THE LEARNING PROCESS ON THE TEACHING OF ENGINEERING

José C. T. da Silva, carlos.tavares@ucp.br
Catholic University of Petrópolis – UCP
Engeneering and Computation Center
Rua Barão do Amazonas 124, Centro
25685-070- Petrópolis, RJ - Brazil

Gisele M. R. Vieira, gisel.vieira@gmail.com
Federal Center of Technological Education Celso Suckow da Fonseca – CEFET/RJ
Departament of Mechanical Engeneering,
Av. Maracanã 229, Maracanã
20271-110- Rio de Janeiro, RJ - Brazil

Abstract. *This article describes the Problem Based Learning technique that was applied to an engineering course. The evaluation process as well as the teaching and learning methodologies are discussed. The results show an increase in motivation and participation of students when real problems are introduced to build new knowledge. The experience was qualitatively and quantitatively positive, making the learning of new content both enjoyable and without resistance.*

Keywords*: Problem Based Learning, Cooperative Learning, Engineering Teaching*

1. INTRODUCTION

Many people researched topics related to learning, in the content focus as well as the behavior focus. Piaget (1978) and Vigotsky (Daniels, 1994) realize that the subject in the symbolic formation process happens in a strong way and has double aspects: at one side it is strongly related to the experiences lived by him and on the other side; those experiences stimulate structures previously existing on his psychological domain. If learning happens from the outside to the inside or from the inside to the outside it isn´t relevant, what matters is the interaction of the two aspects. A teacher´s fundamental task is to know what must be done to make the learning easier.

The knowledge of how intelligence, memory, perception, etc., are stimulated by the relation with the environment is also something to be taken into account when you intend to make learning feasible (Piaget, 1978). It matters to the process how affections are stimulated on the context of learning. The student´s motivation can be supported and can also be continuously stimulated to grow. The teacher resources are many and varied, however it is known the real way of learning happens based on the culture, the symbolic, understood as the way of representing and giving meaning to the contents and the language, known as the real way of meanings communication. The culture is the symbolic storage of a group; the symbolic is the human differential function to understand the universe phenomenon and the language is the support tool to the symbolic formation.

Mariani and Martim (2007) consider favoring pedagogy styles that promote stimulant, active, reflexive and creative teaching-learning process, one of the great education challenges. Assuming the didactic method has plural aspects and that the fundamental is articulate these aspects in a balanced way, not considering them unique and singly is something complex to the teachers.

Lévy (2000) presents a cooperative labor theory based in collective intelligence. It says, the speech become eternal but the writing registers and signs. The writings act in a representing way, bringing the missing things. The sign relates to the symbols that induce the human cognitive converting it to knowledge.

Britto (1986) proposes a student centered learning, taking consideration the cognitive and affective aspects of it. His proposal emphasizes the need of a bidirectional vision and a mutual responsibility. To center the learning on the student doesn´t mean transferring to him the total responsibility of learning. It is, primarily, the approach that takes the cultural and moral differences of each student, into consideration. The cognitive researchers claim that the best way of learning is building your own knowledge (Bonk and Cunningham, 1998).

According to Gardner (1994) human intelligence is different from people to people and is made by the combination of many intelligence styles he considers basic. At the engineering it´s fundamental to stimulate the person to use many kinds of intelligence, such as, the mathematic logical intelligence, spatial-visual and linguistic, and in a sustain plan, the harmonic intelligence, intra and interpersonal. Supporting all the process, the corporeal and naturalist intelligences.

This assignment presents a proposal to engineering education based on learning technique guided by problems. Therefore, will be related an experience happened with this technique and the main results obtained will be discussed.

2. THE EVALUATION PROCESS

It is known that each person is unique and distinct. Trying to evaluate all of them under the same criteria is delusional. The uniformity would only be achievable if there was a way of making everyone the same in capacity and

performance. That´s why every evaluation has a certain level of lack of argument, some affective manifestations occurs that can damage the learning. Per person is understood that someone who already learned something, who already has a way of relating to the task of learning, has his own ideas and virtues to administrate, that comes from his own culture and has his own way of meaning experiences he will go through. To understand process, it´s important to first understand a sequence, stages and challenges to be presented to the person so that he formulate an internal representation and from that he can get advantages on the new experiences. By learning strategies we understand orientation directives to the learning. Those can be made of many ways and different methodological approaches. However is the relationship person-learning-content that interests to the educational process. Every person´s answer is behavioral. It is important do not evaluate only the content; we must also evaluate the behavior showed by the person when manipulating contents and solving problems.

It´s only possible to know what the person has learned if, when presenting a variation of the challenge that has made the symbolic formulation, he gets to generalize, particularize, notice similarities and differences and, he is able to project the best solution, according his own previous experience and according to chosen standards to evaluation.

Of course it is not supposed to believe that the teacher has the ability of changing the person; in fact the person changes himself, a lot more influenced by the cumulative experiences he has been through than by books consultations and classes' attendance.

No one who is part of the teaching-learning process is neutral. Everyone is observing everyone and they do not only learn contents, they also learn new and more effective behaviors. So, it's necessary that the teacher be very careful when demonstrating negativism/positivism to the others.

A common illusion comes from the attitude of an authority electing to evaluate the others. If they are all different, and if it´s not possible to know everyone very well, some imperfection level will come up. The culture brings ways of evaluating, ways of looking at the world and types of behaviors. The moral and ethic bring the valid behavior rules, but these rules are only valid when shared by everyone. The philosophic values that orientate all the human activity are the guide to the evaluation on the teaching-learning process.

There is a dual responsibility on this context. Learning modifies culture and culture pulls the learning desire. The person is the purpose of culture and part of its evolution. Culture is dated in the time and the person registers it as an internal representation and uses it in a behavior way to transfer to his partners. In the modern world we live, there are large and fast changes. The information technology is allied to the evolution process as it brings easy and fast information access. The globalization quickly modifies the values of a culture introducing new values in a velocity never tried before. It´s necessary forge adjusting behaviors and share the idea that before, the self-learning was not as necessary as now.

According to the learning strategy based in problems, the learner faces challenges and must find the solutions, acting in cooperation with other learners, guided by a facilitator-teacher (or a group of them) who is the source of compatible information with the presented problem. In a strategy people not only find content, it stimulates the learner to use the naturalist intelligence, to look for other sources of knowledge, research along with others, be part of meetings to approach the problem and compromise with the solution.

The vinculum theory was conceived by Pichon-Rivière (1981-1982) and shows the rise of working in groups, where each person has a specific part at a certain time of the task resolution process. This theory consists in a good evaluation tool as well as self-evaluation. Instead of focusing the person in to the group, the group is focused in the task and everyone should walk together towards it. This is a compatible technique with the cooperative learning theory from Lévy (2000) frequently used in many fields of activities, and also convenient to the teaching administration.

There are three ways of seeing a group in action. One of them is to focus in the individual to the group, another is to focus in the group to the group and the third is to focus in the group centered in the task.

3. THE SUBJECT PLANNING AND PRODUCTION CONTROL

A group was chosen from the last period of mechanical engineering course studying planning and production control (PPC) as a study object. This subject has as study topics: concepts and planning techniques, scheduling and production control, and a methodology of the system evolution MRPII to JIT; administration and stocks control, including material acquisition and offer on the factory ground. The presentation way of the program content has as guideline and motivation a PPC system project of a product chosen for each working team.

The vinculum is built and become strong by the group process, because this process is dynamic and active. At first, there is a blockage of the activity group in terms of the basic universal images-fantasies of the group which induces the use of defensive techniques that structure the changes. At the beginning, when the group starts to execute the tasks, the approach and the development of the anxiety occur and from that, the roles emerge.

Since most of the times students are used to the expose classes methodology and ready experiments, the introduction of the new methodology causes impact and curiosity. For example, the teacher comes into the class with a yardstick and a school chair. Then, he proposes to the students, as object of the course, the project of a production process of this chair. The students, when questioned and invited to take part of the process presented a variety of answers and behaviors, from surprises to interests' demonstration.

As some students are familiar with the methodology actively practiced in many high schools and elementary school, when the initial phase has gone, they begin the selection of the immediate tasks. A student took the task of measuring the chair, while another one enquired about the manufacturing disposition of the lay-out. In a specific class under this methodology, there was also the suggestion of a visit to a metallurgic company. Then, slowly the interests for the different activity becomes evident. The students are divided into groups to solve the challenge. Following the teacher's proposal, the group becomes separated in subgroups to produce different projects. Each group begins to discuss the task details. The responsibilities are divided. They assume, initially, the posture of presenting to the teacher what they will project.

After the first week, in the case example, the theory begun to be taught, guided by composition of presentation of the theory and debates about the application. The students, motivated by the chosen problem, were becoming interested in making connections between the theory and the chosen task generating moments of intense debates. Since the process is open to the active participation, the learning was taking place in a very nice way, with no resistance. The problem motivated the interest for the stock administration content, for the algorithm PERT/CPM, for the lay-out of production through cellularization, for the *kanban* control etc. Since the students had something objective and immediate, the fact of having common goal produced the vinculum that kept the level of motivation.

In this case, a technical visit to a metallurgy company allowed to check out the various contents studied in practical way. Many questions were asked to discover the reasons which led the company to establish the production process they were visiting. The contact with professional reality provided the vision of the integration of knowledge. The classroom activities were interspersed with group meetings for the resolution of a plan to manufacture the chairs. The facilitator (role played by the teacher) was setting at each stage, along with the students, the techniques, the basic lay-out and the features to be modified on the product that could optimize the costs and ensure its proprieties. The partial evaluations were done by another activity, reducing the conventional exams anxiety, as the problem-activity had awakened enough motivation for them to acquire the program content in a soft and nice way. These features should be suggested to the Engineering Department, since in this case and in many cases, the production focuses on the repetition of industrial processes not related to the product design but to the manufacturing process. It was decided in agreement with the students, points in time, where the defined phases should be reached. For each point a partial evaluation of the progress of the groups was accomplished as a natural result of the expectations of the production, reducing the anxiety of the conventional exams. The problem-activity had awakened enough motivation for them to acquire the program content in a soft and nice way, although a lot of times of complex acquisition.

With each new content offered in class, as the project progresses, the group reflected on whether his project of making a lot of reference was as expected or not and decide any necessary adjustments. Every significant advance, the project suffered reviews. In the discussions they decided what was to be modeled in terms of lay-out, what was the point of decision about manufacturing or outsource certain component, and if was necessary to revise the master plan of production. Midway, at the end of the second month of activities, there are concerns about what to do to comply with the schedule. They review manufacturing goals, redo the organization of the production stages, calculated and recalculated times and movements, although estimated. They already knew what to do in practice as the “cronoanálise” and its importance for determining costs. They simulated demands for the product, calculated and recalculated the size of personnel and machine hours, so that within three years they reached return on invested capital in both equipment and the other needs for production. Thus, concepts such as contribution margin, optimum storage, or hiring staff to seasonal demands, or the use of *kanban* methodology where applicable. They discussed the relationship with the entire production chain, from the customer to the partners of partners in production of components and supply of materials.

At the final phase, when they were supposed to present the project, frustration were showed as what they have prepared was about to lose the strength because of the reality tests they were submitted through the project preparation. The affective features were shown with intensity. Each student´s part was in evidence. The own group, in some cases based on the experience of the facilitator, understood the importance of caring interpersonal relationships and might experience the difficulties in choosing a leader, selecting personnel, and other issues concerning the role agents of fabrication, whether operators of machines, or buyers of components and raw materials. Finally, they understood how difficulties can arise in issues of cooperation and the psychosocial implications of generating misunderstandings.

At the end of the semester, completed the project, each group did its best to "sell" their product. One group did its best in presenting your project, being criticized by the other and vice-versa. In the end, all recognized the qualities and the defects pointed out and concluded with proficiency, showing knowledge of the contents of the discipline, if each product would have its space on the market. There was discussion about the best approach to production and which would be the best lay-out. Finally, it was evident to the teacher that contents of the disciplines and considerations on the disciplines of the curriculum articulated to the Production discipline flowed in oral communication of the groups.

As the final evaluation, a system was used where the projects represented half of the note of the global evaluation. The other half was composed of an average between the partial evaluations, including in this average, a self-evaluation based on the concepts of the theory of Pichon-Rivière. Each student should evaluate himself in degrees in the following dimensions: relevance, affiliation and centering on the task. He should also give the group a grade for each dimension, cooperation, communication and empathy. To each one it was also required self-evaluation about learning, content, attendance and punctuality in the participation in the project.

4. TEACHING-LEARNING METHODOLOGY

The teaching-learning methodology has guided the production control and planning subject activities and was based on learning guided by problems. To be understood in a clear way, the position of this technique is necessary to discuss first the vinculum theory and the group process.

4.1. The vinculum theory and group process

This theory was developed by Enrique Pichon-Rivière (1981) establishing a group observation way while devoted to solve a task. To these groups Pichon-Rivière (1981) name working groups that have as working tool, a methodology characterized for being centered in an explicit way, in a task that, in this case study, is the learning guided by a challenge proposed to the learners group. The main premise of the vinculum theory is focusing the person inserted in a group, noticing the intersection between personal history and the others till the moment of his affiliation to the group and consequently his actions in the group.

According to Pichon-Rivière (1981), a group would be a limited number of people, connected by an affinity, defined in time and space, which acts are articulated by a mutual internal representation, and whose purpose and existence would be the union to solve a simple or complex task. In a group, the individual is seen as a dynamic result in the established interplay between the subject and the internal and external object to it, and its dialectics interaction that sets through the link.

Each participant has a different internal representation of the task from the others. Each one participates in the group has a proper behavior signature, interfering in the others' activity and receiving the interaction from all of them. It prepares all of them to a Gestalt effect, that is not in everyone, but ends up working there as a group. According to the referred author, a relationship that can be metaphorically presented as a dialectic spiral where the subject and the object feed themselves mutually, breaking the classic teacher-student linearity and polarity. The whole approach of the situation-problem has the form of a continuous spiral, where the communication happens by example-interpretation, making the learner´s reaction, which is learned by the facilitator and by the others that reintroduce it in a new interpretation.

The vinculum theory, also proposed by Pichon-Rivière (1981), establishes a third element in the bilateral relationship. This triangular composition introduces a plan of reference based on the concept of an internal world in continuous interaction that affects the unconscious producing images that require test of reality for its preparation. These images occur in the content and affective areas. The doubts are shared, the challenge is divided in understandable parts, and an internal and mutual representation is built, in order to create conditions to get a solution. These unconscious images are products of the interactions of the links between the internal group objects. It can cause a distorted picture of the content and the relationship with it, in different degrees, since it is based on the parts of the *"others"* that also produce perceptions from the situations of the objects' reunion of this internal group. These perceptions are compatible in form, content and other attributes with the internal representations reported by the others, creating a process of standardization of concepts, ideas and emotions, and providing the bridge to decide on the common knowledge. So, the group is producer of knowledge and reference of the symbolic formed from the group dynamics.

The operative group let the participant create and explore the images-fantasies about what should be done, creating the conditions on the basis to mobilize and break the stereotyped structures on the basis of the behavior signatures previously acquired. Here there is a key to a good evaluation. In the object relations in operational activity, there is no single link in action. There is a division promoted by the different internals representations of each participant. There are those whose performance are expected, there are those who expect the group to give some solutions, and those who, in a certain moment, are unable to work. There are positive and negative events in the affective, but it is expected, and should be object of supervision and management by the facilitator. The process of knowledge of the external, objective reality is determined by the aspects or characteristics obtained prior learning of internal, subjective reality that occurs between the subject and its internals objects in an intangible process. This process is noticed only by the behavior way, which exposes a person to others through language and other forms of communication, to choose and practice their part in the group.

Moreover, as the evaluation is also focused on students, the concepts of the part and link are crossed, and that's why the examiner should approach the structure of the bond, and also the various parts that the facilitator and learners are attributed. The part is crucial in the link situation. It is temporary and has a specific function that can appear in a specific way and in a particular situation and in every person. The way the learners deal with certain concert contexts will influence the attitude of each one, this form is called behavior part.

To a well success evaluation, Pichon-Rivière (1981) developed a definition called "inverted cone". The learning themes should be offered as a challenge and it is expected that it has been previously discussed in various activities and contacts so that the participants come prepared for the meetings. The completion happens in a meeting where occur

debates, but the most interesting is the level of knowledge previously studied by the participants. It is expected that the group get content and cohesion to each consecutive step. At the end of the course, it can be evaluated the overall performance of each and assign a grade in the participations as part of the evaluation of the learner.

4.2. The problem based learning

According to Bonk and Cunningham (1998), this kind of learning is a method that encourages the self-learning, and gives to the learner the conditions to practice his knowledge by applying it to practical situations, and to understand his failures of knowledge or understanding, and provides conditions to this learner to search for solutions, making researches, realizing the situation problem, and acting individually or in groups to achieve the competence in understanding and solving of the problems.

Similar to the observation bias Pichon-Rivière (1981), the methodology is made of "activities-problems" as a challenge to the working group. Every "activity-problem" must be linked to a typical activity of the profession. A plan must be prepared to guide the learning process, providing a good way of searching the knowledge. This planning should be shared with the learners of each group, aiming to fit the requirements of the type of problem to be solved.

The group is invited to make a basic schedule to control the activities, and points are scored at the time, where there will be discussing meetings, evaluations and self-evaluations. The facilitator can act orientating or moderating these meetings, if necessary. It is expected that the group is involved and committed to the progress of the activity offered, and more than one "activity-problem" can be offered.

The mould task, the faults diagnose and the knowledge apply to find a solution are duties of the group, who is helped by the facilitator, that can be a teacher or a group of teachers, depending on the case. This serves to encourage the self-learning and create effective conditions so the learner gives a response to the challenge.

According to Franklin (1995), a conscious mind doesn't work like a computer; it is based on associative chains, and cannot be considered as a monolith, but an aggregate. The information is recovered by the reconstruction, using the associative chains as an arrow from the perception of an external phenomenon to the mind.

The profile of the learner/professional of the Engineering Graduation Course is the Engineer who is generalist, humanist, critic and reflexive, able to absorbed and develop new technologies, stimulating his critical and creative actuation when has to identify and solve problems, considering his politics, economics, social, environmental and cultural aspects, attending the society demand. (National Curriculum Guidelines for Graduate Courses in Engineering - CNE/CES Resolution, 11/03/2002, Brazilian Education Ministery)

The objectives of the learning by problems are in agreement with the desired profile for the Engineering training. (Bonk and Cunningham, 1998) have, among others, the following objectives:

- enhance the development of a process of effective reasoning, including the synthesis, the create of hypotheses, the critical evaluation of the information about the problem, the data analysis and the decision-making;
- be an effective and active participant in small groups focused on the tasks of learning and giving solutions;
- cultivate relationships, showing wisdom and understanding with the others participants and evaluate the individual, self and the staff progress.

5. CONCLUSION

This process of presentation and evaluation of discipline was effective and appropriate for these days, where the post-modernism requires action and spectacle. In reality, it meets the element that gives the tone of the whole success of a world communication project nowadays: the interactivity. Instead of betting against the hand of cultural evolution, it was choose to give way to think and seek alternatives for actions to encourage the learning according to the culture, the symbolic and the third millennium language (behavior). It is important to be allied to the new technologies and not compete with them. Our Engineers need to know that is important to deal with the contents in the daily situations of the profession, and that intelligence, not as a monolith but as a set of intelligence dimensions as well designed by Gardner (1994), combines the rational thought to the others components of intelligence, nowadays it is more than necessary to the completion of the tasks.

This proposal came from a real problem, that called all the mental tools needed, and mediated by the rational, build the competent and efficient knowledge, not different from the culture or thoughts of today's learner, who is waiting for an invitation for the natural, spontaneous and effective learning. He is waiting for a reliable company able to help the cross between what he ignores and the discovery of a new knowledge. He waits interactivity and complete immersion in learning. Of course there is no learning without teaching, even in self-learning the person is fulfilling the part of teaching himself. When interact in groups, enjoying the support of the collective intelligence (Lèvy, 2000), and being guided by the teacher-facilitator, the student learns more than contents, learns how to live in a new community where everybody share the value of the learning for life. The bridge proposed by the technical group is the affective and

cognitive basis and is made of behavior signatures interconnected and supported by each other, making everybody's subjective richer by the action with the world.

This methodology has been repeatedly used each semester by the teacher that considers it of great importance to effective learning, for the significance of the goals, for the targeting of students for the discipline and its curriculum relationship with others, and most importantly, to lead the student to contact the objective reality of production, removing the academic "mold", renewing the academic vision due to the responsibility to deliver to market a proven professional competence, theoretical and practice, in modern systems of production.

The complete man is the one who knows what is able to do, know the structural interdependence that shapes a society and how to get more. Many teachers of the Engineering area know that engineers are not thinking machines, but creators of new structural platforms, new knowledge, new inventions, and when really stimulated, they may produce in a effective way and they can help in the solution of several problems for humanity.

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