Improving student's motivation for sensors and actuators courses: "a multi thematic mini rolling robot design project"

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Abstract: This paper first show the necessity of a global reform in our school. Then, we explain the importance of human factors and we describe the complexity of the relation between the new student generation and the teachers. The consequences on the quality and efficiency of traditional pedagogy are indicated. As a typical example, we show that our traditional approach for teaching "Sensors and actuators theory and applications" does not match any more with the students needs.. And we present here an alternating pedagogical approach (bottom-up practical and attractive method, small robot system design and test) in order to replace this ancient course.

Key words : "teaching efficiency ", multi thematic project, global approach, educational reform, motivation,.

1. Introduction

1.1 ENSEIRB learning overview

1.1.1 Classical teaching reform

Since a few years, we observe in our electronic and informatics engineer school, a kind of increasing gap between the student's needs and what we gave to them. A global disaffection for all theoretical lessons appeared and our traditional pedagogical reached its limits.

These tendencies we noticed in our school are confirmed by French national statistics: there is a global demotivation for the scientific curriculum. The number of students interested in Sciences is decreasing year after year. Economical, commercial studies seem to be now more attractive for this new generation of students.

In front of this situation, a Quality program has then been engaged in our school inducing a deep pedagogical reform as well on the bottom as on the form. All the scientific, electronic, and other engineering fields of the ENSEIRB program will have to be reformatted. Each one of us had to suggest improvement, modification in each own field of competence. As an example of this reform, we describe here what we did for "sensors and actuators teaching module".

1.1.2 The students

We have attended for a few years, a change of behaviour students. The teachers are in front of a new kind of public and do not know how to manage behaviours which are not familiar. Among the major evolutions, we can extract the most important one's:

- The international origin and the diversity of social origin of our students increase the difficulties of teaching: level dispersion and cultural diversity is not anymore compatible with traditional lessons in full classroom.

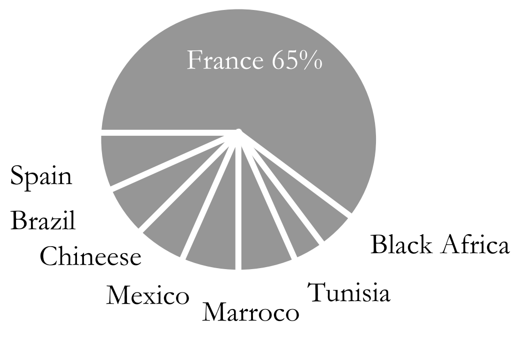

Fig 1 : student's origin repartition

- Most of the students have a lot of extra scholar activities such as sport, internet electronic games, and other leisure's. They are interesting from a personal development point of view, but they also generate a too big mental energy dispersion which is not favourable to a rigorous school work.
- A reduction of capacity of attention (inherent in human being and normally about 45 min with 1

hour) has also been observed. Thus, the efficiency of a traditional theoretical course of 1 hour is now poor, due to a progressive unhooking of the audience faster than before. Theses phenomenons are amplified for our young adults in our “training in alternation” Department. All these observations are confirmed by Neuro Linguistic Programming studies [1] among others. And a typical “ cycle and micro cycle” diagram is given in Figure 2. These cycles are related to the natural biological rhythm of an individual and also to the permanent internal/external conscious states switching.

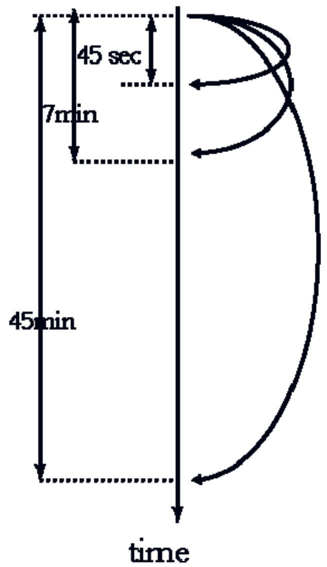

Fig 2 : natural adult attention cycles

- At least, our students act now like volatile customers, and are able to switch quickly from an activity to an other one without apparent reason. This “zapping” phenomenon is destabilizing for the teachers.

1.1.3 Impact on classical courses efficiency

According to this situation, it appears that supply and demand as regards teaching, need to be given in phase. As the previous teaching methods doesn’t match anymore with these students of today, we have to test other teaching methods to restore effectiveness and quality.

We must now considerer the relation teachers/ students like a customer/supplier relationship, in term of business. The customer satisfaction must become one of our priorities.

1.1.4 Impact on “sensors and actuators course”

Our previous”sensors and actuator teaching”, was a full classroom traditional teaching with ten sessions of one hour and a half each. The content looked like a tiresome enumeration of the physical principles and descriptions of the sensors perfectly classified.

Since two years the student’s satisfaction rate was poor : the students absenteeism rate was increasing; it became difficult to maintain the concentration of the students du to the too high information density and to the linear structure of the course. So, we decided a total modification of our strategy.

After some discussions and comparisons with other experiences [2] [3], we started a “learning by project approach” for this subject.

2. Learning sensors and actuators through a multi thematic project

2.1 Introduction

If this concept is obviously not new, its introduction in our scientific school is quite recent. The aim of this approach is to restore the motivation and to develop the curiosity of the students by a more practical approach and a “bottom up” teaching strategy.

Such approach allows a soft approach to difficult theoretical courses and trainings which are nowadays rejected by the students. It also makes the student more confident and responsible of his work and results.

An other interesting effect of a long term project is the opportunity for the student to develop his team work spirit and his management ability.

2.2 Application

The funny mini sumo robot (figure 2) (from parallax company) [4] has been chosen to experiment this learning strategy in replacement of the traditional sensors course. As this robot’s use was initially suggested for teenager’s hobbyists, some modifications have been done to make this robot appropriate to a engineer level teaching: the initial processing board has been replaced by a microcontroller PIC 16F873 board in order to program in assembler or C language instead of the BASIC language from Parallax.

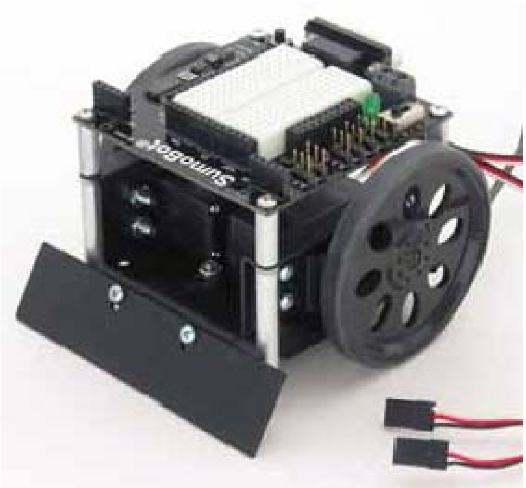

Fig 3: mini sumo robot view

With the use of this robot, the old full classroom course concept is now replaced by a global and practical approach : It allows a cross connection between different fields of science in one project: the "sensor world" of course, the embedded software for sensor management, the actuator control, the feed back theory, and power management. This approach covers exactly the same main fields than the old course but the human approach and the motivation process are completely different.
In that way, a mini sumo-bot "fight" can be organized at the end of the project, to improve a little more the motivation of the students.

3. Short description of the robot

3.1 General description [8]

This mini robot consists mainly of:
- -Four battery cells
- -A set of sensors,
- -Two motors and wheels
- -A Basic stamp processing board
- - Mechanical parts

It is 15 cm high, and 350gr weight.

3.2 The set of sensors

Robots are a perfect support to study the "sensor world" (Sensors and analogue conditioning circuits). In our small robot, a set of quite simple or sophisticated various sensors is available for motion control and moving strategy. They are enough to illustrate the main principles we need to teach. The most popular are shortly described below.

3.2.1 Line sensor

This line sensor is a simple infrared emitter/receivers (Fairchild QRD series) dedicated to border line detection. Thus, the robot will stay into the playing area.
The principle of this sensor is given in figure 4a and b. It can operate as a binary detector (on, off) but also as a variable resistor function of the reflected infrared light.

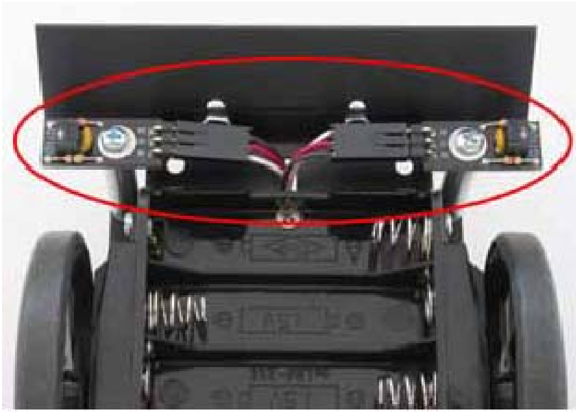

Fig 4a: line sensors

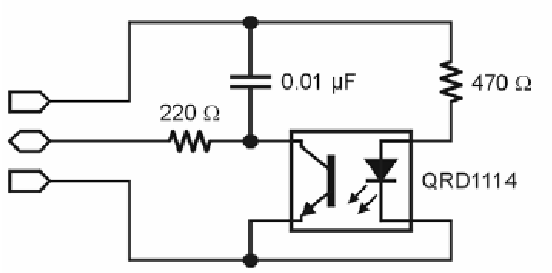

Fig 4b : line sensor principle

Thus, by including two kind of conditioning circuits (Threshold comparator or RC time constant measurement), we can illustrate two possible uses of this sensor. And some calibration problems can also be viewed through this example.

3.2.2 IR obstacle sensors

The figure 5 shows the infrared front detector which can be used for obstacle detection. The receiver can be a simple photo transistor or a more sophisticated sensor including an analogue pre-processing conditioning circuit such as the classical PNA4602M (which can be used for TV remote

control for example) with a carrier frequency at 38 kHz.
The questions of sensitivity, parasitic light rejection, selectivity, reflexion or transmission mode can be studied trough the use of theses sensors. It is also the opportunity to give some details about the Infrared radiation theory and electronic technology.

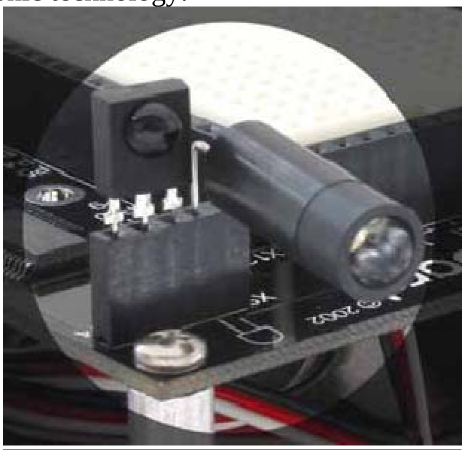

Figure 5 : Front IR sensors

Theses sensors can operate as a binary detector or can work as distance measurement by sweeping correctly the carrier frequency around 40 Khz (Figure 6) if knowing the IR characteristics of the target.

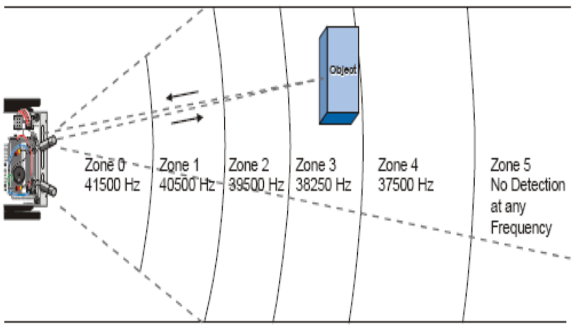

Fig 6 : IR distance measurement

3.2.3 Compass modules

Two compass modules are available. They illustrate two different physical effects.
The first one is an integrated CMP03 module (Figure 7) including two magneto resistor sensors and a microcontroller. A reliable direction measurement can be done, only if the module is in a perfect horizontal position.

Fig 7 : CMP03 compass module

As a linked interest, CMP03 module implementation could also be the opportunity to discover I2C bus protocol and management.

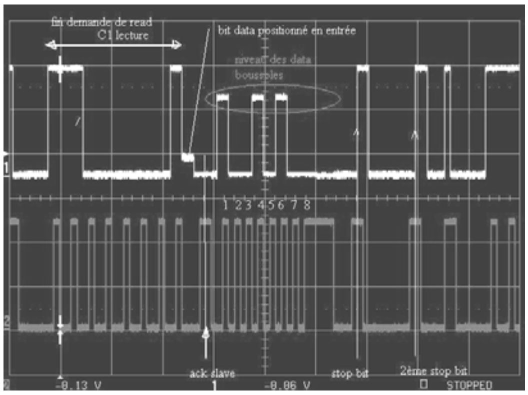

Fig 8 : I2C bus management

Figure 8 shows an example of I2C message exchange between CMP03 and the main processing board. (Upper trace “data line”, lower trace “clock line”).

The second is a Dinsmore 1490 sensor (robson company) mounted on a processing board (figure 9a and 9b). This sensor acts like the needle of a mechanical compass. A set of four Hall Effect sensors is used to estimate the motion direction. The use of theses sensors is also an opportunity to learn some details about the magnetic fields theory.

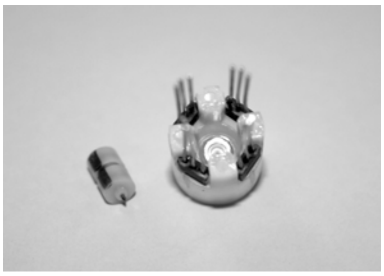

Fig 9a : needle and hall effect sensors

Fig 9b : Compass sensor board

3.2.4 Memsic 2125 accelerometer and tilt sensor
This integrated MEMS sensor from MEMSIC Company works by measuring a thermal difference into a micro cavity (Figure 10). This circuit can be used for example, into a feed back loop to control the horizontality of the compass module.

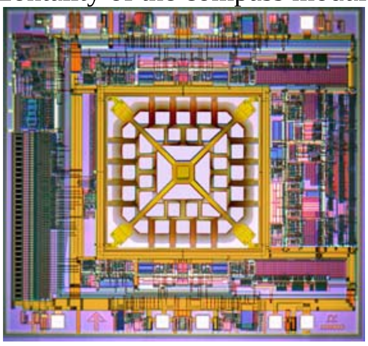
Fig 10 : from MEMSIC documentation

3.2.5 Other sensors
Other extra sensors such as ultrasonic detectors, temperature sensors, can obviously be used depending on student's preferences and available time.

3.3 Processing board
Depending of the time schedule, we can use the included basic stamp board or design our own microcontroller board. In this case, a micro chip PIC 16F873 is often used and a C language sensor management program can be written.

3.4 motion motors
We use here two classical servo motor for left and right wheels driving. A small modification allows a full 360° rotation.(Figure 12)
As the two servo are not coupled, the rotation speed must be calibrated (mechanically or by software) to insure a right trajectory when the control signals are identical.


Fig 12 : modified servomotor

4. Pedagogical flowchart

The project proceeds by group of 4 students (second year study) . It is distributed over one six-month period with 10 practical lessons of 3 hours. Because of the multi competence aspect of our approach, a "teacher team" is constituted. This allows sharing the knowledge and a better cross connection between the different fields. The miles stones of the project are :

- Brainstorming session and student group constitution: During this first step, an initiation to motivation processes and creativity phenomenon's is performed. Based on individual Herman test [5] the student's teams are then made up. The team profile is then identified (open, close synchronous, random). For each team type, the methodology, and the human organisation, (task management, leadership…) is then described in a short management session given by a internal or external consultant [6]. This allows a first student sensitizing to team management,

- Practical demonstration: a Sumobot in action is shown to the students. They are invited to "to play" with it in order to improve their interest and to develop their curiosity. Learning sensors will then become a pleasure and not a constraint!

- Specifications definitions: The specifications are defined all together in order to give some freedom to the students : among the set of available sensors, the students choose the one's they want to use. Then, they think about the motion and fight strategy.
- Project management initiation: Once the specifications are defined, the job of each member of the team must be defined. By a short seminar on project management, we help the students to make their task repartition, project manager designation and role attribution.

- Thematic bibliography: Showing the necessity of collecting information before starting working, we encourage the student to find documents, books, and articles in our library rather than on internet. This process is often more efficient and quick.

- Sensors implementation: At this step of the teaching process, the students became conscious by their own, that they have to understand the physical principles and detailed description of the sensors before going further: In a short lessons given by the sensor teacher, Infrared and magnetic laws, the main physical effects are explained. Some training about conditioning circuits, calibration, are done before going back to the project. Each sensor used, is individually characterized (i.e response time, sensitivity, operating range…). So our students become not only “simple users” but furthermore “intelligent users”…

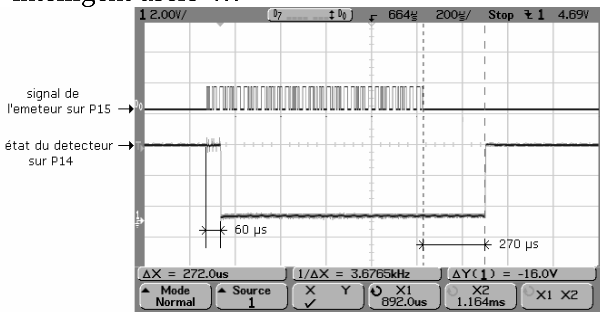

Figure 13 : PNA4602M infrared obstacle sensor characterization

For example, the figure 13 shows an obstacle detection timing diagram; upper trace emitted pulse train 38 kHz, bottom trace sensor output changes : low level indicates an obstacle detection).

- Motion: a few lessons given by the electro technical teacher are dedicated to DC motors, electronic drivers sizing, feed back theory, position coding and speed control. Each servomotor used by the students, is individually characterized. The figure 14 gives an example of speed characterisation. Vertical scale: rotational velocity in rpm; horizontal scale, pulse width servo control signal in ms).

- Manufacturing: The robot is then wired and mechanical elements are assembled by the students. In parallel, software is implemented into the processing board.

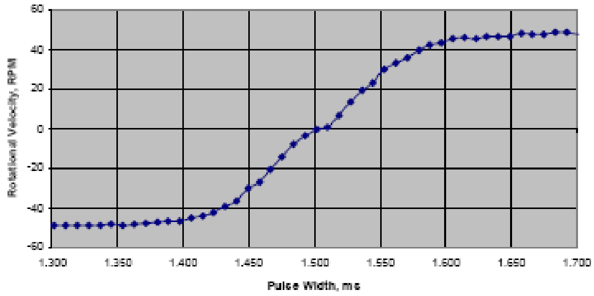

Figure 14 rotational speed vs servo pulse width

- Manufacturing report: in this report (based on a industrial model for training reasons), the students must clearly describe the wiring and assembly process as in the industrial life.

- Semi global and global test: once the whole system is correctly manufactured, the behaviour of the sensors is individually tested. The motor behaviour is also verified. Finally, a “under true conditions test” is performed by verifying the motion strategy on the playing area or ring.

- Final report: In this report, we request the students to reformulate what they understood during the project. This enables us to be sure that the sensors and actuators bases were assimilated.

- Oral report : each group must orally expose the covered subject during the last meeting.

5. Advantages of “learning by multi thematic project”

- The funny aspects of the project (the robot is moving and fighting against an other one) are a source of interest. It is also an opportunity to teach some unpleasing fields of electronic as simply as possible.
- Some freedom into the design gives the impression to the students to be actor and creator. It acts like a creativity amplifier.
- While in a classical approach, the students often complain about the ”bulk-heading” or the absence of connection between the courses, here, our « system » approach allows connecting different fields of electronic (Analogue, digital, sensors, micro programming, power motor driving). It ensures a better comprehension, and causes a global interest for the lessons.
- The physical and mathematical complexity of the sensors world is better received through a practical and funny approach.

- This multi thematic project is the opportunity of a self encouragement to the student to deepen himself his knowledge by necessity and not obligation.
- The project is also a time for a human experience, a pleasant team work, and management Each student can discover his own preferences, and personal interest in his work.
- At least, the idea of a final fighting robot tournament develops a positive emulation inter group.

6. Results

Even if it is always difficult to "measure" the impact of a teaching strategy, this one seems to be more attractive than before.

We asked to ours electronic department and training in alternation" department to make a opinion poll or report, to get the feelings of the students. The last result shows that the satisfaction rate raised from 45% up to 65%. Of course, we are far from the perfection but what is important is that the satisfaction rate increases.

In this report, the students point out the funny aspect of the project, and also the system approach which allows mixing their different acquired technical knowledge.

Even the technical level of this project is not very high, the most important for us is to improve the motivation, the interest, physical and mental presence of ours students.

Comparing to other experiences [2]; [3] done in different French engineer schools, we see first that many colleagues are now testing this approach. The same evolution in term of motivation is observed, even if it will never possible to obtained 100% of satisfaction rate.

However, we must be careful, because "learning by project approach" has also its own limits in term efficiency and quantity of information given to the student by unit of time. Despite our efforts, we have had also some chess with students who prefer a perfect scholar guided framework. As becoming engineer requires progressive autonomy and initiative from the students, we are presently working on these residual problems: Even it never will be possible to reach a 100% satisfaction rate, working on deep human behaviour mechanism using "Neuro linguistic programming", "Yoga" tools will probably help us to better understand the individual "keys motivation processes" and so to find an appropriate pedagogical answer to each student's needs.

7. Conclusion

We showed in this paper that the traditional teaching methods do not match anymore with the actual pedagogical needs, for environmental, individual, and society reasons. As we can not change the students, the only thing we can do, is to adapt our pedagogical approach to them: Replacing some classical unpleasing lectures by "Learning by project" approach seems to be a good way (among others) to improve the efficiency and the quality of our teaching. Through a serious but funny robot project, we showed that it was possible to improve the behaviour, the motivation and the curiosity of our students and thus the efficiency. We are obviously conscious that pedagogy requires permanent adjustments to fit as well as possible to the student's needs. But we never forget that, even if the manner changes, the scientific bases must however always be taught.

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