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Abstract

The paper reports an experimentation driven and improved since three years in an Institute of Technology. The question of students in math lectures was on how and where the theoretical results can be applied in electrical engineering application. Conversely in electronics lectures students are asking for more fundamental applications to carry out the purposes and intents. One answer could be the weaving of math and electronics in a common application. Since many years the teachers are applying their domain with high level calculators, computer algebraic software and programming languages. These wide and common skills and knowledge have made this multidisciplinary experiment possible. The micro controller based device has been chosen here for its connection with high level programming language with an access to the processor registers and its versatility in industrial uses.

The article details the teaching experiences in that environment. Each year the experience has been completed, fulfilling the following points: general organisation, teaching and practice, feedback and recommendations. The students are taking the second grade course of bachelor of technology in the electrical engineering domain either in a full time course or in a part time course. The syllabus of the bachelor of technology in electrical engineering domain mentions theoretical and practical works on how to design, install, realize, maintain and qualify an electronic device for a control process of a multi-technological product.

The practical studies and realization are dealing with a blinking led and a keypad manager. The working class spread on twelve weeks with four hours a week. The classroom is composed of twelve students split in units of two students. The group is guided and mentored by two teachers at any time. This gives the students a new approach of the electrical engineering teachings. They must perform the required activities based on the mixed teachings.

The yearly module is composed of ten percent of short lectures plus five percent of assessments and the rest in lab works. The classroom architecture must not be neglected in that experimentation. The room is divided in two parts. A U-shape set of tables for the lectures and a system of individual equipment fixed to the walls. The structure simplifies the teacher's motions in front of the group or behind each platform. The typical geometry of the U-shaped classroom avoids chatting and stimulates the concentration of students. We can note that it is causing some students stress as mentioned in their final recommendation. For practical work, two students are sharing the same individual platform, freeing them from the previous constraints, supporting the discussion with their peers and revealing their autonomy.

All works and new skills have to be validated by short assessments, multiple choice questionnaires, reports and efficient achievements. The behavior of students and the events are also checked by the teachers at any time in order to give an added value to the expected skills in the syllabus. At the end of the course, students are invited to fulfill a questionnaire. The questionnaire is pointing on organization, time schedule, difficulties and comments on the weaving of different sciences.

The article ends with the recommendation coming from the students experience and the regular teachers feedback adapting the lessons in real time. This experimentation has been successful for years and is going on.

Keywords: Multidisciplinary, technology, micro-controller, blended learning, sharing know-how.

1 INTRODUCTION

During past few years, the Sciences Technology Engineering Mathematics –STEM- authors worked alone but discussed and claimed about the lack of skills of their students not able to adapt themselves in another context and run towards the vanishing student motivations. They are always asking for the

best way to teach, to adapt trainings to the new generation of students and to use the modern tools in classrooms. They used the slide rule and the pocket calculator long years ago, they are now riding on the electronics highway. For pedagogical purposes, the internet in education has become the essential tool to do experimentations as distance learning[1], flipped classroom[2], Mooc usage[3], learning analytics, educational data mining.

The e-era is launching new behaviour for students and their teachers. Rather handwriting down notes on events or measurements the students prefer to copy-paste screenshots. The consequence is the leaving time usually spent to design figure is dropped down. Thus the neuronal organization is different. The more leaving time is spent to design a figure, the more the memory is well organized to take and fix the information. As recent examples, an integral, a discriminant a differential equation, the symbol of power of ten are regarded as images not as full of meaning formulas or rules. A picture is worth a thousand words said Confucius, indicating how any set of events can be modeled as an image orienting the mind from words to image. Conversely, in ancient culture only a few copyist monks or monastic scribes were able to understand the meaning of what they were writing down all day long. At the 21st century, in particular in the scientific domain learning from images to sense is emptying the sense. The 10% efficiency of mooc lessons confirms the weak success of the autonomy learning.

The authors and colleagues worked during years in order to find new ways to enhance the student behaviour for learning and oriented them to work in autonomy. They have experimented modern learning technics from local computers to the web ([4],[5], [6]) and also in a multidisciplinary context ([7],[8], [9]).

According to the context, the students have seen their well known teachers as engineer driving a project or teachers censoring and evaluating their work, or big brother able to give them back useful help.

The main subject deals with the sharing knowledge and know-how between teachers. Moreover, the previous experiences feedback by the students themselves served the next generation and had made the experimentation more profitable.

The subject is the micro controller and the common skills are the computer science. For one teacher in mathematics it was theoretical programming and the second teacher in the electronics domain was the hardware programming. Both share the same enthusiasm in order to give a new behavior while teaching in front of students. The students are more confident as they know and practice pretty well as a mathematics teacher and an electronics teacher.

The syllabus of the bachelor of technology in electrical engineering domain mentions theoretical and practical works on how to design, install, realize, maintain and qualify an electronic device for a control process of a multi-technological product.

Due to the academic syllabus, the teachings and learning are necessary compartmentalized. It comes mainly from pedagogical reasons as the long history of educational systems that splits all the knowledge in modules. And also from practical and safety reasons as the organization of the planning of labs, classrooms and amphitheaters, sharing the equipment for other lessons and the teaching timetables for teachers and students.

The second section provides a short description of the French institutes of technology. It points out the syllabus of the electrical engineering department in order to explain how it is possible in some classroom to propose a multidisciplinary field of investigation in some classroom. The classroom architecture, the subject of the practical works, the pedagogical organization are detailed in the third section. The forth section is opening a discussion on the results of the yearly questionnaire given to the students at the end of the session and draws some conclusion.

2 BACKGROUND

2.1 The French Institutes of Technology

The creation of Institute of Technologies in France was decided on January 7th 1966. The aim was to provide French companies with qualified employees specialized in fast developing technologies. These employees should be trained in two years at the University and then employed as qualified technicians to bring help to engineers and companies in their efforts to modernization. Institutes of Technology have now existed for fifty years but they still keep this key role in the transmission of technical progress. This implies for their lecturers the necessity of life-long learning, and to try any

opportunity to do something equivalent. The creation of Institutes of Technology was also part of territorial management. As Universities are only located in bigger towns, the creation of Institute of Technology in medium-sized cities is an opportunity to bring new technologies everywhere in the country to help local companies. It is also an opportunity to bring more young people to new jobs, in particular people from families with low income, who could not afford studies in bigger and more expansive towns. The map on Fig.1 shows the geographical breakdown of IUT.

Figure 1 : The Institutes of Technology in France

The domain taught are directly in connection with companies activities. The Institute of technology delivers a University Diploma of Technology –DUT in French-. The diploma indicates a level of theoretical and practical skills in order to get a legal superior technician salary. The course takes two years after the French Baccalauréat. Some students are going on for a one year specialization in a bachelor of technology course. The best of them are changing their career path while going on in an engineer school. The next section describes some elements of the Institute of Technology in Valenciennes and points out the one which welcomes all students and teachers concerned in this article.

2.2 The Electrical Engineering and Industrial Computing Department

The region of Valenciennes is the France's number-one automotive region including seven automaker sites, more than 150 companies and 30% of national sites production. The Transalley technology park, a cluster for sustainable and innovative mobility, is located in Valenciennes across from the University campus (http://www.transalley.com/en/). Among faculties, institutes and engineer school, appears the Institute of Technology (www.uvhc.fr). The Institute of Technology takes part to the answer on the search of synergies between educational system and local economy.

The Institute of Technology of Valenciennes is organized in nine departments specialized in different domains such as Mechanics, Physical Measuring Procedures, Quality Management and among these departments our Electronic Engineering and Industrial Computing department.

Depending on years, the number of students involved in our department for the two years is over one hundred fifty students, equally spread over the two years. Our department also offers a third year of specialization not treated in this paper. Ninety percent of all students are full time students. The rest is composed of part time students who are working in local, national or international industrial companies partly located in the North of France.

All departments of Electrical Engineering and Industrial Computing have to follow, with a rate of ninety per cent, the same schedule, that is, the so called "PPN", Programme Pédagogique National, in French. The contents, the motivation and the schedule can be found on the internet on the site of the government dedicated to Education. This schedule explains the subjects that have to be taught and

how many hours have to be spent on each subject. This schedule is constantly discussed in national meetings involving both lecturers, academic staff and company managers, looking at the needs of economy and at local experimentation (http://www.education.gouv.fr/). The syllabus comprises three topics called teaching units described below:

1 Components, systems and applications.

2 Innovation by the use of technology and projects.

3 Scientific training and human sciences training.

The second point mentions theoretical and practical works on how to design, install, realize, maintain and qualify an electronic device for a control process of a multi-technological product. This is developed in the next section.

3 WEAVING ELECTRONICS COMPUTER SCIENCE AND MATHEMATICS

3.1 Topics and general organization

The academic lectures provide a theoretical framework of main domains known as STEM. The acronym STEM stands for Sciences Technology Engineering Mathematics. These lectures are given in amphitheatre in front of a one year group. Then, some applied exercises are proposed in small groups composed of twenty-five students at most. Finally, a tiny group structure is composed of twelve students and provides the opportunity to weave the separate knowledge into applications and realizations.

In that case, the practical studies and realizations are dealing with a blinking led and a keypad manager. The working class spread on twelve weeks with four hours a week. The classroom is composed of twelve students split in units of two students. The group is guided and mentored at any time by two teachers. This gives the students a new approach of the electrical engineering teachings. They must perform the required activities based on the mixed teachings.

3.2 Motivation

The motivation for this experimentation came from discussions with former group of students who completed the practical works, the results of a final questionnaire, discussion with the teacher taking account of the students' opinion and rising difficulties.

All multidisciplinary experiences presented here are coming after long time and fruitful discussions between two mathematicians and a physicist on the students' difficulties to drag a concept seen in mathematics and apply it to physics and electronics. Moreover, the authors are sharing close skills in computer science: hardware programming and theoretical programming. That launched the experiments. Such an experimentation has been possible thank to the local staff that eases the organisation of any pedagogical and technical elements. That includes the lab access, the time schedule and its modification if any. The teacher motivation is relayed by the students' motivation giving a feedback while answering to a questionnaire. The questionnaire includes the technological and pedagogical elements from the course. A few personal comments are also enlightening the practises.

3.3 Management

3.3.1 The classroom architecture must be not neglected

The classroom design affects the student engagement. One parameter on the students' engagement is based on the classroom architecture. The recent arrangement of the furniture in the classroom came after remarks, comments and feedback of the students and teachers discussion. In order to identify the lectures and its direct applications on the devices, the classroom has been designed within two parts.

First a U-shape set of table makes the group sitting in front the teacher. That eases the teacher to talk to any student while taking care of its concentration and sometimes makes him a small stress as he can't do anything else but listening to the speech. Another advantage is the quick answer to any rising question.

The second part of the classroom is devoted to the practical work. A set a six platforms is installed in front of wall or windows such that the students can easily move from their platform to another and discuss with others. The technical equipment is composed of the microprocessor mounted on a board, an oscilloscope, wired connectors and a computer and its software development tool. An oscilloscope, a power supply, a voltmeter end the equipment.

Figure 2. The classroom and the labroom.

3.3.2 The micro controller

The micro controller MSP430-2012 from Texas Instrument (http://www.ti.com/) is an in ultra-low-power microcontrollers with advanced peripherals for precise sensing and measurement. A low cost, an ultra performance and numerous resources on the web, interruptions management, a debugging and a C++ programming interface (http://www.codeblocks.org) have motivated the choice.

The micro controller is programmed by the use of a software development tool. The IAR Embedded Workbench Integrated Development Environment (https://www.iar.com) provides a high level of C/C++ programming and a low-level assembly language. The trace of any program and the checking of any register gives the user a simple way to manage and maintain the program. IAR Systems is a Swedish computer software company. IAR" is an abbreviation of Ingenjörsfirman Anders Rundgren stands for Anders Rundgren Engineering Company. IAR systems offers development tools for embedded systems.

The micro-processor MSP430F2012 is a product of Texas Instruments mounted in a target board (Fig. 3b) in order to be adapted to an debugging interface mounted on a USB key (Fig 3c). An additional wired board supporting all these elements has been designed and built by the technical staff. The connections are drift on a board making the plugging quick, safe and easier for measurements on the new connector. (Fig. 3a)

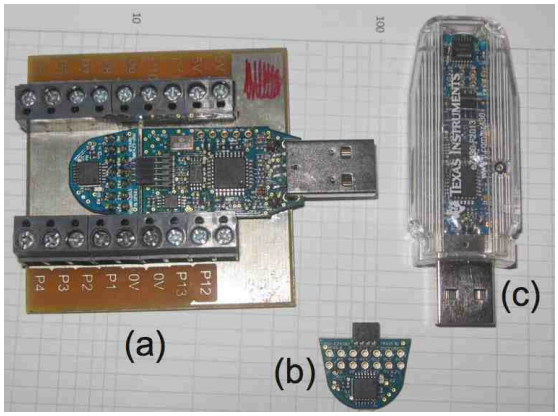

Figure 3. The micro controller MSP430 mounted on a big board (a), target board (b) on a debugging interface (c)

3.3.3 The tasks

Each group of two students has an access to the internet and to the local data base in a Moodle environment. This data base contains the micro-processor documentation, a survival guide, a digest of micro-processor instructions, the schedule of the teachings module and the final questionnaire. Nevertheless a printed handbook of the micro and a printed specification sheet are also available in the classroom.

A specification sheet is given to any student. It includes the sessions schedule and the links to the technical documentations, already built programs and examples and the tasks to be completed. The student group is split in 2- persons units for trials and gathered for lessons in the same classroom. They must learn and practise the basics of the microcontroller and share with their friends. Any completed task is thus checked by the teacher.

A final report ends the session. While students are working, teachers are fulfilling a document giving lines for evaluation. The behaviour of students is thus checked by these guided lines as pooling the knowledge and skills, sharing a point of view with other groups. In the lab work, any teacher is able to answer any question belonging to its basic domain or to the shared skills.

3.3.4 The questionnaire

At the end of the session, a questionnaire is proposed to the students in an anonymous way or not. The answers are on a scale running from 1 = low to 5= high plus a personal opinion to write down at the last asked questions. The items and average answers to the questionnaire are shown on table 1. The answers show that the majority of students is satisfied of the organization. The following comments and students opinions add new perspectives.

"I do not like to work in computer with connection in electronics, I prefer the electronic engineering domain", Valentin.

"I was quite motivated because of the forthcoming Erasmus placement in Germany is based on the same micro controller for an universal infrared remote control", Brian

"While the time is going on, the difficulties are growing up. Thus, some more homework is required. But not completed by myself that is causing me more difficulties" ,Arthur

"The C language lessons are too theoretical lessons. We need more time for practicing and understanding", Sarah

"I feel proud while sharing my skills", Adama

"The theoretical lessons in C language or for the software handling is stressing me as I always have the sensation to be spied. I suggest to use a classical classroom design ", *Pierre*

Table 1. *A final questionnaire*

Questions	Results
Topics : linking led, phone keypad, sinus generator, filtering	4
Links of micro controller and C language	4
Difficulty of Micro controller lessons	5
Difficulty of C language lessons	5
Student discussions in their own group, with other groups	3
Homework load	3
Level teachers availability	4
Mixed skills of teachers	5
Furniture layout in classroom	4
Access to the technical documentation	5

4 CONCLUSION

The paper reports a multidisciplinary experimentation. This provides the opportunity to weave math, computer science into electronics and its microprocessor field. A group of twelve students in bachelor of technology takes part to a fifty hours learning and practicing module. In that case, the teachers' presence and the teachers' availability guarantee the success of this learning approach.

The positive answers can be explained by the taking account on previous answers and comments from former students meaning that the teachers are always adapting their talks, lessons, tests, subjects. Teachers are always slowing down the level of difficulties as mentioned in the questionnaire.

It has been noticed by the teachers that the student's mind is quickly turning confused while doing many tasks together as writing down notes, reading technical handbook where most of them are written in English language, doing experimentations and tracing the programs. A suggestion would be the help of a specialist in communication knowing the required technical English.

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