INTERNATIONAL ENGINEERING AND PRODUCT DESIGN EDUCATION CONFERENCE
2-3 SEPTEMBER 2004 DELFT THE NETHERLANDS

A NEW DISCIPLINE IN DESIGN EDUCATION: COGNITIVE PROCESSES IN DESIGN

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ABSTRACT
Our thinking and learning process is influenced by the fact that the brain is a self-referential system. Knowledge from Constructivist Theory and cognitive psychology is fundamental for the conception of a new discipline that we are starting to develop in our Design School.
Understanding and trying out different kinds of cognitive processes in design activity promise to improve problems with reasoning, solution finding, conception or communication. Radical Constructivism explains the phenomenon of 'interests guided by findings', which means that new knowledge is perceived and synthesized in a biographical way. Learning results are not the reflection of the input, but the construction of one's own world. So, instead of teaching in the traditional way, we should give the students tools, which provoke a new way of thinking.
The term 'cognitive processes in design' refers to the thinking and interactive skills of design like the perceptive, the creative, the communicational, the learning and also the emotional and the teamwork processes.

Keywords: cognitive process, Constructivist Theory, perception, creativity, emotions, thinking tools, learning process

1 INTRODUCTION

In order to complement the educational curriculum of the first years, we are starting to develop in our Design School in Porto (*Escola Superior de Artes e Design*) a course that is bringing together the different kinds of cognitive processes in design activity. It's the query over cognition, thinking and learning in the new millennium that is prompting us to integrate new contents and new didactic methods in the basic education of our students. Using the term 'cognitive processes in design', we refer to the thinking and interactive skills of design like the perceptive, the creative, the communicational, the learning and also the emotional and the teamwork processes. Disciplinary and interdisciplinary knowledge about the different aspects in design, like the technical, the semantic, the historic or methodological knowledge is not enough to practice a creative activity like design is. Instrumental knowledge of thinking processes, that is, the constructive, operative and creative aspects of thinking are just as important as knowledge of facts and methods. Christiaans called these cognitive aspects of design the "developmental process in design". [1]
Knowledge from Constructivist Theory [2] and cognitive psychology lead us to the idea that knowledge don't mean statically stored information but the capacity to react appropriately in an individual or collective design situation. With this perspective we

move to the design paradigm that Schön (1987) and Dorst (1997) describe as a Reflection-in-Action process. [3|4]

2 THE BACKGROUND

Since the seventies, but particularly in the last years, we can note an increasing trend in design research to give more importance to the cognitive aspects, seeing that design is an essentially human activity (for example: Simon 1969, Lawson 1986, Schön 1987, Cross, Dorst & Roozenburg 1992, Hekkert & Overbeeke 1999, Love 2003 or Norman 2003). [5|6|7|8|9|10] Research work from other disciplines like psychology, neuro-cognition or physics is contributing to the growing import of aspects like creativity, imagination, emotions or intuition in design theory. The work of scientists like Gardner (1989), Guntern (1995, 1996), Damásio (1994, 2000) or Binnig (1996) were important influences on this recent trend. [11|12|13|14|15|16]

As early as 1910, John Dewey pointed out the urgent need for thought training in education. Demonstrating the causes of 'bad mental habits', he concludes, "the work of teaching must not only transform natural tendencies into trained habits of thought, but must also fortify the mind against irrational tendencies current in the social environment, and help displace erroneous habits already produced." [17] Today we express the same emphasis in the need for more creative and ethical thinking.

The seminal impulse for the development of the new discipline that we present in this paper comes from real preoccupations in our school:

- Several project teachers criticized the weak creativity of 3rd and 4th year students in new perspective and concept finding.
- They also detect a lot of interaction and communication problems in teamwork-projects.
- Students towards the end of their courses expressed the desire to learn more creative thinking techniques.
- They also complained about the different methodologies, teaching conceptions and styles of their teachers that are reflected in the notes they give.
- Some students, at the end of their design course, regretted that they hadn't used the available opportunities in the four years of study.

For these reasons we are seeking to create a course where students are initiated into the proceedings of design thinking, design interaction and the learning process itself.

The main objective of the new discipline is to show students the subjective aspects of design and learning, and thus to help them understand and improve their learning process, and at the same time, the design process of each project. We want to develop Meta cognitive competence through trying out different thinking and interactive proceedings in design. It would be wonderful if the students at the end of the academic year have a clear appreciation of thinking as a skill, and a self-image as a 'thinker' in the same way that they see themselves as 'creator'. Design should be seen by the students as a subject-dependent creation of innovative product-possibilities.

3 THE SUBJECTS OF THE DISCIPLINE

The subjects in the course that we are developing are based, amongst other things, on the mental blockages in the creative process of design, such as perceptive, intellectual and emotional. [18,19]

One of the most frequent intellectual and perceptive blocks is the difficulty to choose the appropriate mental strategy for the resolution of a problem. The difficulties are not

only in finding the solution, but also in problem finding and the analysis of an initial design situation. Design students should become conscious of the importance of perception and its nature as a pattern-making and pattern-using system. An overall view of the importance of emotions, feelings, intuition and values in thinking, also can help to manage the creative design process more effectively.
The following subjects amongst others, are approached in the new discipline:

3.1 The process of perception

Constructivist Theory and cognitive psychology shows us that perception operates as a 'self-organizing-information-system', which restricts our thinking through already set up patterns. According to Roth perception is interpretation and attribution of significance. [20] And this attribution of significance happens in accordance with the principles of Gestalt psychology. So it is not surprising that the most frequent cognitive block in general, and in design in particular, is the perceptive block, an impediment for the clear comprehension of the initial design problem and the necessary information to find a new response. An inflexible attitude (*Einstellung*) towards products and situations and a stereotypical or prejudiced opinion limit the perception of new possibilities. Designers need some ways of broadening and changing perception, which is a creative act. To learn anything or to design a new concept, there is a need for 'real perception', "in the sense that without it a person is unable to see, in any new situation, what is real and what is not". [21]
The creative designer is the one with vision and imagination, who makes connections between previously unassociated concepts. Students have to understand that perception can be an active process, a process of searching, led by our expectations and goals, and not just the passive reception of sensory impressions. So 'real perception', according to Bohm (as opposed to a routine and mechanical kind of perception), requires that students learn to be more attentive, alert, aware and sensitive. We have to be aware that the repertoire of patterns, which we have in our minds, will determine our recognition, our classifications, our analysis and all of our subsequent thought processes.
During the course, students should feel and try out, in short exercises, the interpretative and subjective extent of the perception process and should, in this way develop a more careful observation of their surroundings. Understanding the major role of perception in design thinking definitely generates more original ideas and practical solutions.

3.2 The process of thinking in general, and of communication

The design process consists of alternating phases of analysing and selecting, making new connections and then synthesising. Information about the project and knowledge of the subject are important elements of the solution, but thinking appropriately is even more essential. Students' need thinking skills to decide what information is relevant or interesting, where to look for it, how to make the best use of it and how to put information together in an original and efficient way.
Our thinking process is influenced by the fact that the brain is a semantically self-referential and self-explanatory system. [22] The examination of cognitive systems at the base of the self-organisation idea of the brain requires a new definition of the thinking and communicating process in design. Notions like *Structural Determinism*, *Informational Self-containment* and *Oriented Interaction* [23], come from the Radical Constructivist Theory of thinking by Maturana and Varela (1987). [24] According to these authors, the behaviour of an organism is determined by its structure.

Environmental stimuli are only disturbances in which the organism reacts as determined by its structure.
Therefore the cognitive system doesn't absorb information, but produces it under a continuous change in it's own structure: the organism is *self-contained in terms of information*. According to these principal of operational integrity, organisms can't 'change' information, but can only reciprocally stimulate the construction of information in an *orientated interaction*. Thus the phenomenon of communication doesn't depend on what is transmitted but on what is happening inside the receptor. [25]
Students have to understand that the subjective aspect of communication is the reason for semantic problems: the selected set of the sender and receiver do not really correspond and have to be agreed on in each act of communication: in the verbal and the visual.

3.3 The creative process and creative thinking

In design education, creativity should be given more priority that it is in reality, seeing that design aims to create something new and different from what already exists.
Today we know that manifestations of creativity in humankind are of the same intrinsic nature as the creative forces in nature and in the universe at large. (Binnig 1989, Bohm 1998). A similar creative process is at work in practical design projects, in the learning process itself and also in the formation of theory in science like design education.
Because of the auto-organisation of the brain, cognitive processes emerge, which means that ideas grow and mature during the creative process.
Explaining the different phases of the creative process, should result in the student operating inside this process with more awareness and better understanding the importance of analytical, synthetic and analogical thinking, intuition and coincidence in the design process. We define creativity in product design as a cognitive capacity of a life system (individual, group, organisation) to produce new combinations (practical, material, aesthetical, semantic), unexpected and useful responses, directed to a certain community.
Different theories and aspects related to creativity like the concepts of 'divergent thinking' (Guilford), 'lateral thinking' (De Bono) and 'holistic thinking' (Morin, Simon), are also covered in the subjects of the discipline.

3.4 Emotional processes

Design is not only a reflective activity, but also an emotional and intuitive process.
Although the emotional experience is not a cognitive process but a 'succession of neuronal and chemical reactions' (Damásio 2000, 2003), we want to consider emotions and feelings in the new discipline. Since the result of these neuronal and chemical reactions is a temporary change of the state of the structures of the brain which form the substrate of thinking [26], students should know about the influence of our emotional condition in the creative design process.
António Damásio shows in his many publications about the brain, that emotions and feelings are fundamental for rational thinking and decision-making. [27] And De Bono demonstrates how it is possible to change feelings by thinking in different perspectives. 'Value-laden' words, for example, can alter the perception of a situation and so the associated feelings. [28]
In the design process emotions and feelings can perform the following functions, but of course they are never a substitute for rational thinking:

- Identify and redefine project problems, quicker and more easily;

- Reduce the unavoidable complexity of design situations, and become a catalyst for decision finding;
- Reinforce already existing preferences (styles, values, attitudes) and accelerate the formation of new preferential structures;
- Judge in a natural way the ambience of group work and the relations in the team and react appropriated;
- Understand and accept the interruption of fluency in the thinking process by sadness, bad mood or fear and help to develop a strategy to overcome these negative feelings.

3.5 The process of teamwork

It isn't news that our cognitive system and the environment have an interactive relationship. Maturana and Varela (1987) attach central importance to the cognition process in human interactions. They use the analogy with the car: the engine keeps going while the car is motionless, but by driving we always have to consider the traffic. Social interactions are not only important in the learning process by helping to adapt to changing life circumstances, but in design they are also an essential factor of the design process.

The design object is never the result of an individual creative genius; products can only be looked upon as a result of a teamwork that includes different kinds of participation and group dynamics. So one of the important aspects of the new course in 'cognitive processes' is that students are working in groups that are continuously being changed so after each exercise they can evaluate the group dynamic.

3.6 The learning process

If we don't want to treat learning simply as information processing or assimilation of new knowledge, but rather as ' the acquisition and constructive production of realities which develop our identity' [28], thus in design education we can't be just interested in transmission of notions and new knowledge, but the focus of interest has to be the internalisation of 'valuable' experiences. According to Siebert, a teacher mustn't only produce the knowledge which has to enter in the students head, but he has to facilitate processes of automatic and independent development and appropriation of knowledge, thus creating conditions for the students own self-organisation. This kind of reflective learning process requires from students meta-cognitive competences and from the educators the deployment of communicative teaching methods which create an atmosphere in which students are allowed to develop subjective fields of experience in design thinking.

To stimulate reflection about their learning process we ask the students to create throughout the whole academic year a dossier with all of the exercises that were completed in the course, and complementary texts about each process: their working methods, problems that they have solved or that they could not overcome, team interactions, communicational problems, and what they have learned in each case. Meta-cognition and Meta-communication is an indispensable element of higher design education. Because we have varying life experiences, differences and different interpretations should be raised and compared. To learn means to be curious about differences and about other perspectives of thought. Constructivism leads us to the reflective learning process; students observe themselves: their selective perception, their thinking processes and their cognitive blockages. And we as educationalists should observe and comment on the self-perception and self-analyses of the students.

4 EDUCATIONAL CONSIDERATIONS

We don't learn from abstract rules, but from concrete situations and experiences. The learning process is a practical related process. The "learning by doing" principle from John Dewey, shows that information only changes into effective knowledge if there is a practical application. Above all the teacher has to enforce the natural resources, an approach that Dewey describes in his work *How we think* (1910, 1997): "If an individual can learn to think only in the sense of learning to employ more economically and effectively powers he already possesses, even more truly one can teach others to think only in the sense of appealing to and fostering powers already active in them." [30]

Now the Constructivist Theory confirms that teachers can only create opportunities and reasons for thinking. The application of various process tools seems to be one of the best didactic methods not only to provoke thinking processes, but also to explain to the students the different cognitive processes in design activity. Design tools are 'attention-directing-tools', without them attention follows the patterns laid down by experience and we remain restricted. In his *Thinking Course*, De Bono defends: "What the thinking tools do is to furnish the mind with some 'executive' concepts so that at different points in our thinking we can instruct our own minds to work as we wish." [31]

In the new discipline we use diverse tools, for example techniques of divergent perception, analogical thinking or visual and verbal communication in different kind of exercises. Besides learning to handle the cognitive process, the testing of tools allowed the students to develop criteria about the usefulness of each technique in different situations for them personally. And one thing is sure: a designer who makes a lot of 'Synectics', with time will develop a good capacity of thinking in analogies and metaphors; somebody who attends 'Brainstorming' sessions regularly will train her/his mental fluency, flexibility and originality.

The educational process should focus on teaching the student how to manage her or his design process; students should be aware how to handle knowledge and information and to choose the appropriate method at each moment of the design process. The main goal of design education should be the development of an intellectual and creative flexibility, a holistic and imaginative thinking, and an attitude of self-responsibility. Siebert (2002) reduced these kinds of requests to one keyword: the 'instruction-didactic' is substituted for an 'animation-didactic'. The learning process of students cannot be planned, only the contents of the course. The whole learning situation should be designed as varied and stimulating, so that students in accordance with their individual situation could have significant educational experiences. A sign of quality in design education cannot be the standardization of opinions, but plurality and diversity of ideas. The consequences for teachers and for teaching methods are the use of various didactical and communicational materials in classes. As well it is important that teachers of one school maintain a diverse approach to design and design languages. The request for a collective design perspective is not only illusory, but also absolutely undesirable, in the constructivist view.

Traditional education is looking for standardization learning results and also for homogenous learning groups with similar knowledge prerequisites. Constructivism emphasizes, in opposition, stubbornness and a strong individualism. Teaching based on instruction has only a small chance of leading students to an extension of their cognitive structure.

4.1 Different exercises

To allow students to test and reflect on different thinking approaches, we propose exercises that are related with the cognitive proceedings in the design process described above. All exercises are short exercises: either they are made during the lesson, or they are 'home work' carried out in one or two weeks. Exercises during the lessons are designed to use an introduced contents or tool, or to feel a certain kind of cognitive blockage for themselves. After introducing the 'Mind-Map' tool, for example, students are encouraged to make a 'Map' of a theoretical class or of a subject related with the course content. This graphic creative thinking tool helps to develop mental flexibility and the logic of inter-relations. We apply numerous similar tools to train the ability to observe, structure, organise and finally communicate.

To really understand a cognitive block, students are invited to resolve typical exercises for each problem, to feel the different kind of blockages under their skin. The frequently cited case of the nine circles connected with only four straight lines without lifting the pencil is just one example that they have to try in the course. [32] As perception is the most important part of thinking and so a base for all problem solving processes, we dedicate most attention to perception exercises. The main goal of these exercises is to sensitise for the importance of perception in design and show how useful focused perception can be.

Feelings are mental manifestations of equilibrium and harmony, of dissonance and displeasure. The exercises and experiments to test and understand the importance of emotional states in the design process are mostly related to social behaviour. The aim is that the students become aware of the importance of empathy in design activity.

5 CONCLUSIONS OR THE INTEGRATION IN THE CURRICULUM

It is not common to have a discipline of 'cognitive processes' as a separate subject on the curriculum in education. De Bono listed some of the reasons for that, foremost among them the trap of traditional thinking and the belief that 'thinking' is already covered during the teaching of other subjects. [33] This is true, but these are only some cognitive skills concerned with analysis and information sorting. Skills like 'generating new ideas' or 'assessing priorities', the emotional aspect of thought or the interactive processes of a group are not considered enough. Of course, a single discipline cannot improve the mental capacity of students, but it can contribute to a better comprehension of processes and thus lead to a better management of their thinking abilities. And it can show that design thinking corresponds to the subject-dependent creative process of life itself.

At the moment we are testing this new course-project in the first year of design education to prepare the students for the realization of projects in the second year, but I'm convinced that it will be more effective to connect the course subjects with the discipline 'Design Projects' in the first two years of the design course. In the second year the Project course could be complemented with considerations of different methodological paradigms and with experimentation with the phases of the Creative Problem Solving process. The only problem that I see in the integration of the 'cognitive process' content in other disciplines is lack of will and knowledge of project teachers in this domain, but this seems easy to overcome. Or is it?

ACKNOWLEDGMENTS

This research was funded by the *Fundação para a Ciência e Tecnologia*, *FCT*, Portugal, POCTI Program, SFRH/BD/6408/2001.

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