SEARCHING FOR NEW WAYS OF TEACHING

Renato Vairo Belhot
Área de Engenharia de Produção
Escola de Engenharia de São Carlos - USP
Av. Dr. Carlos Botelho, 1465
13560-250 - São Carlos - SP Brasil

Abstract *- The adopted model for engineering education forces the teaching institutions to have a internally-oriented conduct, always searching for better efficiency on its activities. As a consequence decision making is based on two basic criterias: 1) past experiences that can be applied to a similar circunstance; 2) based on a reference model, usually copied from another institution. In both cases the vocation and the competences are not considered, neither are the internal and external influences from the environment. The traditional engineering education does not seem to be opened to its relations with the society, the enterprises, as well as to the development of alternative educational methods and techniques. Guiding the choice of the appropriated parameters to an educational model is a hard problem to solve, specially when we take into account the fact that there is not a wide literature about it. It is assumed that the existent system is adequate, and the forces are all driven to improve its operational aspects. When it is established "what" and "how" it is going to be teached, the past and personal experiences enter as the main source of information. The result is that we end up giving similar treatments (practical and theoretical) to different cases. The curricular revision rarely occurs, it is the "strait-jacket of the educational regulation". It is also the case of the teaching techniques and instructional resources utilized, which are usually non resistent to a critical analysis about its aplications and adequacy. The situation gets even worse when we get the evaluation system, which measures only the students ability to repeat what was discussed in class. In most cases the teachers evaluate what they did teach and not what the students did learn. For better analysing that situation, it is required to discuss pedagogical, phylosophical and psycological questions involved in the teaching-learning process, that, in some way are negleted in Engineering Education, through the teaching-learning cycle. The cycle should be understood as a structured reference process, where each step depends on the performance of the former allowing a systematic analysis of the factors that affect the teaching-learning process, according four different quarters. In this context, the objective of this paper is to present a theoretical model for the development of educational strategies and teaching techniques, based on the characteristics of each quarter and teaching techniques.*

The Learning Cycle

We deal with creative and innovative students that have easiness to recognize existent problems and that like to know the value of what they will learn (**why**). We also deal with students that are more interested in the logic and in the concept than properly in its practical application (**what**). Other type of student is the one that likes to integrate theory and practice to solve real problems (**how**). And, finally students that learn from trial and error, that extrapolate initial conditions and demonstrate independence (**what-if**) [6].

The learning cycle is a framework that has a lot of usefulness in the solution of problems related to the teaching process. The cycle is a structured and ordered process, where each step depends on the execution of the previous, as it can be seen in the figure 1. In the figure could be gathered several datas concerning teaching styles and techniques. In order to move in the cycle, it is necessary to choose the teaching techniques, the specific instructional resources, and adapt all these parameters to each step of the cycle, satisfying the environmental constrints [8].

This structure is a reference point to the planning of the teaching and learning activities. It shows how the styles combine, and they can explain to the teacher why in certain groups everything runs well, and in other it does not. Perhaps the answer is in the cycle, in the casual encounter of similar interests.

The traditional teaching focuses in the content, partly "property" of the teacher who is the expert inside the classroom and that transmits the knowledge in sessions where fixed in time and local. The concepts presented are not contextualized and the problems solved in classroom are usually far away from the reality. Normally teachers don't accept ideas and opinions different from theirs.

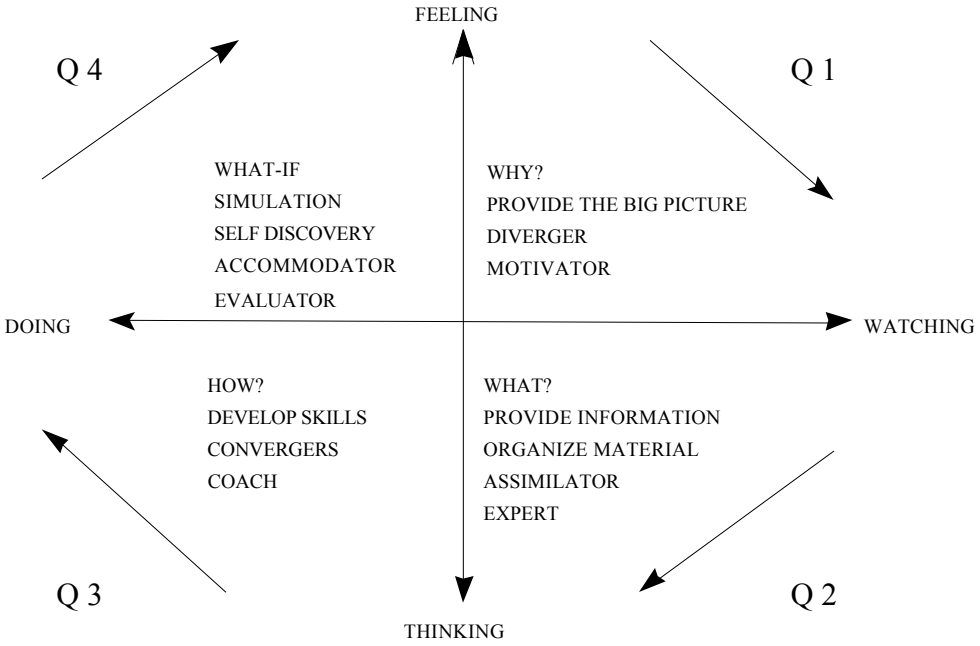

Figure 1. The Learning Cycle, with the Identification of the of Teaching and Learning Styles and the Teaching Methods Adapted to Each Quadrant [6].

The picture would not be complete without the explicit consideration of the technology. There are two basic reasons that attest its importance in the education: the demand of the employments and the variety of learning modalities that the technology provides. The employments of high qualification of the future will demand familiarity with the technology. With the speed that the world develops, everybody needs to become apprentice, and the individual's formation should privilege the development of the necessary abilities to continuity of the learning process.

Looking for a Reference Model

The model adopted for the engineering education forces universities to emphasize resource productivity, looking for the efficient execution of its operations [2]. In that way, decisions are taken based in two basic concernings:

1) The accumulated experience, where the direction to be proceeded depends on the success of a previous action, undertaken in similar circumstance.
2) A reference model, most of the time copied from another institution.

In both cases, the competences, the changes and the influences of the external and internal context are not taken in account. Engineering education seems to be closed for the relationships with the market, with the society and with the companies, and also for the incorporation of new methods and teaching techniques.

It should be reminded, that a decision doesn't necessarily become an action that modifies an existent condition. It can simply transform the operational procedure of an established routine, or be the origin of a significant change. So, when a problem is detected, the decisions might be: routine, innovative, improvised or planned.

Guiding the choice of the appropriate parameters to an educational model, it is a complex problem once it is not explored in the literature. Normally we start from the presumption that the existent system is adjusted and then we trie to improve its operational performance. However, to correct the deficiencies or to solve specific problems of a system that it is not adjusted to the needs and demands of the market, could involves the worng idea of improvement or efficiency.

Due to the incessant search for efficiency and partly because of the interest, several techniques, methods and programs developed in several countries are incorporate to the teaching in an isolated way, seeking to optimize parts of a system, that are interrelated and interacted. It is necessary to combat the idea that the assembly of efficient parts takes to an efficient whole . In that direction, all and any initiative that is undertaken will make some improvement, even if it is temporary, but not in terms of global effectiveness [1].

To the establishment of what will be taught and its organization we answer with our practical experience of years, giving the same theoretical, practical and technological treatment to different subjects. Once the curricular revision is not very frequent, it has in the legislation its “strait jacket.” It is also the case of the teaching techniques and the used instructional resources utilized that probably don't resist to a critical analysis concerning its adaptation and application to the new reality.

That model has its bottleneck in the evaluation, that basically measures the student ability of to reproduce situations discussed in classroom , during the application of an exam. Most of the time it is evaluated what was taught and not what the student learned.

Exploring Possibilities

The teaching and learning cycle is a model that has a lot of usefulness in the understanding of the subjects linked to the teaching. The cycle is a structured and ordered process, where each step depends on the execution of the previous: Why; What; How and If; as it can be seen in figure 2.

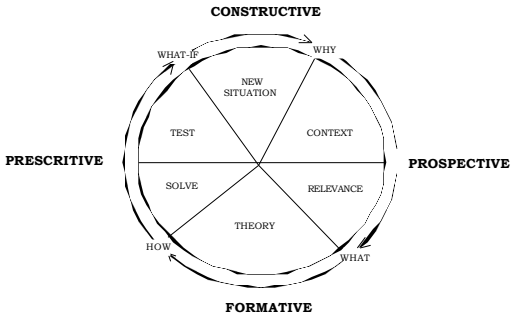

Figure 2 - Cycle of Teaching and Learning and the Educational Strategies.

It could be verified that the teaching activity is strongly based on the "WHAT" and "HOW" stages. As a result students have theoretical classes (with excessive and, sometimes unnecessary, detail degree) or practical classes (where the problem is already isolated from its context and from other problems). Few attention has been given to the planning of the teaching activities.

Starting from the teaching and learning cycle, can be established four different approaches, compatible with each one of the stages: prospective, formative, prescritive and constructive. In that way, it is possible to establish a theoretical reference for the development of educational strategies.

Prospective Approach

In the first stage of the learning cycle the context of a course should be discussed . It is on that moment that comes the different situations that happen, its relative importance, the vindication of studying them and the relevance of the associated problems ("**WHY**"). It is the phase of the student's preparation (convincing and motivation) for the presentation of the theory and concepts. The reality should be unmasked for the student, showing its work object, the problems commonly found. However, what is usually observed, is that among the presented situations, one is prioritized and all the attention is turned to it. Then, it is discussed what is necessary to know in order to formulate and solve it.

For this phase, the teacher should use the prospective approach . The strategy is to select and to arrange the environmental parameters, so the reality can be characterized and noticed. The creative and innovative students should be reached at this time, because they have easiness to propose alternatives, to recognize problems and to understand the people.

On its side, the teachers should try to develop the cooperation and the discussion about the professional and social life, through the discussion of values and meanings in class.

In this approach, teachers influence the values and faiths, transferring their knowledge and experience by perspectives, personal values, reference structures, models, conceptions, world vision, and so on. Everything should be used to give practical sense to the theory and its impact in the future professional life of the engineers [4].

Experiences from the past are useful to understand the future. The truthfulness of this statement is based on the importance of the historical context in which decisions were made. It means that, more important than understanding the decision, is to analyze the context where it was taken.

Motivation for learning depends a lot on what is done, and on the resources that are used . As an introductory stage, it should be supported by the contact with the reality, through technical visits, lectures from experts , technical papers or even case study.

Formative Approach

In the stage "**WHAT**" of the learning and teaching cycle, students should have contact with the concepts that solve the exposed problems presented in the previous stage. At this point students should be interested (motivated) to know how to solve them.

The theory motivates the students that naturally have a more reflexive profile, who are stimulated by the value of the logic of an idea and for the use of deduction in problem. solving. It is in that stage that most of the teachers feel comfortable, because they are responsible for the transmission of the knowledge. Once that activity depends, usually, on its theoretical knowledge, professors motivation lies in the demonstration of their ability and expertise.

In this phase, the student should be provided with models, rules of decision and measure instruments, that improve their personal perceptions of the problems and offer an alternative way to its solution. The formative approach assures the rationality, presenting a pattern of behavior, sustained by a group of axioms as, for example, linearity and transitivity. The ability to formulate problems and to construct models should be developed.

Teachers responsibilities involves, besides the definition of the content and its sequence, the definition of the instructional resources that will be used. Thus, the method chosed to the transmission of knowledge should also receive a special attention, particularly the the computer-based one [6].

The development of computer-based systems have given appropriate answers to the challenge placed by the globalization and excess of information. However, its use should not be driven to simple domain of the technology, but, as a pedagogic answer to the current needs. Nowadays, the use of the computer in the teaching and training activities assumes an important paper. It places teachers and students together, on the way to the learning. The survival is in doubt for both; the adaptation to the new conditions of the market is indispensable.

Prescritive Approach

In the stage "**HOW**", the identified and prioritized problems are solved through the presented theory. It is at this time that the student integrates the theory into the practice, inside of a context. It is where it makes sense to find the optimized solution. The teacher should stimulate the productivity and the competence, as well as the necessary abilities to be a good engineer.

The prescritive approach is characterized by the values used to improve decision making, to clearly define objectives , hypotheses, actions and measures. This stage takes charge of the solution of the problem through the use of different techniques and algorithms. It is the problem identified in the first stage, being solved upon the concepts supplied in the second stage of the teaching cycle and of learning.

The computer started to be used to facilitate the problem solving process through the application of computer routines that reduce the time and increase the reliability of the answer. It is the computer in its more conventional use, and for the purpose that it was projected - to calculate quickly and with precision [9].

Due to this capacity, the computer ended up being used to solve more and more complex problems, that depended on the understanding and simultaneous consideration of several parameters. It is the simulation, used to generate, to test and to solve problems.

For a long time, the engineering teaching was based on the reducible vision, that is based on the idea that the solution of a larger problem can be obtained by the meeting of the solutions of the subproblems, originated from its decomposion. Under that orientation, the emphasis rests in the solution of those small problems and, naturally, in the search for new and more efficient techniques. It is the valuation of "**how to do**".

Nowadays, due to the globalization and excess of information it is necessary to value the planning, that is, "**what to do**." The emphasis stops being in the correct application of the sequence of steps and it becomes to be placed in problem diagnosis, decision analysis and priorization of potential problems. For that reason, the next quadrant should be visited.

Constructive Approach

After the students have had contact with the formulation, analysis and solution of the problems, normally well-structured, (with all the information available, and that demand a common logic), more and more complex problems can be used [3].

The semi-structured problems, where only the minimum information are available and that demand a specialized logic for its solution, are appropriate in this stage of the teaching and learning cycle. It is the case of the open problems, where a good solution should be chosen among the different alternatives. The emphasis lies the rising and in the analysis of the consequences and impacts of the several alternatives; in the definition of the necessary resources and in the evaluation of the probability of each alternative to reach the proposed objective. In that direction, the construtivism can be used to give form to a proposal [5].

The use of the construtivism in the stage "**WHAT IF**" facilitates the integration of the experience, the induction of data in the resolution of problems, and the creativity and discussion of new situations. The teacher stimulates the experimental learning and the self discovery (learn to learn), to expand the student's intellectual limits.

Final Remarks

Nowadays, we should valorize the complexity and magnitude of the real problems, giving opportunity to the students to manipulate them, within controlled conditions. An educational strategy that is being used with success is the combination of simulation (commercial softwares) with the intensive use of case studies. That strategy extends the range of decisions that can be taken, and goes over the conventional simulation and case studies. Besides that combination facilitates the learning through the "learning by doing."

The use of the simulation in the teaching is not new. However, the use of the simulation as an isolated tool tends to simplify the enviromment, to restrict the scope of the problem, and to limit the human being involvement. The most recent developments take charge of overcoming the pointed questions [7, 10].

Through the simulation games, enterprises games , students may gain experience in decision making, either on strategic or on operacional ones, through intensive exercises of simulation, that can be done by the computer or not. It seems obviously that to supply students with knowledge, experience and understanding of the reality, we need the support of an adequate educational strategy. With this in mind we have presented the teaching and learning cycle and the four approaches. The purpose is to provide a framework for the improvement of the educational process, and for the understanding of the different pedagogic propositions. We also intended to supply teachers with a framework that could orientate the proposition of new educational strategies, according to current paradigms.

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