A Pedagogical Reflection
-- The Ateneo SCADA Project --

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Abstract: *The classroom is the platform for the growth of human beings. The teachers manage this platform in a way that they creates an environment, where the human being's "freedom to think" is unleashed and enhanced. The subject matter at hand focuses the development of this "freedom to think", and this is along the technical lines in the course description. This emphasis equips the human being in developing creative solutions to future challenges. The teachers are active participants, not only in the students' learning process, but also in their own. They assume the role as facilitators and a resource persons. At the end of the reflection, the authors raise the following questions: (1) When will the Philippines as a nation ever effectively cultivate the culture of creating? (2) Developed countries have made us users, buyers, and ahentes (or agents), mostly relegating our technical graduates into explaining how a system is installed, operated and maintained. (3) Professionals that we all are, we are deeply concerned that if the environment which the Philippines presents to our graduates continue the way they are, technology in our country will continue to be shackled, thus encouraging other countries to keep on stealing our professionals and new graduates.*

I. Introduction

The classroom is the platform for the growth of human beings. The teachers manage this platform in a way that they create an environment, where the human being's "freedom to think" is unleashed and enhanced.

If the human being was not there in the first place, there would be no school, no classroom, and no teacher. The subject matter at hand focuses the development of this "freedom to think", and this is along the technical lines in the course description. This emphasis equips the human being in developing creative solutions to future challenges.

The person's "freedom to think" will inevitably lead him to the "creation of something".

The teachers are an active participants, not only in the students' learning process, but also in their own. They assume the role as facilitators and a resource persons.

II. A Learning Philosophy

A. Student-centered Approach to Electronics Education

1. "Freedom to Think"

The person's search and attempt at developing the "freedom to think" has its foundation on how the human beings live and learn.

As young children, they use their senses to reach out to the world around them. They test things out and immediately learn. The world for them is "interactive". They get results almost immediately after their "tests" are conducted. At this point, they have not yet defined rigid boundaries of behavior or sense of guilt and fear.

This reflection asks whether the teaching of electronics could somehow develop an environment similar to that which the children find themselves in? Moreover, is it somehow desirable, or even possible to bring the students and the teacher to that state of awe, freedom and joy in discovering, as they discover electronics, themselves, and their specific and unique role in a meaningful whole, while retaining their individuality?

Yes! is this paper's answer to the questions raised.

Behavioral experiments provide some leads. Experiments have shown that persons rate of learning are related to their motivation. This relation is such that the faster they learn something they enjoy, the more they are encouraged to pursue it even more.

2. A Real-life Example

In a real-life situation, the National Power Corporation organized an automation task force in 1980. Recruited for the task force as volunteers were people, who were not all engineers, but all of whom possessed the desire to learn electronics. Nobody had any electronics background. The facilitator, who had no schooling in electronics and learned it by himself, brought them to conduct experiments to address specific activities. One of which was to monitor the rate of change of metal temperature in a "once-through" boiler. The specifications provided that the change of metal temperature should not exceed 250 degrees Fahrenheit per hour. The challenge was to build an analog differentiating electronic circuit that would be able to monitor this change.

The project was not all that successful, but the learning process and the motivation has been so enkindled by this experience that the group decided to convert the 138-kv substations of Kabasalan and Sangali in Zamboanga into un-manned substations to be controlled from the Aurora substation, also in Zamboanga. The communication system was to be via the narrow-band, analog power-line carrier. This group was joined later by other volunteers, also without any training in electronics.

Within one year and a half, this group succeeded in designing, building and installing that system, at about 10% (90% savings) the cost of a system that would have performed a similar function, if procured from Japan or the United States.

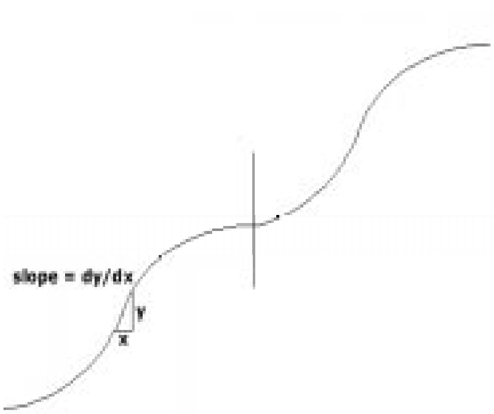
The concept that is relevant to this discussion is that the members of the task force were given complete freedom to do what they wanted to do, where they wanted to work, the time they felt like working, and most of all, without supervision.

Only one guideline was given: that the task force was to meet after two weeks.

The prevailing management practice that specifies that work should be very well defined applies in learning only to the point that the inputs and outputs to specific functional modules are crystal clear. In the example above, the method of implementing the design of the functional modules have been purposely left vague and undefined. In this way, enough room is left for individual and group creativity.

This experience leads to the question of whether the concept of “supervision” and “guidance” are, somehow, misnomers in electronics education?

3. The Learning Curve



--x is time
--y is perceived learning
--motivation is highest when the slope is steepest
--line is when another learning challenge is present

The learning curve above shows that learning starts slowly, and gradually starts to increase at a faster rate. The slope at the point denoted by "x" and "y" is quite steep. It is at this point that a person's motivation is at its highest. As learning starts of proceed at a slower rate, or plateau, this motivation also starts to decrease. The person gets bored.

The facilitator/resource person will become sensitive to the atmosphere that this will bring and will seek to re-establish a new set of learning challenge to bring the class back to the condition when the said slope becomes steep again.

In the corporate world, this process is accomplished through a mechanism called "job rotation".

In the classroom, milestones, discussed below, that provide closure to a particular stage of a project, can hopefully, facilitate this process.

4. Questions and Concerns in the Classroom

The students and facilitator/resource person in that classroom described in the Introduction Section are persons, who may have questions and concerns in their minds similar to the following:

o “What if this, or that?”
o “Up to what can I try?”
o “Will I look like a fool in the process?”
o “I have not done this before, let alone seen the result. I may destroy something”
o “Will I gain approval?”
o “Gee, I really don’t know where and how to start”

o "Where do I get assurance and do I have a wall to lean on?"
o and so on.

To suggest a response, it would be well to go back to the basis for that classroom, and that is, that the learner, whom we call the student, is the human being, a "person". Along with the group of students is the teacher, who is a facilitator and a resource person that assists them as a group, and the student as an individual, in responding to major issues above.

One form of assistance is a realistic milestones schedule, jointly formulated with the class for purposes of evaluating progress so that timely corrective measures could be applied.

One critical information that can be derived from milestones is that the students may be encountering stumbling blocks, which they may or may not be responsible for. The teacher, then, develops rehabilitative measures that are effective in eliminating or minimizing the stumbling perceived blocks.

Another information that such milestone shows is that some students may be ahead of schedule. This becomes a golden opportunity for the teacher to reflect and possibly see that an environment for further challenge may be created, as suggested in the discussion on the learning curve above.

In all these discussions, the teacher "must" ensure that the atmosphere being created contains strong ambiguities that will continue to challenge the student's "freedom to think". The teacher must also assure that dependencies are present most of the time, as this develops group interaction, which is part of the human growth process. A creative environment that responds to the questions and concerns raised above includes tolerance of mistakes and encouragement of learning through the undertaking of reasonable risks.

As the teacher fosters an atmosphere conducive to growth, there is the further need for the students to identify themselves in the work done, and even in the work that the group has completed.

5. Signature in a Successful Project

In a way, it is important for the students to be able to mentally "affix their signatures" to each module that they *successfully* finished and above all, in the overall *successful* project.

There is an example of a manufacturing plant had a very long line, in such a way, that much of the credit was accorded the people at the end process. Motivation there was high, but motivation in the earlier sections of the line left much to be desired. One solution applied there was to divide the line into segments that lent themselves to physical evaluation of the quality of the input and of the output. In other words, the quality of a product can be assessed as it enters the beginning of a line, and its quality can also be assessed as it leaves that line. *Success* of the various groups in this plant was related to product quality. The more seconds and rejects they produced, the less was their success level. Operational procedures were also developed by each group so that they are assured that the quality of their work.

The theory behind this is such that if the quality of the input and the performance of each task conform to the approved operational procedures that assure a high quality output, then, the output product should be of the highest quality, with the least amount of seconds and rejects.

This sense of having undertaken a job successfully and becoming a part of bigger and successful project applies just as well to students as they do in the manufacturing sector.

The Ateneo SCADA Project was provided a venue for a higher-level closure and a wider ownership base. The mechanism for this was a presentation to the whole ECCE Faculty, which simulated the "acceptance" process in industry. The respective groups that worked on them duly presented the various functions of each module. The teacher/facilitator simply provided the introduction and the conclusion.

III. Conclusion

In brief this reflection has simply recounted a focus around the human person in the student and underlined the objective of the classroom as an enhancement of this person's "freedom to think", and with this, unleash his "creative" powers.

On a personal ending note, the authors ask the following questions:

1) When will the Philippines as a nation ever effectively cultivate the culture of *creating*?

2) Developed countries have made us users, buyers, and ahentes (or agents), mostly relegating our technical graduates into explaining how a system is installed, operated and maintained.

3) Professionals that we all are, we are deeply concerned that if the environment which the Philippines presents to our graduates continue the way they are, technology in our country will continue to be shackled, thus encouraging other countries to keep on *stealing* our professionals and new graduates.

IV. Appendices

Appendix A. Students' interaction with the teacher/facilitator

In outline form are suggestions of this interaction:

- provide outline schematics and other materials in order assure the desired level of ambiguity and the encouragement of the thinking process
- “show and tell” approach as preferred to "tell and show"
- build circuits so that the behavior of each device can be "shown"
- does it work?
- why does it work?
- why doesn’t it work?
- how can it be made to work?
- after it works, how does the output behave in relation to the input?
- how are the circuit values calculated to produce the desired relationship between the output from the input?
- what circuit components and values are needed for calibration?
- what is the most convenient procedure to follow to achieve the best calibration balance?

Food for thought: *does the teacher mold*?

Appendix B. Students' aspirations at the start of the semester

- practical
- hardware

- foundation
- expand uses of computers to take into account control applications
- new applications for computers
- learn
- software uses
- enjoy
- computer trouble shooting
- our place in the grand scheme
- openness to new technologies

Appendix C. Outline of the Technical Content of the Ateneo SCADA Project

- The project mimics the operation of a "distributed control system" (DCS). In the DCS, each control and/or monitoring function is performed by relatively independent microcomputers, with common communication lines to a "master", which are able to communicate with the outside world.

- In the project, each function is controlled by independently running Personal Computers, which are linked by a communication system to a "local master", which is also capable of communicating with the a "remote master", anywhere in the world, to receive "set-point" values for each of the control functions, and to transmit data to that "remote master" as required.

- Control philosophy is that all systems will "fail" on the safe side. Each function is provided with arbitrary fail-safe control philosophy that is appropriate to the equipment being controlled. In case of failure, for example, the air-conditioning system will shut down, but the lighting system will continue to be operational.

- All sensors have been designed and built by the project.

Appendix D. Outline of Learning Elements

Precaution section - Since this is an interface project between the PC and various other devices, a precaution was made that all interconnections be done through an opto-isolator IC (4N25)

Analog section
- the LM555, LM741, 2N2222, 2N2907 and several other electronic components proved formed the platform for the learning process
- the ability to use potentiometers in designing circuits proved to be effective time-savers for adjusting the quiescent state "zero" levels, and the required "span"

Analog sensors
- the base-emitter junction of the 2N2222 was utilized as the sensing element for temperature
- the light-sensitive resistor was utilized as the sensing element for illumination
- as a matter of policy, the project deliberately avoided purchasing calibrated, ready-made sensors
- this enabled the project to "create" sensors, in contrast to "using" sensors

Microcomputer and software section
- show outline of software to directly control hardware ports
- single-step each assembler mnemonic command
- in the case of "output" commands to see how the hexadecimal code at the microprocessor's AX register is reflected at each of the pins of the specified computer port, whose address is contained in the DX register
- in the case of input commands, to see if the content of the microprocessor's AL register reflects the digital code presented at each of the pins of the input port, whose address is contained in the DX register

Digital output hardware section
- this section is composed of logic gates (74LS00, 74LS02, 74LS04), multiplexers

(74LS258), latches (74LS273), and other TTL-compatible devices
- o an output command, which is intended for a digital function is sent to an 8-bit latch, which is duly enabled in time
- o similarly, an output command, which is intended for an function is sent to an 8-bit latch, duly enabled, and sent to a digital-to-analog converter (DAC)
- o this analog signal would become one of the following set-point values: (a) the set-point for the illumination, (b) the set-point for the temperature control, and (c) the set-point for the fan speed.
- o input function

Digital input hardware section
- o this section is composed of the same TTL and TTL-compatible devices as the digital output hardware section
- o in this case, an input command takes data from an analog value, which has been digitized at the analog-to-digital converter (DAC), whose output is stored in a latch
- o the multiplexer (74LS258) takes the higher four bits (nibble) and sends it to four status pins of the printer port
- o the software reads this value into the microcomputer's AL register and is shifted to the AH register
- o the multiplexer then takes the lower four bits and sends it to the same four status pins of the printer port
- o the software again reads it into the AL register
- o the combination becomes the value of the digital code presented to the computer

Interface between the analog and digital signals - the LM555, LM741, 2N2222 and the 2N2907 have proven to be among the most convenient interface devices for shifting between analog to TTL and vice-versa

The communication interface between computers
- o the serial port of the PC is designed for one machine communicating with another machine
- o this design is for exclusive one-to-one communication
- o a one-to-many, or a many-to-many, communication is often done with the use of hardware converters that could become quite expensive
- o a one-to-many communication was achieved by the project with the use of very inexpensive hardware, consisting of opto-isolators to convert voltage levels found in RS232 ports into current loops and vice versa with the use of the opto-isolator 4N25.

The communication interface with a remote computer
- o interface with a remote computer was via a 56K modem
- o the use of non-standard communication protocols and software is one way of changing communication encoding algorithms at will
- o this means that secure data transfer can be achieved without going for the purchase of software that can be rather expensive or engage consultant/vendor assistance to achieve the purpose
- o the remote computer (or "remote master") has the specific function of gathering business information so that it can plot trends in profitability.
- o it assigns costs to the energy consumed in the electrical appliances in the room
- o it also assigns hourly costs to each individual present in the room

The security section
- o a person seeking access to the room will enter his unique code
- o he also enters the same unique code when he leaves the room
- o the system acknowledges a valid code, opens the door's dead bolt, and keeps track of the time the person stayed in the room

The power section - power is controlled at six (6) points, namely

1) the "on/off" switch of the airconditioner for a maximum instantaneous current of about 1 ampere at 230 volts for the coils of a pilot relay
2) the compressor of the airconditioner with a maximum instantaneous current of about 120 amperes at 230 volts
3) one bank of light bulbs with 200 watts with independent variable energy control to achieve the desired illumination levels
4) another bank of light bulbs with 200 watts, also with independent variable energy control to achieve the desired illumination levels
5) a bank of two ceiling fans with an approximate maximum load of about 100 watts, also provided with independent variable energy speed control to provide the necessary air circulation to make the temperature readings a around the room as uniform as possible
6) power to a 2-ampere reversible DC motor that controls the "dead bolt lock" of the door

Appendix E. Management of Project

Presentation to Faculty - October 5, 2000

Project Leaders
Project Manager -- Albert Causo
Assistant Project Manager -- John Paul Fajardo
Logistics and Documentation -- Tyrone Tai
Quality Assurance -- Joanne Dy

Appendix F. Project Components and Schedules

1. Lights - Lights and fans will be individually controlled using set points given by the "local master controller". (John Paul Fajardo, Maritoni Rose Lee, Mimienne Celemin)
SCR, RS232, ADC - Jul 25
DAC - Aug 1
Dimmer Function - Aug 15
Algorithms - Sep 1
System Commissioning - Sep 21

2. Air Conditioner - Compressor operation will be controlled ON/OFF to maintain temperature. (Ryan Chong, Thomas Edison Yu)
Relay, RS232, ADC, DAC - Aug 1
Compressor Control - Aug 15
Algorithms - Sep 1
System Commissioning - Sep 21

3. Access Control - Specific people are allowed or disallowed access and/or egress. (Rommel Castillo, Albert Causo)
Concept and Block Diagram - Jul 25
Procurement of Materials - Aug 1
RS232, Algorithms - Sep 1
System Commissioning - Sep 21

4. Local Master Controller - Gathers operating parameters from A through C, sends them to the "remote master" via telephone and receives set-point values for each of the operating parameters. (Tyrone Tai, Joanne Dy)
RS232 (4 slaves to 1 master) - Jul 25
Local Algorithm - Sep 1
Remote Algorithm and Modem - Sep 21

5. Remote Master Controller - Analyze operating parameters according to specific algorithms and send set points back to the local master. Calculates operating cost of F311 and plots this against time. It will also plot "rate of change of variance" from operating costs. (Rosby Quiambao, Antonio Ganzon)
Concept, Block Diagram, RS232 - Jul 25
Procure Materials - Aug 1
Algorithms - Sep 1
System Commissioning - Sep 21