# THE IMPORTANCE OF ETHICS IN THE ENGINEERS´EDUCATION

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*This work intends to evidence the importance of ethics in the formation of the human resources of the technological area, especially of the engineering one, in order to provide them with the tool to manage and to generate the society demands. This way, a fine education should be committed to working not only the technological aspects but also the professional ethics; it must also enable the accomplishment of a reflection and the development of research abilities and also lead to the use of new technologies, but through a responsible citizenship, with self-satisfaction, aware of its rights and duties and disposition towards working. From the scientific revolution, in the 17th century, the world has been facing the challenge of the rupture between the humanistic culture and the scientific one. The scientific culture, better characterized as a specialized one, tends to close, making that disjunction bigger. The primordial mission of teaching implies much more in learning how to reconnect knowledge than separating it. Reconnecting the scientific and human knowledge is a vital task, because it allows not only the contextualization of knowledge, but also the interdisciplinarity. Without this caracteristics knowledge becomes closed and fragmented.. The justification for such statement comes from the fact that the lack of communication between the humanistic culture and the scientific one, in the engineering student's education, brings with it serious consequences for both, because, in spite of the fact that the scientific culture causes a theory devoted thought, it still lacks the habit of pondering over the human destiny and over the future of science itself and of technology. The purpose of this work lies, then, in weaving a thread capable to put those two cultures together.*

*Key-words: ethics - technology - citizenship-engineering*

## 1. Introduction

The proposal of this work is to evidence the importance of ethics in the education of the human resources of the technological area, from the reflection on the new directions of higher education, especially the engineers' education facing the scientific development and the new paradigms of education.

This approach is due to the fact that it is fundamental that all the engineering undergraduate students acquire a critical vision towards the emerging issues of society. It brings to the debate of the relationship between science and ethics and it analyzes the possibility of solving some moral problems that always generate conflicts, so that ethical codes may be linked to scientific issues. In the same way that scientific issues can influence ethical judgments.

According to Kuhn (1987), *"each society develops moral codes, but the ethical debate is much more general"*. One may add to this fact, that morals don't possess eternal and unalterable truths, they are relative and they change along history, varying in intensity and speed according to the culture of a certain society.

When examining any subject, science is based on the presuppositions of its paradigm. This happens with the physical, biological or political sciences. When an engineer faces a certain problem, he will try to solve it within the specific knowledge of his area.

The great concern falls mainly on the directions to be followed by the university, a privileged place of the scientific knowledge construction, full of questionings and of continuous search for its own sense.

In these questionings, one of the innovative proposals is the transdisciplinary approach of knowledge that inaugurates a new stage in history, for it overcomes the fragmented model, inheritance of the scientific thought. Besides tying different subjects, this new focus of education points to a new way of observing reality.

## 2. The Development of the Scientific Thought

The current scientific knowledge broke out in history starting from the Scientific Revolution in the 17th century and it provoked a true explosion of events, transforming man's life in the world, once *"the idea of science becomes that of a transmissible, cumulating knowledge, to which the following generations must contribute"*. In that process one may identify the origin of technology as it is understood today, in other words, a know-how based on the theory of scientific experimentation. (Cardoso, 1999:198)

The passage from the empirical knowledge to science marks one of the deepest revolutions known by the history of mankind. It is characterized as that moment in which the rationality rises over the enigmas of the myth, in the millenarian effort of man to submit nature to his aims, to search in it the symbolic matrixes of his representations and

beliefs and to organize his own human world. The origins of the scientific thought marked the beginning of the structure of a system that had reason as a center. It is important to remind that science has developed simultaneously with Philosophy since its beginning. That's the reason for its character of curiosity before the things that exist in the world.

Among the fundamental characteristics of that period, one can find the displacement of the *téchne* formed by a group of knowledge and professional abilities transmissible from generation to generation, from its outlying place to the central axis. In its origin, the technique was a know-how that characterized the human presence in the world. However,

> *"Today the téchne, in its form of modern technique, became an infinite impulse of the species heading for the future, in other words, in its more important goal, the progress. It searches to see the mission of mankind as the success in reaching the maximum domain over the things and over men themselves." (Neves, 1999:138)*

An important inheritance of the great epistemological discussions of the 20th century is the idea that sciences in general, natural or social ones, are not definitive and cumulative knowledge, but classes of hypotheses subject to permanent revision. So, the process of the construction of scientific knowledge is not only in relation to the growth of knowledge, because it similarly refers to the transformations and ruptures, due to the passage from a theory to another.

For Popper (1973), the evolution of science suffers a natural selection, that is, there are theories that resist for some time to be more adapted to the contemporary knowledge. It is unquestionable that the scientific knowledge is in constant renewal.

According to Tomas Kuhn (1995), there are paradigms that dominate the scientific knowledge in a certain time and the great changes of a scientific revolution happen when a paradigm gives way to a new paradigm, that is, there is a rupture of the world conceptions, from a theory to another.

The contemporary world, fertile for science, has been facing new challenges due to the appearance of emerging knowledge and of the uncertainty about some already established truths, enlarging the universe of the scientists' inquiries. The scientific discoveries, often generated in labs, demand an ethical reflection not only from the academic environment but also from the whole society, concerning the consequences they can raise, according to their use. As an example we can mention the question of using or not genetically modified food.

**3. Ethical Dimension of Science**

Ethics, according to Fourez, (1995), is "*the part of the Philosophy that considers the choices that are important in man's life, particularly before the empiric fact that, in all societies there are moral codes or similar notions"*.

From this affirmative one may infer that it is a much more general and difficult issue to approach, because it refers to values that are characteristic of each society. For that reason, the focus of this analysis will be restricted to the relationship between science and ethics, mainly when solving the ethical and social-political problems, provided that science can solve them.

Mainly today and after three centuries of continuous successes of the new science of nature, the discussion around the Ethics originated from the proven conclusions of science is open and lively since it leads to an ethical science. The statement of a kingdom of independent and autonomous values and ends opposes to this ethical sicence, regarding the scientific facts.

> *"For three centuries the scientific knowledge hasn't done anything else but proving its virtues of verification and discoveries in relation to all the other ways of knowledge. It is knowledge itself that drives the great adventure of the discovery of the universe, of life, of man". (Morin, 2000 p. 15)*

The definitive act of the foundation of a science of the ethos is in the origin of one of the programmatic issues that Kant (1982) enumerates in the threshold of Philosophy: What should we do? This subject that demands the originality of the practical reason puts in the starting point of the ethics, the problem of an ought-to-be relationship.

On the other hand, along the 19th century, the extraordinary progress of the so-called man's sciences turned the ethos' scope infinitely more general and complex in the geographical and historical diversities of the cultures. The discussions of the contemporary epistemology of the sciences unequivocally show that the problem of the objective truth of the world cannot be declared senseless for science.

If there is a consensus among the scientists about the humanized virtue of science, the definition of scientific humanism necessarily supposes that science has come to open a new horizon of truth for man. And it is referring to this horizon that the practice of the scientific knowledge reaches an ethical level, either as an act or as an object of a true knowledge.

The idea of an universal Ethics, as it is, is still a problem in the technical-scientific civilization because there are several extra scientific instances that intend to prescribe their ethical norms to science. Among them, one can mention: religions, philosophy, ideologies and cultural traditions.

By trying to establish itself as a source of a specific ethical code, science necessarily goes beyond the limits of the scientific explanation and gets into the matter of understanding. And when this comprehension is opened in the horizon of the totality, which is the horizon of human life, it finds itself in the full domain of Philosophy.

Defining the relationships in order to achieve a coherent vision between the ethos and the scientific logos is not an easy task. The so-called "normal science", as defined by Kuhn (1995), despite its evolutionary character and the transitory characteristic of its theories, enjoys an effective universality, legitimated by the knowledge of the scientific community that doesn't know any cultural or national limit.

Morin (1999) makes a distinction between the false morals and the morals when referred to ethics. The false morals transforms in a Manichaean opposition between good and evil, which is really a conflict of values. The false morals confuses the normality and the norm. The ethical problem is a problem of conflict of values. The choice between good and evil is not an ethical problem; it is a purely physical or psychological problem, of courage, of intelligence and ethical will. The problem appears when there is a plurality of contradictory conflicts. For the author, a new ethics doesn't exist. There are permanent problems that shock against each other with unexpected situations, that raise ethical conflicts.

An important aspect to be considered in relation to Ethics and Science is that science has become such a serious problem that it cannot just be left in the scientists' and the statesmen's hands.

According to Neves (1999: p.139)

> *The enlargement of man's power surpasses, in matters of prestige, all the rest that belongs to his human plenitude. So, this enlargement, submitting men's forces more and more to its purpose, goes together with a contraction of its being and of its concept of itself."*

This means to say, that with the unexpected and uncertain future caused by the countless scientific discoveries and due to the future inventions, morals will certainly have to invade the science's sphere. Due to these uncertainties, ethics has to be incorporated to theory, mainly in face of the prognostics (much more catastrophic than optimistic), pointed by some studious, like Hans Jonas. (idem).

Hans Jonas's work analyzes the need that everybody has to be aware of an imperative of responsibility with the future generations. A clear example refers to the possible consequences that the cybernetic advances may cause such as robots creation and cloning. He warns us to the fact of the responsibility of the life conditions of each human being and of the future generations that might be affected by the techno-scientific experiments.

Among the issues of ethical nature, originated from the scientific advances, we can find nuclear and chemical weapon experiments, hydrogen bombs, problems related to the means of communication, computing programs, problems related to the global economy, as well as those which refer to wealth inequality.

If, on one hand, one can find the scientists that consider the ethical significance of their science, on the other hand, one can observe a disagreement in relation to the unanimity of the scientific community about the proven results by science itself, and which attests the universality of the fact. Therefore, a safe indication of the interrelation between Ethics and Science is formed because the latter surpasses its methodological limits and goes into the land of Philosophy. Actually, it is the implicit or explicit Philosophy that guides the scientist's ethical options in the specific exercise of its practice.

Mário Bunge (1969) praises the moral values of the scientific community itself and counts on science for the solution of the ethical problems that has challenged man up to now.

Both Teilhard of Chardin (1966) and Jaques Monod (1970) have proclaimed their adhesion that was decided at a scale of ethical values founded in science itself.

Therefore, outlining a way from Science to Ethics is a task that is presented to the contemporary philosophical reflection, which makes it much more difficult to attach science to a previously constituted ethical system.

The criticism of modernity that echoes to the great crisis in the western world is dramatically visible from the late sixties. One of these ways of criticism was the so-called counterculture movement, mainly in the United States, raising real problems. The techno science is presented exactly as the most effective destructive force of the tradition of the cultures and of the solidity slowly built from the symbolic home of the individuals and of the groups. The deepest root of the ethical nihilism should be searched in the techno science. According Neves: *The question is: how to have an ethics to control the enormous technological capacity achieved nowadays, from categories destroyed by the scientific knowledge.* (Neves, 1999:146)

When the civilization of the reason accomplishes some centuries of an apparently irreversible historical experience, one can affirm that no Ethics may intend to rule the scientific practice if it doesn't articulate intrinsically to the own structure of science. According to Popper (1973):

> *The history of the sciences, like all the human ideas, is a history of irresponsible dreams, of obstinacies and mistakes. However, science is one of the rare human activities, maybe the only one, in which the mistakes are systematically marked and constantly corrected as time goes by."*

For this reason it is important to care about the technologists' education, particularly that of engineers, who must be able to reflect upon the human and social implications which originate from their professional practice. This vision is linked to a higher education policy which will differ according to the country and to the institution.

According to Fourez (1995), educating scientists without providing them with human sciences concepts would be an irresponsibility. The university prepares professionals that will carry out social functions, even if they belong to the technological area. Therefore, when studying issues connected to Philosophy, the engineer would be able to choose the way to follow ethically. Controversial issues such as abortion, human cloning, weapon race must also be analyzed from the ethical point of view.

Similarly, an engineer who works at a nuclear plant, deals with safety related matters, that is, with the possibility of an explosion, according to his own paradigm. He doesn't take into account a vision of totality, of the complexity of the problem itself, he restricts his decision based on his own knowledge.

**4. Transdisciplinarity: Overcoming the Fragmentation of Knowledge**

The transdisciplinarity is characterized by cognitive schemes that cross the disciplines, including complex nets that played an important role in the development of the sciences.

Since the 17th century, the development of the western science has not only been disciplinary but also a transdisciplinary one. The history of science has been explored by great transdisciplinary unifications.

The document elaborated in the First World Congress of Trandisciplinarity held in Lisbon, Portugal, in 1994, describes the fundamental principles of this subject. Two articles have been detached out of this document, for a better understanding of the meaning of this new dimension of knowledge:

> *Article 3:*
> *The trandisciplinarity is complement to the disciplinary approach: it makes new data emerge from the confrontation of the disciplines which articulate them amongst themselves. It offers us a new vision of nature and of reality. The transdisciplinarity doesn't seek the domain over several other disciplines, but the opening of them all to what crosses and surpasses them"*
>
> *Article 5:*
> *The transdisciplinary view is resolutely open in a way that it crosses the domain of the exact sciences through its dialogue and its reconciliation, not only with the humanities but also with art, literature, poetry and the spiritual experience."*

In the classic Greek tradition until the late 19th century, knowledge was supposed to be understood, considered and contemplated. Today the individuals face each other deprived from the right to reflection, especially due to the accelerated rhythm the scientific discoveries and the technological innovations are announced, going through a naturalization process and an immediate consumption incompatible with the reflection and the development of a critical consciousness.

Tomas Kuhn, (1995) states that the development of science is not executed by accumulation of knowledge, but by the transformation of the principles that organize them. Especially because science is changeable and dynamic. Therefore, it is paramount that the transdisciplinarity is promoted, and that a new paradigm is searched, competent enough to separate and to associate, at the same time, promoting a permanent communication of the scientific domains. The paradigm of the simplification and separation is insufficient.

Gigantic progresses happened in the 20th century, concerning the disciplinary specializations. However, the specialization often causes the fragmentation of knowledge and it can provoke the separation between the humanities and the sciences. The hyper specialization hinders the global perception of any area of knowledge. Besides, the essential problems should never be parceled out, because if so happens the object is extracted from its context. The disciplinary organization was instituted in the 19th century, mainly with the formation of the modern universities and later it developed in the 20th century with the establishment of the scientific research.

In the cognitive plan, no society is able to think in a contextualized way using the model of fragmentation, of specialization and of disciplinarization, supposing that only the techno-scientific competences are enough to solve the contradictions of a globalized and trans-nationalized world.

Modern societies are faced in this way with a pretty complex problem due to the development of science and of technique, which is called techno-science nowadays.

> *The fragmented, compartmentalized, mechanistic, disjunctive and diminutive intelligence breaks the compound of the world in disconnected fragments, fractions the problems, separates what is united, turns the multidimensional into unidimensional.* (*Morin, 2000:43)*

The 20th century lived under the domain of the pseudo-rationality that was supposed to be the only rationality, but it atrophied understanding, reflection and vision in the long run.

Concerning reason, it is necessary to reject all the absolute, closed and self-sufficient reason. Reason is a phenomenon that doesn't progress in a linear way, but through mutations and deep reorganizations.

Nowadays research itself has been planned and practiced in a transdisciplinary and complex perspective. Several research and investigation projects have already been carried out this way. They have been reorganizing the search for

knowledge. The disciplinary fragment gives way to the development of the context, of the complexity and of the worldwide problems, so as not to lose the totality view.

It is noticed that several sciences have become systemic as, for instance, the sciences of the Earth.

**5. Challenges and Perspectives in the Educational Field**

Ethics studies the values and man's moral conduct. It treats relevant issues about the human behavior. In other words, Ethics is the study of the appreciation that refers to the human behavior, susceptible to qualification from the point of view of good and evil, either relatively to a certain society or to an absolute way.

> *"Human beings have taken centuries to discover that they are responsible for their destiny and for what they do or that man's root is man himself. It is from this presupposition that one can understand the relationship among ethics, society, technology and knowledge".* (*Frigotto, 2002:13)*

Maybe the current changes of the scientific and technological progresses in the latest years have not still been absorbed by society in their essence. However, here they are and they have caused paradigmatic ruptures in a world recently ruled by untouchable dogmas. This way, the need of an ethical discussion grows due to this new reality.

In his book "Introduction to a Post-modern Science", Boaventura de Souza Santos (1989) presents the two epistemological fields that resulted in a collapse of the positivist consensus. He analyzes the hegemony of the natural science in a scientific-technical world and he affirms that the paradigm of the modern science is founded in this distinction: nature and society that tends to be overcome. The construction of the hegemony of the social sciences presupposes the overcoming of the paradigm of the modern science. According to the author, the impact of the scientific-technological development has made the current human world scientifically built.

Therefore, it is essential that in the pedagogic projects of the Higher Education Institutions, in all areas of knowledge, humanistic character disciplines are included in the curricular structures, in order to lead to reflection. The justification for such statement derives from the fact that the lack of communication between the humanistic and the scientific cultures in the student's education, mainly from the technological area, as it is the case of engineering, brings serious consequences, because in spite of the fact that the scientific culture raises a theory-sacred thought, it doesn't think over the human destiny and over the future of science itself.

Besides the scientific education, the engineer should consider the relevant issues that concern man, nature, society, the unpredictability of the future, as KANT (1982) formulated:

*What can we know?*
*What should we do?*
*What can we expect?*
*What should we avoid?*

This is the dilemma of the recently-started 21st century. While researchers and technologists proudly present a new discovery, philosophers worry about ethics. Technology is unethical in its essence. Its use cannot leave ethics aside.

So, the engineer must permanently study these issues that belong to the field of the social sciences. It is necessary to weave a thread capable to unite the humanistic and the scientific cultures. The revitalized humanistic culture is a culture of general character that studies the fundamental problems of humanity through Philosophy and encourages reflection. In other words, it is a challenge for the education of the 21st century.

This reform through which the university must go through refers fundamentally to the reform of the thought, in other words, a thought able to integrate the totality of knowledge, of reorganizing knowledge, overcoming the disciplinary division. It is necessary to form citizens who will be able to understand the problems of their time. This consists of giving the students who will face the world of the third millennium a culture that allows them to articulate, to connect, to place themselves in a context and, if possible, to gather the acquired knowledge.

According to Morin (2002), *"the University preserves, memorizes, integrates and ritualizes a cultural inheritance of knowledge, ideas, values, because it is engaged in reexamining it, updating it and transmitting it, which has an regenerating effect"*. For that reason the university tends to be conservative. In order to have a significant and deep change, the university has to promote reforms that make the change of the thought possible. Therefore, it is a paradigmatic reform that shall bring existential and ethical consequences, thus marking an important historical moment.

Rationality and the scientific doctrine started to be redefined from the works of Popper, Kuhn and Lakatos, but especially of Bachelard's.

When analyzing the thought and the philosophical and epistemological work of Bachelard, philosopher of science, one notices that it is translated into a scientific pedagogy, in a pedagogy of the open reason of the scientific knowledge that it is always affirmed as a continuous process of rectification. He is against any kind of dogmatism as well as the fragility of the absolute reason.

The author enunciates principles of a new pedagogy that overcomes the rigidity, introducing the pedagogy of the uncertainty that allows this surpassing, besides the exercise of freedom and of the common search for truth. The acquisition of the uncertainty is one of the greatest conquests of conscience, because the human adventure, since its beginning, has always been ignored.

The bachelardian scientific pedagogy tries to foment the students' intelligence. The objective of the pedagogic action is to promote, to invent and to reinvent culture. An accepted and dogmatic truth doesn't allow the daily exercise

of the freedom of the spirit. So, what is important is to resume, to exercise the renewal activity. According to Bachelard, the pedagogy of the sciences implies a criticism of reason. For such a thing, it is necessary to break with the acquired habits that prevent from progressing and to overcome the rigidity of the previously conceived ideas.

However, what is noticed in relation to the students' education, mainly of the technological area, is a total ignorance of the social sciences that certainly would help in the attitude changing in face of the established truths. Some universities have in their curricula the discipline Philosophy of the Sciences, which is of little significance, but it certainly minimizes the distortion in the education of the student of the technological area. It is necessary to articulate the world of the ideas with the world of the things.

Bachelard, creator of the new scientific spirit, supplies essential elements in his work for the establishment of a new pedagogic spirit.

**6. Conclusion**

For everything that has been presented, mainly in relation to the current problems society is confronted with, is that, in fact, it is quite a wide change because it involves the reform of thought. Therefore, it is necessary that a wide reflection is made, not only on the part of the higher education institutions but also on the teachers' and on the students', of all areas of knowledge, in the sense of looking for new directions for university, especially the engineering schools, that intend to be agents of the development in these complex times, but that must first recognize the emergency of a new kind of knowledge.

Such attitude implies a change in the education of the students of the technological area, whose curriculum should be reviewed, modified and/or enlarged, tending to a humanistic perspective and, at the same time, a transdisciplinary one, that doesn't deny the existence of the disciplines, on the contrary, the transdisciplinary knowledge is a complement to the conventional disciplinary knowledge.

The great challenge is in practicing the transdisciplinarity because it implies in recognizing that the concepts of learning to learn and of learning to do, so much discussed nowadays as maximum paradigms of education and of employment, are insufficient to fulfill the contemporary mission of higher education. It is necessary to go beyond, in other words, to learn to live together and to learn to be.

Including the humanistic and the scientific cultures, the student of the technological area, especially the engineering one, will have a more integrated view of his knowledge, making it even possible a wider and more appropriate education in relation to the contemporary world.

As for ethics, there must be a relationship between science and ethics, in face of the new scientific discoveries and of the ones that might still appear, imposing a philosophical reflection about their implications in man's life and in the whole society's.

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