English at school attend this oral session. The presentation lasts 20 minutes, and a 10-minute slot is then dedicated to the questions of the jury. During the presentation, the students have to present the technical aspects of their project as well as how the projects were managed. In addition, the students have to provide a report written in English. This is hence a good opportunity for them to communicate in a foreign language.

The students are then evaluated. Several criteria are taken into account: ability to communicate, ability to explain technical aspects in a simple way, creativity, autonomy, quality of project management etc.

2.6. Awards

To conclude the industrial projects, an award ceremony is held at school in which several awards in various categories are given. The two most important awards are the best technical project and the best project management. The winning groups are chosen by our industrial partners. The students receive gifts such as headphones, GPS, books of management or mp3 players. The head of the school, the project supervisors, the technical representatives and the human resources from the industrial partners also attend the ceremony. Videos about the activities of each industrial partner are also broadcasted. Then, discussions between the industrial partners and the students are initiated. Concerning the ceremony of the 2nd-year project, every student of the 1st year also attends to support their 2nd-year fellows. A cocktail ends up the day.

2.7. Examples of projects

In this section, we present several concrete examples of project in the field of signal processing.

2.7.1. Biomedical projects

Various projects dealing with biomedical applications have been proposed for the last years and many students are always willing to work on these issues.

A first project aimed at analyzing the electromyographic activity of various patients. This work was done in collaboration with G. BARRIERE, researcher at the Cognitive and Integrative Neuroscience Aquitaine Institute (INICIA), located at the university hospital center in Bordeaux. His activities deal with coordination and plasticity of spinal generators. The project aimed at improving the extraction of information from recorded signals in order to understand the neuromuscular control. For this purpose, the students had first to go to the institute in order to record the data at the motricity analysis platform. They also discussed with G. BARRIERE, who was not an expert in signal processing. He explained his problems. Then, the students had to see how to meet his needs. Spectrum analysis was the solution. For this purpose, they developed their skills in spectral analysis [8, 9] including the periodogram, the correlogram, the high-resolution spectrum analysis such as ESPRIT, MUSIC, Capon's method and the autoregressive-model based method as well as a time-frequency analysis such as the Wigner-Ville distribution and wavelets. They had to compare all these approaches from the point of view of computational cost, extra-information to be a priori defined such as the model order, the predominant eigenvalues of the correlation matrix, etc. Then, they had to design a user interface so that the practitioner can easily load the recorded signal, watch the temporal representation of the signal and select the methods that could provide a spectrum or a time-frequency analysis of the signal. They also wrote a document in which they explained how each method could be used. It should be noted that some students wanted to learn more about the recovery of locomotion following spinal cord injury, etc. One of them decided to do a 3-month internship with G. BARRIERE.

Another project dealt with electroencephalogram classification for the detection of mental states and electrocardiogram analysis. In this case, the students used alternative approaches based on intercorrelation, K-means, principal component analysis, etc. Once again, a user interface was created to load the data, to select the type of signal processing, etc. The student team working on this project received the award of 2nd-year project last year. During the oral defense, they pointed out the relevance of their approaches and their skills in project management. The industrial partner was very satisfied with their way of presenting the project and the innovation.

2.7.2. Target tracking projects

Some projects can deal with maneuvering-target tracking. In this case, since the target can follow several types of motions, tracking the target from noisy observations is not necessar-

ily an easy task. Indeed, a single Kalman filter-based algorithm based on a unique state-space representation of the system cannot be used. For this reason, the students had first to become familiar with the types of motion models such as the Singer motion model, the constant velocity model (CV), etc. Then, they had to look at estimators such as Kalman filtering and their variants such as the extended Kalman filter when the estimation is non-linear [10]. Then, they had to study multiple-model based-approaches. More particularly, they had to evaluate the relevance of interactive multiple models. It should be noted that they had also to present their works to some colleagues working on the same topic in a big company. This meeting was useful to the students because they had to present their work to people they did not know. In addition the meeting did not take place at the school. The students were very motivated. Then, some of the students did their final internships on the same topic and now work as engineers on these issues.

3. EVALUATION

In this evaluation, we first discuss the results of the annual survey proposed to the students of our school. This survey is anonymous. The students have to answer several questions for each lecture. In the following, we compare the results obtained by the industrial projects to the ones with the other lectures. Then, we provide some testimonies written by students and by one of our industrial partners.

3.1. Survey

Every year in our school, the quality office collects an online anonymous survey to gather the feedbacks from the students about their courses. In this survey, various questions are asked. Among them, three are particularly important:

1. How do you perceive the interest of the lecture w.r.t. your degree (INTEREST)?
2. Did you appreciate the lecture (APPRECIATION)?
3. What was your involvement in the lecture (INVOLVEMENT)?

All these questions are evaluated through an ordinal value between 0 (very negative answer) and 5 (very positive answer). To establish a baseline, the average for each question is computed by taking into account all the lectures of the degree during the 3 years and in the same semester as the industrial projects. The marks are compared with the average of three years of answers concerning the industrial projects. The results are shown in table 1, in the next page. This table clearly shows that for the three questions, the opinion of the student is more positive concerning the projects than the other courses. This demonstrates the interest of this original way of teaching signal and image processing.

3.2. Testimonies

In this section, we present several testimonies: one from a representative of one of our industrial partners, namely THALES, and two from students in the 3rd-year of our degree who already did both projects.

3.2.1. Industrial partner: Nicolas Berthou

“As an industrial partner of the 3rd year projects, THALES is willing to share its experience on all the good practices of project management with the students and the teaching staff. After a sensitization phase, students were able to apply these practices to real situations and address the recurring problems of project management: contract, planning, financial management, management of risks and opportunities, customer relationship, etc. This activity allows students to better understand the professional world and its constraints.”

3.2.2. Students: Mathias de Cacqueray and Charles Damien Papot, 3rd-year students, currently doing their final internships

“At the end of the project, complex ideas and results needed to be explained during a 20-minute oral defense. We have hence to present our work in a smart way so that both teachers and industrial partners who are not necessarily experts in the field of signal processing can understand our project.

Project management was also a key part of these projects. Therefore, a team leader was chosen, a training program was delivered by the industrial partners from our school and, in the 3rd-year projects, there was a specific session to check if we were on time. This was also an interesting part because, it was a way to discover how projects can be handled in the professional world, with budget constraints, man-hour time and delays. Even if school is not the perfect place to discuss these issues as there is not necessarily time constraint and budget, it was a good introduction for us.

The main interest is that we had the feeling to be in a real development context. It allowed us to make a link between our lectures and real industry issues. In the signal processing and digital communications courses, we gained theoretical knowledge. In lab classes, we applied them on toy examples. During these projects, we used real signals emitted by beacons or sensors, with various bugs and difficulties that we did not often face at school”.

3.2.3. Student: Xavier Leturc, 3rd-year student, currently doing his final internship

“Since we are engineering students, a large part of us will work in the industry. That is why having a point of view from project managers was interesting, in order to focus on some issues we do not really encounter during our regular projects during the year. These two projects allowed me to study some

Table 1. Results from the lectures quality survey gathered from 3 consecutive years (2011 to 2014)

	2nd-year		3rd-year	
	Baseline	Projects	Baseline	Projects
INTEREST	3,93	4,74	4,04	4,565
INVOLVEMENT	4,63	4,99	4,65	4,88
APPRECIATION	3,34	4,05	3,36	3,81

specificities of the underwater acoustic channel, which is different from radio channel that we study during our digital communication courses. I also studied a methodology based on a RJMCMC algorithm to classify electrical signals. This project was a good opportunity to learn by myself this complicated algorithm and develop my skills in non-supervised classification”.

4. CONCLUSIONS AND PERSPECTIVES

After 5 years, we have the feeling that industrial partnership can bring in much to the students, to the pedagogic team and to the industrial partners. The students reinforce their knowledge, establish links between the various courses of our degree, develop their know-how and know-being: the seminar dealing with project management give students complementary skills. They start to understand how to communicate efficiently. We have also noticed that the students are more and more enthusiastic when they present their works to their friends, to the 1st-year students, or to our industrial partners. Introducing student interviews before the beginning of the project can help select the students. It can show if the student is the right candidate for the project. It is also a good opportunity for the students to become familiar with this type of exercise. They can feel more confident when they apply for a position. Concerning the relationships between industrial and academic partners, they become closer and closer. It should be noted some common research projects can be launched.

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