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CREATIVE FORMATION. STRUCTURE AND SOME RESULTS OF THIS COURSE FOR PRODUCT AND SERVICE INNOVATION

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1. Introduction. Beginnings of course

This paper describes the structure, syllabus, methodology, some results and future trends of the postgraduate training course of "Creative formation".
Engineering Design is a compulsory subject matter in engineering studies in Spain. During the 92/93 academic year, one class began to specialise in innovative technical engineering design, and in 1995 the subject matter of technological innovative projects was established in this class at the Industrial Engineering School of Barcelona. This line of innovative technical engineering design emphasizes improved performance on innovative results of new engineering designs. The goal of achieving more production of ideas was improved in a natural way of idea development by the study and practice of formalised creativity techniques.
In 96/97 a PhD training course called "Creative Phase" was offered and at the same time offered as a postgraduate course with the intention to have a research and teaching in creativity, this postgraduate course was the first in these characteristics in Spain.
A pioneer on these themes in Spain (Claudí, L.) is in charge of the "Engineering Thinking" module of this course. Another expert (García-Delgado, C.), who was a lecturer in our Engineering Design department (1977-96) and gave creative theory and practical creative exercises to students, is in charge of the module "Invention Theory"; and another part of the course is about "Creativity Techniques" (Lloveras, J.). The course was called: "Creative Phase" for the first three years, after which was changed to: "Creative Formation" and also included the "Invention and patent system" module taught by the director of patent centre of Barcelona University (Segura, P.), as an interesting and necessary complement to technical creative activity.

2. Course objectives

Because one important parameter of present-day market competition is innovation, and the essence of all innovation is a new idea, creativity plays an important role in engineering design. The training course Creative Formation aims to increase the student's ability to reach new ideas in the generation idea phase of a design. Students are trained to improve their performance and abilities in this creative phase by employing several creative techniques; the knowledge mechanism of appropriate mental state; an evaluation of a good ambience and so on. A patent general view is also given.
This course is directed to graduate professionals, company staff and R+D personnel, especially to those involved in the area of engineering design. University graduates who show course interest are also welcome.

3. Methods and syllabus

The sessions are theoretical or theoretical-practical sessions with interactive exercises. They include lectures, exercises for case resolution, exercises of generation ideas or for inventiveness resolution, and exercises of patent search. Practical exercises are an important part of this course, and students prepare a final exercise to compile an inventive problem-solving through the use of various creative techniques. The course has four modules each with a different lecturer. The syllabus is explained below, with some principles and module methods.

3.1 Creativity Techniques module (L., J.)

Creative techniques serve to enhance the mental production of ideas; some of these techniques were started in the 50s, and since then several lines have been developed or applied to design [Eder, 1996], [De Bono, 1994], [Michalko, 2001], [Sternberg, 1999], [Krizan, B, 1999], etc.
There are two main groups of creative techniques: the psychologically based methods; and the theory of resolution of inventive problems (TRIZ method), based on the knowledge of patterns of how to resolve a huge amount of patents. Both groups of creative techniques are explained and some of them are worked through practice.

3.1.1 Main topics enumeration

Enunciates of the main topics are: Introduction to the ideas generation and arrangement; Brainstorming; Brainwriting; Alternations; Mind maps; Morphological diagrams; Six hats to think; Concept range; Checklist; Provoking phrases; Ideal Design; Reiterative Multidesign; and Theory resolution of invention problems (TRIZ).

3.1.2 Methodology

The class time is generally divided into three parts: the first part of each class is dedicated to theoretical explanations of one of the creativity techniques; in the second part, this technique is applied to the resolution of an inventive problem, and all the students participate interactively; during the third part of time of class the professor is dedicated to tutoring the working groups in the application of the various creative techniques to the specific group theme. The different groups of work, made up of 3 to 5 students, complete at the end of the course a final report.
Through this process, the student learns and practices incrementally, from anonymous to individually, these abilities, that is: from general, anonymously formulated explications, to a bit more individual role with all class work together, where individuals actively participate, to the work in small group when the individual expression is more free and intense and finally to a totally individual expression in some exercises. This incremental individual practice is a methodology that makes incremental confidence to individuals in controlling their abilities in these techniques.
In the last course 2002/03 explanations and practices of several creative software program aids were introduced. There are based on several known techniques such as: brainstorming, mind maps, checklist or by words or images suggestion.

3.2 Invention Theory module (G.-D., C.)

This module has two main parts:

- The process analysis by which our mind finds answers (or makes decisions) to the continuous selection of different possible solutions in all activities; the range of elections goes from normally automatic or non-conscientious to very transcendent, vital decisions carefully considered; that is, from small or intuitive creative answers to great pondered creative activity, and their related creative quality. The analysis of automatic solutions that produces normally right answers.
- Methodology to increase the creative process efficiently.

The question is: Why is it so difficult to explain the creative act?
To analyse the creative activity –from automatic to pondered activity or from small creative quality to high creative quality-, there is a need to define some new concepts and also to engage in a deep

analysis of western civilisation which, with its myths and beliefs, makes difficult, at present, the comprehension of the creative act. These considerations are presented in detail.
The nature of the creative act as a non-lineal phenomenon is defined and drawn schematically as an explorative tree. The words needed are, for example: “diffuse” or “probably”, instead of “logic” and “exact”. [Prigogine, 1983].
Thereafter a general definition of memory in inorganic and organic world [Riedl, 1983] and humans are proposed. The human mental system of memory-conscience and there are several states between: awake, semi-awake and sleeping. These several states produce different kind of thinking: from conscious thinking to non-conscious dreams. The imaginative or more “creative” dreams in the non-conscious states can be preserved, in some manner, at the edge of semi-awake state as one maximum point of creative efficacy. [Popper, K. and Eccles, 1982].
Finally there is a description of methods to reach this point.

3.2.1 Main topics enumeration

Invention, innovation and discovery. Topics and taboos of western thinking. Conventional thinking and divergent thinking. Lineal and synthetic problems. Systemic problems resolution. Heuristics. Analogy thinking and lineal rationality. Exploratory tree. Faculties of the exploratory act: memory, conscience, imagination and intuition. General definition of memory. Auto-corrector system of memory-conscience. The conscience attributes. Maximum point of creative efficacy and methods to reach it. Practical exercises of invention, and manual construction of devices. Group evaluation of exercises.

3.2.2 Methodology

There are explanations of theory with text lectures of some known classical and modern creative man, questions, reflections, and schematic diagrams in the blackboard and class exercises.
Several practical creative exercises, which students must do individually, are proposed; exercises of artefact realisation with only light pieces of wood, thread and glue. One example to enunciate this exercise is: To construct an artefact of maximum: 20 x 20 x 20 cm that once started moves 50 cm on a plain and smooth surface; another example: To construct the same artefact, but that once started waits 5 seconds still and after that, automatically moves 50 cm.

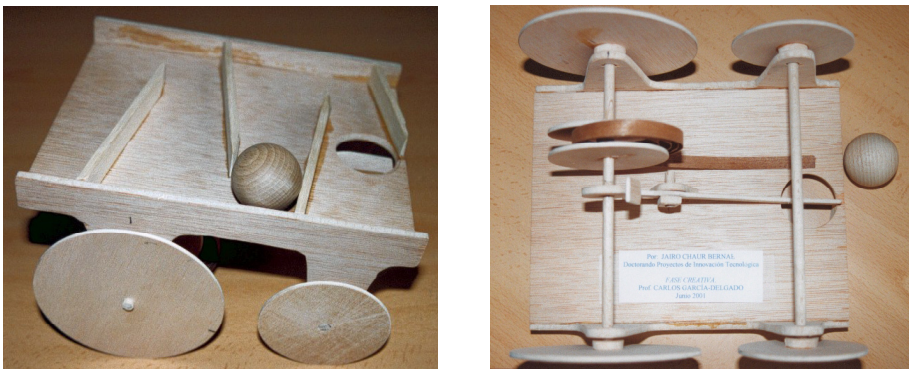

Figure 1. Example of creativity exercise realisation of an artefact that once started wait 5 seconds still and after that covers 50 cm. Left picture: top; right: bottom half

Fig. 1, shows an example of realisation from the exercise above (from J. Chaur, student). One flexible artificial wood lame acts as spring to move the rear wheels and displaces the device 50 cm; a mechanism is unblocked when the ball falls in the hole after it crossing a inclined plane with zigzag track in 5 seconds.

3.3 Thinking Engineering module (C., L.)

Pressing need for a new design of our being in front of the exponentially changing future we are subjected to. This has an effect over the cognitive processes in all areas of knowledge and action. These circumstances involve the confronting of man with the reality.
All problems have its identification in concrete points or moments of the reality, though a more intelligent identification place them in certain surroundings bringing mutational innovation, through qualitative bounds as those performed by the thinking engineering.
The classical scientific method is very valid for the discovery of the still unknown reality, but it doesn't allow the generation of new ideas that doesn't exist in it.
We emphasize the basis of the Brainstorming, Synectics, Lateral Thinking and many others, based on "de-conditioning" of the "acquired knowledge". We don't have at our disposal the formalized, systematic means for the accomplishment, from the infancy, of a non-conditioning education, based on the Thinking Engineering.

3.3.1 Principles

Basic-Principle of Thinking Engineering: "Creativity isn't the Production of ideas but the Systems Identification". It discusses the objectivation, formalization, systematization and implementation of the biologic and artificial mechanisms of mind through discovery, invention, creation and basically mutational innovation in all areas of knowledge. But always within the frame of the future prospective: predictive, normative and preventive. [Claudí, 1995].
The distinction between the concepts of "knowledge" and "thinking" is important since the difference is fundamental for the action innovative control. This difference can be expressed by Bertold Brecht assertion's: "Car is knowing" and "thinking is to drive". The bases and steps are:

- Optimization mechanisms for the intelligent behaviour: Natural or biologic: The binary brain: Analytic and systemic (functions and structures: memory, reasoning and imagination). And artificial and methodological classification and exhaustive interrelation of the holistic knowledge, for the mutational innovation generation through the complete listing of the existing relations: Abstract, spatial, intellectual, volitive, and so on, with all its contents.
- Formalization and implementation methods and models for a correct and complete interdisciplinary perfusion: Biologic, poetic, artistic, musical, emotional, etc.
- Language as thinking support: Morphological and instrumental method of mutational innovation, through mathematical linguistics, tool for the "creativity through discovery" since the imagination can be formalized by it.
- Prospective: Predictive, normative and preventive. More outstanding models of prognosis: Experts' opinion, Delphi method, scenes generation and structural analysis matrices. Exhaustive analysis of ideas obtained for its validity ensures.

3.3.2 Main topics enumeration

Revision of classical methods of creativity. Engineering Thinking of knowledge and imagination. Biological and artificial mechanisms of thinking: memory, imagination and rationality. The language as support of thinking. The mathematical linguistics brings creativity for discovery. Prospective Methods. Exhaustive ideas analysis. Examples.

3.3.3 Methodology

At the beginning of the course, an intelligence test: rational, emotional and creative (fig. 2) is administered. These test are added to those achieved along several years performed in other scientific or technological areas of post-graduation, including the evaluation of about 1,600 subjects. One person arrives to 196 points of score; the maximum score, unattainable in practice, is 219; the mean is 105 with the typical deviation 9.2
In this module, also interactive exercises are made between theoretical explanations.

3.4 Inventions and the patent system: Industrial property module (S., P.)

The later part of course is dedicated to patents because it is a complementary part to the technical generation ideas. After a student training in ideas production, a certain knowledge of the patent system is necessary to protect against copying those technical ideas that can be reduced to practice and give rise to an invention. Any person who wants to research or to innovate, especially people who produce or sell something, need patents knowledge. Different reasons are in accordance:

- Patent databases are an enormous source of technical knowledge.
- For the inventors, the patent databases are a reference point for compare the own inventive production.
- Patents are a source of technical ideas inspiration.
- A technical innovation research must know the state of art, patents specially, because it is a waste of time investigates something that is known.
- In the industrial activity (or possible activity) must know the state of art, because otherwise can violate some property rights.
- The patents are assets, which can be, sell or licensed, it depends on the interested parties.
- A technical source of no protected invention, or even not well protected, or expired invention that to be profitable.

All these reasons show the interest of this knowledge and the close relation with this course. The patent knowledge level in our country is not very well developed.
This information improves personal student knowledge and, in the case, improves their future relation with patent agent.

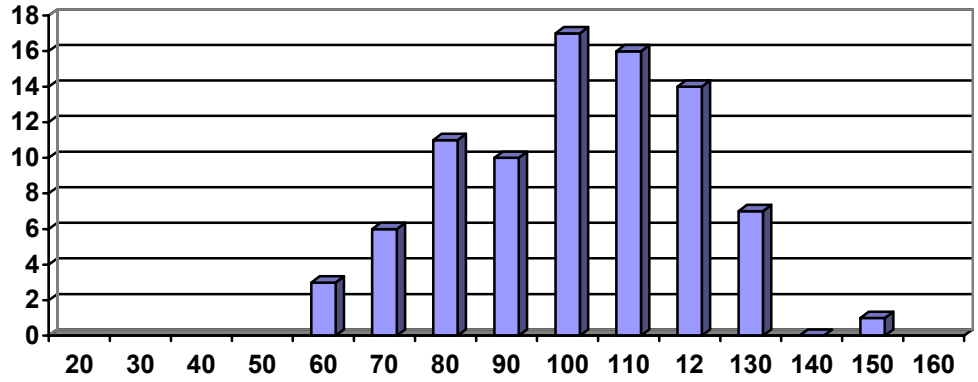

Figure 2. Average score frequencies of about 1.600 creativity tests

3.4.1 Main topics enumeration

Patents as principal technical information source. Industrial property and copyright. Economic importance. Confidential information protection. Know-how. Industrial design protection. Patents and Utility Models. Patent legislation. Spanish law. Patents in several industrial sectors. Inventions category: products, processes, use. National, European and international (PCT) patent procedures. Structure of a patent document. Patent searches: on-line/CD-ROM. Royalties, transference of patent rights, etc. Patent infringement and lawsuit. Preventive measures. Company patent policies: What? How? When? Where?… to patent.

3.4.2 Methodology

A patent general view is given with the aid of slides; real case examples of interesting applications and lawsuit are made. Finally there are exercises of patent search with Internet facilities in an important patent database.

4. Results

This is a postgraduate / doctoral training course is in its seventh year running. The course has not been widely advertised. The same course has also been offered privately to a company interested in training persons in a new I+D department. The students take a confidential test of creativity (fig. 2). A graphic curve shows an average punctuation of creativity test results of several courses: the percentage of students of each punctuation range. Normally the best of them are easily identified in the several class participatory exercises.
The professors have wide teaching experience, and the opinion poll from the students from year to year, is in general favourable to the structure of this course and for the professors.

5. Key Conclusions and future work

As explained in this paper, the syllabus and methodology of this course composed by four modules, three of them given by the three professors are related to complementary knowledge of creative formation and the fourth module gives basic patent notions by the other professor, to protect the innovations in close relation with technical invention activity.
This course serves to give confidence and methodology in creative abilities to students; in general students improve their creative possibilities, because they can apply several creative aid methodologies after the course. A small number of students of several courses are identified, by the test and exercises results, to have high level of creativity. They have natural qualities of creativity, and have acquired through the course, creativity techniques and basic knowledge in patents; they acquire also the confidence in themselves on invention practice. So, they have a basis that permits them to have more possibilities to reach quality innovations. A team of such individuals will be ideal to form a quality inventions group [Lloveras, 2002], if they are motivated, well informed and trained to innovate in a determinate technology.
Other trends of this course are to use or improve creative software program aids, and reach some doctoral thesis presently in progress, about creativity in engineering design.

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