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Situating Environmental Design in the Studio

An ecological learning approach

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Abstract

Situating Environmental Design in the Studio

An Ecological Learning Approach

This work explores the problem of implementation of environmental design in architectural training. This problem has been identified as a disconnection between the delivery of information by lecturing, and the application of that information in the studio. The essential nature of students in that view is passive, and their task is to correctly apply information developed by others. This work pursues the idea that 'environmental knowledge' can be grown from within the conversational nature of the design process based on the active nature of the student. The main contribution is the proposal of an ecological approach to learning, in which the whole person of the learner is deeply engaged with his learning environment.

The present understanding has been informed mainly by the ecological approach to perception of James Gibson, and the conception of design of Donald Schon.

Through the view of Donald Schon, environmental design comes forth as a particular instance of '*conversations*' with environmental situations, involving the modeling of actual phenomena, as a central element of the learning process. Seen from an ecological approach to learning, the implementation of those '*conversations*' appears as part of a larger orchestration of affordances of the learning environment, involving tangible and intangible resources. This proposal is intended to illuminate other implementation strategies of environmental design in other schools.

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Chapter 1. Introduction

The integration of environmental design has troubled schools of architecture for various decades, and different options to overcome this problem have been proposed. Some schools have decided to separate environmental design from the studio altogether, leaving the responsibility of integration to students. Others schools have decided to integrate this knowledge in the studio in different ways.

The current environmental and economic crisis has brought back 'the environment' within the concerns of architects, but this time with a considerable emphasis in the rational use of energy. This emphasis has been transferred into the education realm, shading the idea of 'environment' with an energy-economic tone. The environment, it is believed, is something that students of architecture will have to confront seriously in their future careers, for which they should prepare themselves by acquiring the best possible technical knowledge.

Is environmental design, design?

As an architecture student trained in the '80s in Chile, practitioner since the early 90s, and studio tutor for 12 years, I have experienced first-hand the growing importance of environmental design in our discipline, and the efforts of some educators to incorporate environmental issues in the design process of students. Some of the difficulties of integration arise from the resistance of instructors of 'architectural design' to integrate it. They do not see environmental design as Design, and perhaps they are right.

By participating in both, studio tutoring and environmental design tutoring, I often have the experience of being two different tutors. While acting in the 'environmental design mode', I confine my comments to environmental aspects of design projects; in my 'studio mode' instead, I can speak of 'architecture' and 'design issues'. While this is anecdotal, it portrays the common divide in architectural curricula of environmental design, and Design.

The cornerstone of Architecture as a discipline is the activity of design. This was acknowledged by Marguerite Villecco (1977) who early observed that any significant achievement in terms of implementation of "new paradigms" must be done in the **realm of design**.

Design has been characterized as "a reflective conversation with the materials of situation", a "voyage of discovery" (Schon 1991). Nigel Cross (2000b), has suggested that Design is an epistemological paradigm different of science, but also different of art. There is a way of knowing which is peculiar to design, "a designerly way of knowing", as he puts it. This kind of exhortations can not escape the notice of educators, because such visions assign a particular role to designing, in the generation of knowledge.

While designing, a student is in 'a state of inquiry' from which knowledge is produced. In this state he is very different from one who passively receives 'knowledge' prepared by others, 'knowledge' that must be properly applied according to standards (Giroux 1988).

Environmental design is often understood in this way, this is, as the correct application of standards of indoor climate in buildings, "designed and controlled so that occupants' comfort and health are assured" (CIBSE 2007, p.1) schools of architecture have assumed this approach to introduce environmental design in their curricula, coupled with a justified concern for a rational consumption of energy. This position is entirely valid in the light of the environmental-economic crisis that the planet is confronting, however, it is not clear that the design to which CIBSE refers, of "control of internal climate of buildings", is the same design, understood as "a voyage of discovery" that Schon, Cross, and Lawson write about. So, in order to answer the initial question of this section -is environmental design, design?- It seems we must ask to what extent is environmental design an activity in which students are confronted with search and discovery performed by themselves.

The global environment vs. our environments

The global environment is for the architect today an ubiquitous issue. Many schools are aware of this, and incorporate environmental subjects in their curricula, either by genuine conviction or because they have to yield to a paradigm shift that seems inevitable, reinforced by requirements imposed by regulations and professional bodies.

There is, however, a distance between the idea of global environment, and the environments in which we live and engage with on a daily basis. When it comes to protecting the global environment in our discipline, we usually refer to the biosphere, an entity that in terms of sensory experience is more abstract than real. Our way of knowing that global environment, says Ingold , (2000c). is "not a matter of **sensory attunement** but a cognitive reconstruction, (we) may observe it, reconstruct it, protect it, tamper with it or destroy it, but (we) do not dwell in it” .

Our relationship with everyday environments, on the other hand, is deeply and inevitably ecological. This is, our environments determine our behaviour as much as our behaviour determine our environments. We are perceptually connected to them, in particular to what we have termed our learning environments. Then a large imbalance occurs in the teaching of our discipline. While there is a great concern for the relationship between buildings and the global environment, the relationship between students of architectural design and their learning environments does not seem to be relevant in the learning process.

The dominant pedagogical model paradoxically seems to ignore the learning environment, in the very attempt to instil environmental awareness, breaking, therefore, a link that some educators consider essential in any learning process: the ecology between learners and the constituents of their learning environment. This is, the learning process is assumed to happen in the mind of the learner, not in the environment, or in the relation between the learner and the learning environment. This paradox can be perceived in teaching in general, but it is more evident in the teaching of environmental design in architecture, because of the very topic it deals with. Students 'learn' about environmental phenomena 'in their minds', as an abstract entity,

Rooted in Cartesian dualism, learning approaches predicated on objectivism have at their basis a deep split between **knower** and **known** (Giroux 1984). According to Descartes (1596-1650) the reality for an individual consists of his thinking mind (res cogitans), and a physical part 'out there' (res extensa). One thing is clear: mind never intersects the external world. In our time we can change the labels and the sense remains the same. Mind never intersects the learning environment. The consequence in our modern idea of teaching is that, if knowledge resides in the mind, knowledge never intersects the learning environment.

Ecological approaches

In the past decades researchers in diverse fields have assumed an ecological approach in their explorations. Such is the case of the ecological approach to artificial intelligence (Brooks 1991b), the ecological approach to perception of musical meaning (Clarke 2005), or the ecological approach to the practice of agriculture (Jackson 2010), to mention three examples seemingly far apart from each other. Despite the heterogeneity of their subject matters, these investigations share a common trait. Their approach to a phenomenon is never to its components, but rather to the system of which those components are part.

The components of a basic ecosystem are an organism and its environment, being the relationship between them, deeply reciprocal. The organism is shaped by the environment, as much as the environment is shaped by the organism. It is this orientation toward the system, with emphasis on the symbiotic relationships between its elements, that characterizes any ecological approach (Sanders 1996). Ingold (2000a) further emphasises this feature of an ecological approach,

> "A properly ecological approach (...) is one that would take, as its point of departure, the whole-organism-in-its-environment. In other words, 'organism plus environment' should denote not a compound of two things, but one indivisible totality. That totality is, in effect, a developmental system"

Student-Environment ecology

The 'ecological approach' in the title of this dissertation does not refer to the ecology of buildings and the environment (Guy & Farmer 2007), but to the ecology between students and their learning environments[1]. Such a ecology has been the subject of investigation of a significant number of educators and researchers in recent decades, but in spite of being a vigorous movement, in particular in the education of scientific related matters, it has not penetrated architecture education.

1.1 Problem: the split of knowing and doing

> “To meet the problem of climate control in an orderly and systematic way requires a pooling of effort by several sciences. The first step is to define the measure and aim of requirements for comfort. For this the answer lies in the field of biology. The next is to review the existing climatic conditions, and this depends on the science of meteorology. Finally for the attainment of a rational solution, the engineering sciences must be drawn upon. With such help, the results may then be synthesized and adapted to architectural expression” Victor Olgyay(1992).

Olgyay's statement reflects the widespread idea that the work of the architect when dealing with technical subjects is to 'apply knowledge', knowledge developed by others. This idea is, in turn, reflected in the curricular structure of architectural training, that separates lectures from studio.

1 Some educators have used the label 'ecologic' to nominate it (Barab & Roth 2003), though the ecological approach to learning is not, a single monolithic doctrine, but an umbrella term inspired in James Gibson's work to refer to a series of contributions from various disciplines separately. These disciplines share two major concerns, namely how knowledge is produced, and second, how students and environment interact in the the learning process.

For many the split of lectures and studio is one of the factors that mostly hinders the implementation of environmental design in the design process of students (Gelernter 1988). This split has been interpreted as a disconnection between the **transmission** of contents, and their **application** in the design process. Such diagnosis appears to be initially right, however, contemporary theories of learning suggest that bridging the gap between **transmission** and **application** of contents would not solve the underlying problem, in terms of learning (Lave 1988; Wenger 1999; Bourdieu 1992; Schon 1991). The logic of transmission/application still retains a positivist principle that separates **knowing** from **doing**, peculiar to the modern university. Knowledge, in this view, is transmitted to students, as a ready-made product. Accordingly, they are not customarily expected to create knowledge, in particular of technological nature, but to apply it correctly in their design projects. The emphasis is placed in the application of knowledge previously transmitted to the students.

The transmission model of education of which lecturing in environments separate from practice is a clear manifestation, is the logical consequence of assuming that knowledge is produced in a sphere different of practice. In this view, three types of actors emerge. Those who create *knowledge*, in a higher sphere; those who transmit *knowledge*, in the intermediate sphere; and finally, those who apply *knowledge*, in the lower sphere. This is the epistemological rationale on which the modern university is founded (Schon 1991), and as a consequence of this rationale, the curricular structures of several disciplines taught at the modern university, tend to reproduce a hierarchy that separates *knowing* from *doing*. The divided curriculum of architectural training is one of the clearest examples of this split, in which *knowing* is related with the lecture theatre, and *doing*, with the studio.

The curriculum of architectural training is usually organised as a set of modules surrounding the centrality of the studio, and according to common practice, these modules are divided in Humanities and Technology, whether we agree or not. While the general purpose of Humanities is to prompt reflection, the purpose of Technology modules, to which environmental design belongs, is thought to be the provision knowledge to be **applied** in the design process of students. In this way, the relationship between technology and studio becomes regrettably one of **transmission/application,** expressing the underlying divide between knowing and doing.

In the transmission/application logic, *knowledge* can be stored in the heads of students, waiting for the right moment to be applied. Therefore, the most appropriate mechanism to acquire *knowledge* is by memorizing information. Memory is assumed as a file cabinet from which the student can retrieve information. In this view, the more *knowledge* a person possesses in his head, the more 'knowledgeable' that person is.

While, the aim of the transmission/application system is to prepare the learner for his practice, its effectiveness is paradoxically not demonstrated by practising, but by making the student reproduce such *knowledge* in answering standardized tests. *Knowledge* in this view is conceived as an object that can be fragmented, and its pieces organized to be delivered to students. Accordingly, the most efficient[2] way of providing *knowledge* is through transmission of packages of information to be correctly applied**.** From this follows that the nature of the learner, in this view of knowledge, is essentially receptive or passive[3]. (Freire 1996; Kincheloe 2008; Crysler 1995).

2 This method is deemed efficient, as from the head of one lecturer, contents flow to the heads of 200 or more students in tightly organised time slots.

3 The learner, in fact, has to assume an immobile attitude in the lecture theatre.

The studio, on the other hand, resists the transmission/application logic because its epistemological foundation is different of (and older than) the positivist epistemological foundation of the modern university. The studio is founded on the logic of practice in which knowing and doing intertwine (Schon 1985).The studio, thus, represents a different conception of knowledge and method of acquiring it. In the studio, knowledge is directly linked to the cultivation of a skill, design, that is not to be taught by means of verbal statements. Knowledge in this sense is not something that can be gained instantaneously and kept fixed in the head, but something that has to be cultivated. Knowledge in the studio is something that 'happens', or 'is done' (Michaels & Carello 1981). Consequently, the most appropriate mode of making knowledge available to students is by training and practicing. The system proves its effectiveness, not because learners are able to play back information from their memory banks, but because they are able to participate in the productive activity of their practice, design.

Remarkably, the epistemology of practice that characterizes the studio is very close to the reality that practitioners must confront outside the university (Schon 1985). In the studio, as in the reality outside the university, problems are more often than not uncertain, dynamic and unique. There is no standardized set of solutions from which students can choose the most appropriate one. Students, confronting these unique situations must generate answers 'on-the-spot'. In each situation, they must adapt, improvise, and survive. Though the studio is an attenuated version of reality (Schon 1985), it is a privileged training arena for the diverse and dynamic external reality, wherein knowing and doing merge into a single act.

Summarising, while the transmission-application system assumes that students need to 'know' first, and 'do' later, Designing, on the other hand, blends 'knowing' and 'doing' into a single act. This paradox motivated the following hypothesis: 'Environmental knowledge can be generated in the studio, by adopting the logic of design'. Putting this hypothesis in more specific terms we may say that knowledge concerning environmental issues can be gained by designing, that is the core practice of the studio.

1.2 Research Aims

The general aim of this research is to suggest a rationale for the implementation of environmental design in the studio within an ecological learning approach.

The specific aims are:

- To identify natural opportunities for integration within the nature of the design process.
- To define the role of physical modeling of environmental phenomena, in the process of learning environmental concepts.
- To understand the nature of the learner in the process of integration of environmental design in the Studio
- To understand the role of the studio, as physical learning environment, in the integration process.

1.3 Method

The research method chosen is a particular approach to grounded theory proposed by Glaser and Strauss (1999). This approach revisits the concept of fieldwork and assigns a predominant role to documentary research.

Qualitative data traditionally has two sources: Field and documentary. Fieldwork in social sciences is associated with data collection, interviews, and the like. And documentary is associated with the library material. Rarely is work in the library considered fieldwork, rather it is considered a background for the 'real' fieldwork.

Glaser and Strauss open a door to reconsider the bibliography as an element of analysis. To this end, some particular areas of the library should be seen as a research locale where the researcher can 'interview people'. 'When someone stands in the library stacks, he is, metaphorically, surrounded by voices begging to be heard. Every book, every magazine article represents at least one person who is equivalent to the anthropologist's informant or the sociologist's interviewee. In those publications, people converse, announce positions, argue with a range of eloquence, and describe events or scenes in ways entirely comparable to what is seen and heard during the field work. The researcher needs only to discover the voices in the library to release them for his use.'(Glaser & Strauss 1999, p.163)

In the current research, the voices of various thinkers have helped to understand the principles of an extended pedagogic experience of integration of environmental design in the studio. Among others, the voices of Donald Schon James Gibson and Tim Ingold, were essential to build the present understanding.

1.4 Thesis Outline

Chapter 1, Introduction (p. 6), discusses the problem, research aims, and method.

Chapter 2, Knowledge and Transmission Model of Education (p. 19), discusses in detail the positivist idea of knowledge on which the modern university is founded. It establishes a link between that idea of knowledge and the transmission model of education, of which lecturing is a manifestation. The Chapter helps to frame the problem of integration of environmental design in the studio, as a disconnection of 'knowing' and 'doing'.

Chapter 3, Void vs. Medium (p. 51), elaborates an interpretation of the concept of 'space as medium' as opposed to the concept of 'space as void'. This Chapter is relevant in that it discusses how one of the main concepts underlying architectural education -space- has defined a setting devoid of environmental attributes that, in turn, is responsible for a primarily visual approach to design.

Chapter 4, Understanding Ecological Learning (p. 73), discusses the ecological approach to learning. It comprises 5 sections. The first introduces the concept of animal-environment coupling, that is a central idea of the ecological approach. It also provides an illustration of cognitive coupling in the architectural learning environment. The second section deals with the relevant concepts of the operation of the animal-environment coupling. These concepts underscore the active nature of the ecological learner, and the role of the body in the learning process. The third section incorporates the idea of the intertwining between knowing and action (either as explorative movement or explorative manipulation). The fourth section discusses the concept of learning as an attunement of the learner to portions of his environment. The fifth section is concerned with the social learning setting.

Chapter 5, Design: an exploratory conversation (p. 115), is concerned with understanding the conversational nature of design. The Chapter comprises three sections the first of which sets out to situate Donald Schon's idea of 'design as a conversation' within a larger context of design models evolution. The second section discusses Schon's concept of design in view of extracting operative elements of the conversation that can be linked to a pedagogical strategy of integration. The third section discusses three relevant features of the designer's peculiar way of participating in this conversation.

Chapter 6, Situating Environmental Design in the Studio (p. 153), describes retrospectively the pedagogic experience of the Dynamic modeling Lab (DML) developed at the School of Architecture of the University of Santiago. This pedagogic experience provides further clues for understanding a project of implementation of environmental design in the studio. The Chapter describes four specific exercises developed by students at different levels of the course, addressing diverse environmental problems. It also discusses the idea of memorable place, that was central to the project of implementation.

Chapter 7, General Conclusions (p. 197) comprises 2 sections. The first, is concerned with the rationale of integration, namely 'situating environmental knowledge in an exploratory conversation', and the second suggests directions to implement the conversation from an ecological approach to learning.

Chapter 2. Knowledge and Transmission Model of Education

The choice of the studio as the locus of learning is based on a principle different of the transmission model of education, dominant in the modern university. The curriculum of architecture, however, divided in studio and lectures, tends to exacerbate the doctrine of transmission. In this context, knowledge, in particular that concerning technical subjects, is seen as contents to be poured in the heads of the students so that they can apply them in their design projects.

Environmental design traditionally deals with issues of thermal, visual and acoustic comfort in spaces designed by architects. Such factors can be measured and calibrated to standards, or, as CIBSE (2007) expresses, they can be 'controlled' so that the health and comfort of the occupants are assured. Environmental design is also in the architecture curriculum one of the modules orbiting the centrality of the design studio. Its function, like the other modules, is to provide knowledge to be applied during the design process of students in the studio. Knowledge in its case is deemed 'technical' and its location in the curriculum is labelled as such, following the traditional position of architectural science in modern studies of architecture. It is therefore a matter that is not usually associated with intuition or creativity, but with a proper application of knowledge in a technical-rational fashion. What this Chapter attempts to raise, however, is that the transmission of knowledge is inheritor of a a positivistic view that prevents students from producing it within the design and learning processes. This idea will be discussed in the following paragraphs.

With strong ties to science, technical rationality arose as a vision of professional practice in the 19th century in parallel with the establishment of the philosophical doctrine of Positivism. At present both technical rationality and Positivism, are widely discredited in philosophical circles, nonetheless in the realm of education, recent literature suggests that its principles are still sound and in full practice (Kincheloe 2008). By extension it is plausible to assume that in the teaching of subjects considered 'technical' in their own right, that tradition remains alive.

The epistemological assumptions of Positivism are relevant to this thesis, because its subject is the creation of knowledge through design, and the role of the educator in this process. Design, as will be apparent over the course of this thesis, is conceived here as a fundamental way of knowing, hence as research. This Chapter introduces two key issues. First, technical rationality, that arguably pervades in varying degrees the teaching of environmental design, and second, a teaching pattern known as Transmission Model of education. Both are inheritors of the same positivist epistemological doctrine. A doctrine that demands a peculiar attitude of the knower in front of the world to be known, characterized by distance and objectivity, hence ruling out intuition and personal involvement as a means of knowledge. A doctrine that also determines how the teaching of these objective truths must be performed. In particular, it defines the actors and their roles in the education business. These are, the producers of knowledge on the one side, and those who 'apply' it on the other, plus a third party -the teacher- acting as an interface between the two, enabling the transmission of knowledge.

In resurrecting some epistemological elements of positivism the intention of this thesis is not to call into question the evident benefits of minimizing misconceptions through the scientific method. The first aim is to underscore that a number of principles mistakenly transferred into the teaching of technical subjects in architecture have resulted in positivist teaching practices that hardly constitute a significant learning process for the student. Second, by introducing some relevant features of the positivist doctrine it will be possible to compare the acquisition of knowledge under this perspective, and the research process and eventual creation of knowledge through what in this thesis is called ecological approach to learning (cf. Chapter 4)

After examining technical rationality that underlies the practice of environmental design, it is argued that a positivistic epistemology makes the transmission model of education appear as the most appropriate and efficient teaching method of environmental design. This pedagogical model, nonetheless, eliminates the possibility of the student as producer of knowledge, particularly technological knowledge, favouring instead the consumption of it. This knowledge to be consumed has been previously produced by others who are considered the experts, hence the uniquely qualified to produce it. Such conception of knowledge, contrasts sharply with an ecological approach to learning, which this thesis is prone to. The contrast is manifest, at an epistemological level, specifically in the way that knowledge emerges in the learning process and is incorporated in the person as a whole mental and biological being.

The Chapter comprises three sections. The first examines the concept of knowledge from a positivist point of view. The second section addresses technical rationality and the influence it has exerted on professional practice and by extension on professional education throughout the twentieth century, arguably extended to this day. Finally, through the lens of Critical Pedagogy and based on insights of educators such as Henry Giroux, Paulo Freire and Joe Kincheloe, a critical view of the transmission model of education is introduced. Such a view, according to the influential educator Donald Schon(1991), is the inevitable culmination, though not beneficial in his view, of the positivist epistemology of practice or technical rationality.

In the following section four features of the epistemology of Positivism underlying the transmission model of education are discussed. This model, as it was mentioned previously in this Chapter, seems to be the best choice for teaching environmental design (a view that this research does not share), in part due to the organization of curricula, divided into technical knowledge on one side, and studio where this knowledge is **applied**, on the other.

2.1 Inquiry in a Positivist Light

Positivism emerged as a dominant doctrine in Western culture accounting for the triumphs of science and technology over mysticism and metaphysics during the 19th century. Heralding the doctrine was the prominent figure of Auguste Comte (1798-1857) who proclaimed its three fundamental principles. First, empirical science is not just a form of knowledge, but the only way to know the world. Second, we must eliminate all forms of false knowledge, this is, superstitions, myths, personal opinions, feelings, etc. Third, -perhaps the most significant principle in terms of practical implications in education- it is necessary to extend the technological knowledge to all areas of human activity, in order to make Technology, in the words of Comte himself, 'no longer exclusively geometrical, mechanical or chemical, but also and primarily political and moral' (Habermas 1986, p.77)

At present, however, the doctrine of Positivism is completely discredited in its own home of origin, the Philosophy of Science[4] , and as Thomas Kuhn (1996) and others have eloquently shown, scientists do not behave, as decreed by Positivism, alien to their social and historical circumstances. For this same reason it seems unjustified and obstinate to blame the epistemology of positivism as the main source of current educational inadequacy. Though what the proponents of a Critical Pedagogy have argued, is not that science is developed according to positivist precepts, but that such precepts, as apparently was the intention of Comte, have permeated all levels of culture, embedded 'in social life and hence... in the discourse, organization and practice of education' (Carr 1995, p.105)

Recent literature sustains that essential epistemological principles, of Positivist nature, continue to exert a great influence in maintaining the status quo of contemporary education. “This view of teaching and knowledge continue to hold sway as we move toward the second decade of the twenty-first century. Teaching practices... that do not hold **knowledge transference** as a primary goal -a key aspiration of Positivism- do not fit into reform scheme' (Kincheloe 2008).

4 Philosopher Richard Bernstein sustained that 'there is no single major thesis advanced by either nineteenth century Positivists of the Vienna Circle that has not been devastatingly criticized when measured by the Positivist' own standards for philosophical argument. The original formulations of the analytic-synthetic dichotomy and the verifiability criterion of meaning have been abandoned. It has been effectively shown that the Positivists' understanding of the natural sciences and the formal disciplines is grossy oversimplified. Whatever one's final judgement about the current disputes in the post-empiricist philosophy and history of science... there is rational agreement about the inadequacy of the original Positivist understanding of science, knowledge and meaning' (Bernstein 1978, p.207)

The assumptions of a positivist epistemology, it has been criticized, emphasize a kind of attitude to knowledge that, among other things, leads to determinacy (that there is a unique truth that can be known), impersonality (the more objective and the less subjective the better), and lack of reflection because in exclusively focusing on methods and outcomes it fails to ask any questions about the inquiry process itself (Usher 2001).

2.1.1 Distance of Knower and Known

Positivism proclaims that only the information produced in accordance to strict scientific standards can justly be called 'knowledge'. Thus, if the knowledge claim is based on observation and measurement, carried out systematically and methodically, and if rules of inference and logic confirmation have been used, then this is taken as valid or true and hence pertaining to epistemological “good grounds”. To be considered as such, the observed phenomenon should be seen as the same for all observers and the truth of its representation should be available to be evaluated by independently sampling it (Usher 2001) .

This assertion is grounded on a key assumption of Positivism the origins of which can be traced back to the Age of Reason in Europe[5]. This assumption posits a stark epistemological divide between subjects and objects, the 'subjective' knower and the 'objective' world. It also postulates a clear distinction between facts (related to the world and therefore pertaining to the realm of the 'objective') and values (which relate to the knower and therefore pertain in the realm of the 'subjective'). The researcher in this doctrine is concerned only with

5 According to Kincheloe (2008, p.159) the need for the control of nature, after suffering the catastrophic effects of the Black Death that wiped out nearly half the population of Europe, legitimized the separation between knower and known. Such split was reinforced with the advent of the age of Reason in the 16^{th} and 17^{th} centuries. The publication of the Discourse on the Method (1637) by Rene Descartes is for many, the milestone that defines the separation between knower and Known -res cogitans and res extensa- and settles a position of Man as opposed to natural phenomena.

the former[6]. The subjective (the researcher 's opinions and values) must not interfere with the end of the inquiry that is the discovery of “objective truth”. It is precisely the neutralization of the knower, in this doctrine, which allows the application of abstract reasoning to the understanding of the natural environment.

In order to obtain valid knowledge the researcher must stand clear from the phenomenon observed. By minimising subjectivity, and therefore bias, the legitimacy of the knowledge claim can be guaranteed. In this way, i.e. without the researcher's personal tinge, it is possible to obtain “a one to one correspondence between what 'reality' is and how it is represented on research” (Scheurich 1997, p.29). This, so called, correspondence theory of truth contends the existence of a direct relationship between thoughts or statements on the one hand, and things or objects on the other. It holds that the truth or the falsity of a representation in principle is determined by whether it accurately describes 'things'. Correspondence theory practically operates on the assumption that truth is a matter of accurately 'copying' the 'objective reality', and then representing it in thoughts, words and other symbols like mathematical formulas (Bradley 2004).The purpose of Knowledge production, in this view, is to bring forth objective truth by separating facts from consciousness and the values that inescapably accompany it.

Evidently the knowledge thus produced has nothing to do with the consciousness of knowledge producers. The knower is for this matter neutral or simply non-existent. The mere idea of a possible relation between the researcher and the phenomenon under study undermine the purity of the information to be found.

6 The term 'researcher' will be used to refer to a professional researcher, but also to designate the student of architecture in the design process.

In the context of education, Kincheloe sustains that the notion that the subjective experience of students might be taken into account as to make knowledge of the most value to them is dismissed as a misguided pedagogical concept. "The proposition is undebatable - the production of objective knowledge involves making sure that facts and personal views never intersect" (Kincheloe 2008, p.21)

2.1.2 Universal Knowledge

Positivist epistemology has been characterized as "unidimensional" and "universalist" (Kincheloe 2008, p.22). Unidimensional, because it is formed by the belief that there is one true reality that can be discovered and fully described by adherence to a correct method of investigation. And universalistic because it is grounded on the belief that "when strictly following the correct method... it applies to all domains of the world and the universe" (Idem, p.22). For this very reason, the positivist construction of knowledge is essentially decontextualized, not only built out of the different contexts of which it is part, therefore not acquiring meaning from them, but also at a distance from where it should be applied. From an ecological perspective of knowledge construction, on the contrary, the context is where knowledge becomes significant, furthermore "without context there is no knowledge at all" (Barab et al. 1999, p.382).

The producer of knowledge in a positivistic spirit aspires to build generalizations or universal truths. Generalizations have been considered "the highest level of research" and often, as the end to which all research must lead (Usher 2001, p.23). For a positivist researcher, data by their own are not considered of value. They get significance only when the researcher can derive descriptions from them, explanations, or preferably, generalizations. While descriptions answer the 'what' of phenomena, explanations answer the 'why' of these, which usually refers to their causes. The role of generalizations in turn is to explain the causes of the phenomena as well, however, the explanation aims to transcend a particular setting. What is relevant here is that this universality of knowledge becomes valuable precisely because it breaks away from a particular setting, making the application possible anywhere (Usher 2001). This positivistic tenet, sustains Donald Schon (1991), legitimises, though wrongly in his view, the technical rationality fashion in which practice is believed to be carried on, this is, as the simple application of a ready-made universal knowledge that practitioners can select from a set of possible responses.

2.1.3 Fragmentation of reality

One of the essential methods of Positivism to understand the complexity of the world is the fragmentation of reality. This idea is founded on the assumption that the world is basically an inert, static entity that can be classified and organized for the purpose of control. Supposedly, because of its very inert nature, fragmentation would not have the lethal effect it would on live organisms when dissected. Critics of Positivism have long noted, however, that the fragmentation of the world, like the tethering and dissection of an animal in the laboratory, extinguishes its life. Thus, the subject of study, in the beginning alive but now dead, is transformed into a completely different thing of what was initially intended.

The fragmentation and microfragmentation of the world is expressed with particular eloquence in the compartmentalization of information in various disciplines and sub-disciplines that the educational business has assembled. In order to fragment information, 'the epistemological and ontological messiness of the reality (must be) cleaned up, ordered, collated, and stored in neat packages readied for easy delivery' (Kincheloe 2008, p.168). So in the teaching of architecture, for example, environmental design is imparted at a safe distance from Humanities with which a conversation is, if not inconceivable, at least scarce. And also separated physically and temporally from the studio, where the design process occur. Paradoxically, though not evident to everybody, it is in the studio where the technical-environmental knowledge, previously transmitted to students in a rather fragmentary fashion is expected to be creatively, or at least, properly applied by students. This means that students, not the educational system, are supposed to be accountable for integration.

Microfragmentation, sustains Kincheloe (2008), has a devastating effect on how the student understands the world and finally acts upon it. This is his eloquent statement. "Standing before this fragmented cosmos where all wholes are reducible to their smallest components, humans loose their sense of meaning and their will to act. The affective dimensions of knowledge are ripped apart, the complex orders in which data patterns emerge are lost, and interpretive insights that allow us to discern our personal relations to the world are dismissed as knowledge is reduced to mechanistic fragments to trivial truth statements that mislead more than enlighten". The fragmentation of disciplines and sub-disciplines, says Kincheloe, with their inability to even communicate with one another has created a disjointed information system. The fragmentation, of course, is not the responsibility of the teacher, but of the whole educational system that often imposes certain number of credits against specific disciplinary domains.

The idea of fragmented knowledge leads to the fourth point of this section, namely knowledge as a discrete substance that can be transferred. This is a contested concept in studies of how people know and learn. While conventional trends in cognition tend to align with the idea of knowledge as an object, the ecological approach tends to align with an idea of knowledge as the product of practice. Thus, the first legitimises the transfer of knowledge and the second legitimises the emergence of knowledge in practice.

2.1.4 Knowledge as a transmittable entity

Fragmentation of knowledge and its 'packaging' makes possible the pedagogical mechanism most closely identified with the positivist epistemology. This is the so-called transmission model of education discussed in page 38. In the logic of the transmission, the ontology of knowledge is a discrete substance that individuals can posses 'in-the-brain', in measurable quantities (Michaels & Carello 1981). Perhaps even more relevant from a pedagogical point of view, it can be transmitted from mind to mind.

This transmission is always from the minds of individuals who 'posses' more knowledge into the minds of others who 'posses' less. In conventional education this scheme invariably designates the teacher and the student respectively, never the reverse. Likewise it is possible to transmit knowledge from mind to mind, it is also possible to transfer knowledge contained in objects, for example books, to the minds of people. Whether from mind to mind or from object to mind, this process involves the traditional and, from a learning perspective, controversial mechanism of memorization of contents. The mind, in this instance, acts as a sort of file cabinet where 'knowledge' can be stored for later use, frequently becoming 'inert', as Whitehead (1916) criticised more than 90 years ago. This practice has been also criticised nowadays as a form of “stupidification” of the student in the hands of the education system that equate learning with memorizing (Kincheloe 2008 after Macedo 2006).

Knowledge, understood in this terms, i.e. as an object contained within the confines of individual minds, contrasts sharply with what an ecological approach to learning postulates. Suffices to say by now that for the latter, knowledge is not something that individuals have in their heads[7], but something that an agent-in-the-environment is continually gaining. This distinction is of key relevance to the activity of knowing through design, or as Nigel Cross has termed it 'a designerly way of knowing' (cf. Chapter 5).

In this first section four traits of the epistemology of positivism have been briefly outlined. It is argued in this thesis that they still underlie the pedagogy of technical subjects in architecture. This description has included part of the criticism Critical Pedagogy has made. Such criticism will be discussed later, in the section Transmission Model of Education (p.38). A topic directly related to the epistemology of positivism and closely related to the teaching of technological subjects should be introduced first. Technical Rationality, identified by Donald Schon as “the positivist epistemology of practice”(Schon 1991, p.163).

2.2 Technical Rationality

Literature on implementation of environmental design in the studio tends to assume as a given its location within the technical 'side' of the curriculum. The existence of 'sides' in the curriculum, also suggests the existence of attitudes in

7 The idea that knowledge is a self-contained process in the confines of individual minds is a cognitivist premise that draws on the metaphor of the knower as an information processor, in turn based on an objectivist epistemology.

order to confront assignments. One of this attitudes is the technical rational, based on rigorous application of principles.

Such rigid characterization has been challenged by Donald Schon, who sustains that the boundary between technical rationality and design blurs, and eventually disappears, when designers confront problems in real situations. Designers typically have to provide responses 'on the spot'. This gives way to what he terms 'reflection in action', which is an indistinguishable blend of thinking and doing[8]. Schon observes that this is an essential feature of all practitioners, but it is particularly clear of designers.

The curriculum of architecture, however, legitimises and perpetuates the contrary, the distinction between technical rationality which embodies the application of received knowledge, on the one hand; and design, on the other, which potentially embodies the creation of knowledge .

However, apart from the obvious temporal and spatial wedge that curricula introduce between the technological and design, in what sense technical rationality complicates the integration in the studio? Next, based on the work of Donald Schon, some contextual elements of such a view, and its close ties with positivism, are introduced. This will help to outline a possible answer, and also to explain the predominance of the transmission model of education in the teaching of technical subjects.

2.2.1 Positivist origins of Technical Rationality

In his influential book "The reflective Practitioner", Donald Schon asks what

8 This issue has been recently addressed by a number of authors in diverse fields. Among others, Juhani Pallasmaa (2009), F. R. Wilson (2000), R. Sennet (2009)

circumstances have raised the logic of Technical Rationality to the special place that it has in our educational system. The answer that Schon himself elaborates is simple and direct. Technical Rationality has co-evolved with the doctrine of Positivism. Likewise Technical Rationality, Positivism sees the application of predefined scientific theory to instrumental practice problems as the validation of knowledge. Having scientific credentials -incontrovertible at that time- it was institutionalized in the modern university during the late 19th century.

For Positivism there were basically two kinds of meaningful statements. First those of analytical or logical mathematical basis, and second those of empirical basis. Both were deemed valid expressions of 'knowledge of the world'. Propositions that were neither empirically testable nor analytically describable were dismissed as emotive utterance, poetry, or mere nonsense'(Schon 1991). As well as the observed world grew in complexity, Positivism had to increase its level of sophistication in order to justify the primacy of scientific knowledge. This led to its proponents to create 'constructs' for explaining the observed phenomena. Science thus became primarily a hypothetical-deductive system[9]. "In order to account for historical observation, the scientist constructed hypotheses, abstract models of an unseen world which could be tested only indirectly through deductions susceptible to confirmation or discomfirmation by experiment". The heart of scientific enquiry consisted in the use of crucial experiments to choose among competing theories of explanation. The connection point of Schon's analysis and the present thesis is what he raises next.

The theoretical-deductive scientific model, not only determined a way of doing science but a way of carrying out professional practice as well. As there is a set of theories to explain a phenomenon, expressed as universal truths, positivism

9 Schon uses the expression hypothetical-deductive system, as used by Karl Popper (2002).

proclaimed a relationship between means and ends that works as follows. Once ascertained the ends, the practice is reduced to a purely instrumental choice of appropriate means according to the theories provided by experts in producing knowledge. Even moral questions could become soluble by the best means selected from the set provided by science.

In the spirit of positivism, professions aspire to be vehicles of progress through the application of scientific knowledge and therefore away from the apprenticeship system and avocational practice. Schon coined the term "technological program" to refer to the process of technologisation in various professions, as engineering, closely tied to technological development[10]. Medicine, for example, distanced from its ancient origins and even more from its medieval period, to reinvent itself as a "science-based technique for the preservation of health"(Schon 1991). Or statecraft, an area often thought adamant to mechanistic thinking associated with technology, is reinvented as social engineering. Great and resonant developments within the professions of engineering and medicine in the late 19th and early 20th century eventually reassured Positivists in Western society. Both professions became prototypes of the science-based practice that had emerged as the logical replacement of craft and artistry, no longer valid sources of knowledge.

10 In a compelling reflection, Tim Ingold (2000f) has suggested that this process of technologisation, may be seen as 'a progressive cutting out of technical from social relations', en consonance with the thinking of Jane Lave(Lave 2009).

2.2.2 Predominance of theory over practice

> "Objectivism, which sets out to establish objective regularities (structures, laws, systems of relationships, etc.) independent of individual consciousnesses and wills, introduces a radical discontinuity between theoretical knowledge and practical knowledge" (Bourdieu 1992)

> "It is the marriage of theoretical knowledge with practical action which characterizes education" (Shulman 1986)

Some educators have strongly advocated the development of a "quantifiable body of knowledge" in the discipline of architecture. They often call for a dramatic departure from the paradigm of Art on which the profession and its training are based upon, to one based on science and research (Salama 2009).

While this appeal seems quite sensible, especially if we take into consideration the environmental indolence of part of the current architectural production, it implies adhering to a view that separates knowledge from practice, or knowing from doing. The effect of this divide is for other scholars who have investigated the production of knowledge linked to practice considerably harmful. (Lave & Wenger 1991; Lave 1988; Bourdieu 1992; Ingold 2000e; Schon 1991).

In Schon's view, for instance, this separation is the basis of what he calls the 'positivist epistemology of practice', of which a concrete expression is technical rationality. Technical rationality has been, he sustains, nothing less than “the view of knowledge which has most powerfully shaped (...) the institutional relations of research, education, and practice”. The essential premise of this view of professional practice is the existence of a **theory** underlying a specialized **skill**. A profession, it is believed, differs and is superior to an avocation, because the latter does not possess such a body of theoretical knowledge. It is based instead upon “customary activities and modified by trial and error of its individual practice” (W.E. Moore quoted in Schon 1991, p.56) .

Trial and error, however, is an essential way of knowing (Popper 2002). In a purely rational technical logic, on the contrary, professional practice is assumed to be an 'instrumental problem solving made rigorous by the application of scientific theory and technique'. Here, knowledge has been prepared in advance, it exists before practice begins, obeying an epistemological hierarchy in which general principles occupy the higher rank and concrete problem solving the lowest.

The relationship between knowledge base and practice is, therefore, of mere 'application'.Schon describes the trade among the actors of this hierarchy as follows, “the application of basic science (basic standing for fundamental), yields diagnostic and problem solving techniques which are applied in turn to the actual delivery of services”. Such a model, he sustains, is embedded in the “institutionalized relations of research and practice”. Institutions tend to separate the researchers from the practitioners, raising the former to a higher level and hence establishing an asymmetrical transaction. The researcher is expected to provide fundamental science, from which solutions can be derived for the practice; while practitioners are supposed to furnish researchers with problems from their own activity.

This predominance of theory over practice is manifest “in the normative curriculum of professional education” as well, as can be seen in the way that professional schools reproduce the order of application of knowledge. The relevant and applied science is imparted as a prerequisite, and only after that the skills of application to solve real world problems come into play. The curriculum thus institutionalizes the model of Technical Rationality when defining the 'real knowledge', in a positivist conception of it, as pertaining to theories and techniques of fundamental science. In this logic, theoretical knowledge must come first. Skills to solve concrete problems should come later on, once the student has learned the relevant science. This is assumed as such, first because it is believed that the students can not learn skills of application before they have acquired the knowledge to apply it, and second because practical skills, in a logo-centric perspective, are not considered knowledge at all. This phenomenon is related to the logo-centric obsession in modern Western culture from which the teaching of technology seemingly has not escaped. The term technology, as we know, consists of two words of the classical Greek, logos which roughly refers to theoretical knowledge and techne that could be related to knowledgeable practice. Although the very term technology is trying to blend these two aspects into a single expression, the teaching of technology, in architecture at least, tends to be presented to students mainly in a logo-centric fashion.

2.2.3 Exchange of knowledge for problems

In the institutions of education, particularly in the modern university, the epistemology of Positivism found fertile ground in which to apply their ideas about an appropriate division of labour. In contrast to the lower vocational schools dedicated to inculcating knowledge and useful habits to be used in the "fabric of workday life", the University was intended to 'fit men for a life of science and scholarship'. This belief would determine a relationship of epistemological ascendancy between high and lower schools that can be described as follows: while practitioners from the lower schools provide scientists with practical problems, higher school scientists, the only entitled to produce valid knowledge, are required to respond with theory, principles, and preferably generalizations, to be applied in particular situations. The relationship in short is one of exchange, but a deeply separated and asymmetric one.

By mid 20th century almost every profession had enter the university system, not without making a big sacrifice, sustains Schon. This was, accepting the positivist epistemology of practice, which in short introduced a division between those creators of knowledge on the one hand, and those who have to apply it on the other, in crude contrast with the old notion of knowledge created by practitioners via the very practice. Thus, the main function of the non-scientific professional schools was defined, as mere **transmitters** of information.

As a summary, Schon sustains that the positivist epistemology of practice rests on three dichotomies, in his own words, "Given the separation of means from ends, instrumental problem solving can be seen as a technical procedure to be measured by its effectiveness in achieving a **pre-established** objective. Given the separation of research from practice, rigorous practice can be seen as an **application** to instrumental problems of research-based theories and techniques whose objectivity and generality derive from the method of controlled experiment. Given the separation of knowing from doing, action is only an implementation and test of technical decision"(Schon 1991, p.165)

What is relevant to point out at this moment is that the studio becomes an anomaly in the current educational system, because among other things, remains reluctant to accept ready made knowledge, and prefers instead the creation of knowledge via practice.

In the next section the transmission model of education is introduced. This model shares with Technical Rationality a positivist epistemological base.

The following discussion is partially informed by the movement of Critical Pedagogy which represents a counterpoint to the transmission model of education. Although Critical pedagogy does not seek a radically ecological model of education, advocates have developed arguments that this thesis adheres to. In the centre of Critical Pedagogy there is a concern for the formation of the student as an integral human being, being this a precondition of the formation of knowledge.

2.3 Transmission Model of Education

> 'Learning transfer is assumed to be the central mechanism for bringing school taught knowledge to bear in life after school' (Lave 1988)

> There is little (in the transmission model of education) that encourages students to generate their own meanings (or) to capitalize their own cultural capital.
>
> (Giroux 1997)

John Habraken (2005) has documented the work of Andrea Palladio (1508-1580) as an early milestone in the internationalization and standardization of architectural design on the planet. Via repr oduction of his austere but beautiful technical drawings, in books of his own authorship, Palladio's architectural production transcended physical and temporal boundaries. His published work could be considered as an early case of transmission of architectural knowledge, regardless of the context where this 'knowledge' was to be applied.

Nowadays, despite the different physical and cultural realities of our planet, the formation of the architect tends to follow the same model across most of countries. This standardization has reached the highest levels and allows an architect trained in one place of the planet to be a practitioner in another completely different, without major problems more than legal accreditation (Salama 2009). Such an orientation toward a professional standard defined by a set of skills and knowledge, has largely been determined, by the pedagogical model known as 'transmission model of education', based on a positivist notion of knowledge.

While positivist principles are not unwanted in all situations, for they intend to promote a search for knowledge without prejudice, Critical Pedagogy advocates have noted that this search for objective knowledge completely valid in the laboratory, applied now in the classroom, has been mistaken for 'objectivism', which is in the view of educator Henry Giroux (2005) "the cornerstone of the culture of positivism in education". In his view, "If objectivity in classroom teaching refers to the attempt to be scrupulously careful about minimizing biases, false beliefs, and discriminating behaviour in rationalizing and developing pedagogical thought and practice, then this is a laudable notion that should govern our work. On the other hand, objectivism refers to an orientation that is atemporal and ahistorical in nature". In Giroux's view the objectivation of knowledge, characteristic of a "positivist pedagogical model (is)parallel with the objectivation of the students themselves" (Giroux 1984, p.56). For this schooling system the student is perceived as "blank screens ready to receive unmediated transmissions of skills and information as delineated by experts" (Giroux 1988 quoted by Crysler).

Referring to schools of architecture in particular, Crysler points out that "proficiency is therefore associated with the amount of knowledge absorbed by individuals"(Crysler 1995). This, in conjunction with the curriculum structure, leads to a pronounced stratification of the school which, rather than being a typical centripetal structure of a community of practice (Lave & Wenger J. 1991), becomes sharply stratified. Novice students are believed to 'posses' less knowledge than their colleagues in higher years, and much less than their instructors. "First-year students [...] are relatively isolated from those in upper years because of their comparative 'emptiness' as vessels of knowledge" (Crysler 1995, p.210).

Such objectivist conception, which is predominant in the traditional didactic system, or transmission model of education, is evident in the distance among the actors involved in the educational process as well. The knower is isolated from the known, as it is knowledge separated from the action. But also the student is separated from the teacher who, far from being a facilitator of the process of knowing, or better yet, another knower from a different position, is assigned to fill the minds of the students with knowledge.

2.3.1 Empty Vessels

The etymology of the word education derives from the Latin verb 'educere' which in turn is formed by the words, 'ex' meaning outside, and 'ducere' meaning 'to lead' (Klein 1969, p.501). The expression 'to educate' originally meant, then, to bring-out, as in the phrase 'you bring out the best in me'. By extension a good educator is one who is able to draw out the best in people. This is not, however, the most common image we have of the people responsible for formal education, the teachers, but almost the opposite, i.e. someone who 'has' a wealth of knowledge and is capable of transmitting it to students. “When (students) have the same statements in their heads as the teacher, it is presumed that they 'know' something” (Bredo 1994a, p.1).

One of the objectivist metaphors most frequently used to describe the student and knowledge in the transmission model of education is that of 'vessels' that must be filled. The students, or more precisely the minds of students, are those vessels, and the person in charge of filling them with knowledge is the teacher. This view is grounded on the assumption that students entering school are empty vessels, empty at least of the knowledge that is considered relevant. In this regard Gelernter points out the following.

> “This treats the mind like some kind of simple filing cabinet. The cabinet is empty when a student begins the course it is usually assumed, and it is the job of lectures to provide folders labelled "environmental behaviour," "structures," "services," "history and theory," to fill these folders up with the appropriate general principles and bodies of knowledge, and then to place them in correct sequence in the mental filing cabinet where they can easily be found again. Later

> in the studio, when the student faces a practical design problem for the first time, he or she simply reaches into these mental folders and retrieves the material which will help in the solution of the practical problem at hand. The entire procedure is assumed to happen sequentially: first the folder is introduced, then filled and filed, then retrieved from”. (Gelernter 1988, p.47)

The educational function of the school then is to assure the proper filling of the vessels with knowledge and consequently the first concern of the teacher consists in the transfer of this knowledge. So the teacher, despite being permanently 'emptying' his mind, must keep it paradoxically replenished. This is so because being full of knowledge is precisely the teacher's value to educational institutions. “Teachers are employed by educational institutions as full vessels of knowledge whose value can be attributed directly to the academic institution” (Sande Cohen quoted by Crysler 1995). The metaphor, therefore, not only portrays an objectification of the stufdent as a container, and of knowledge as a discreet substance that is transferred, but of the teacher as well, who is the agent that performs the transfer.

Due to the hectic dynamics of a changing world, however, the 'fullness' of this provider of knowledge can hardly be maintained at the top. This push him to feed himself with 'knowledge' prepared in advance, 'lessons written by textbook companies or commercially produced software'. 'The teacher is thus 'deskilled' as educator and his/her function is reduced to answering questions, distributing materials and time, or at best to monitoring the correct reproduction of knowledge previously delivered to students, now bouncing back from their minds. Notwithstanding, the role of teachers, even in this diminished role, should not be overlooked. They are still the filter through which the world enters the consciousness of students (Kincheloe 2008)

A number of metaphors have been issued to represent the transmission model of education[11]. The influential Brazilian educator Paulo Freire, for example, has argued that this educational system is like a bank transaction, specifically an act of deposit, in which students are the depositories and the teacher is the depositor. The deposit rate proves the efficiency of the teacher before the system. As a counterpart, students prove their suitability as good depositories, the more they meekly accept the deposits. For critical educators the only margin that this system offers to learners is to receive deposits, store and archive them. Margin that only allows them to be collectors of things to be archived.

> It follows logically from the banking notion of consciousness that the educator's role is to regulate the way the world "enters into" the students. The teacher's task is to organize a process which already occurs spontaneously, to "fill" the students by making deposits of information which he or she considers to constitute true knowledge. (Freire 1996, p.57)

2.3.2 Empty Vessels in the Studio

The mechanism of filling of vessels in our discipline is associated first with the transmission of theory by lecturing in the modules surrounding the studio. While the lecture epitomises the transmission model of education, the studio is assumed to epitomise the free and creative learning environment. This

11 A case in point is Ken Robinson (2010) who claims that 'we have built our education on the model of 'fast food'that is impoverishing our spirit and our energies as much as fast food is depleting our physical bodies'... we have to move from an industrial model of education, which is based on linearity, and conformity, and badging people, to a model which is based on principles of agriculture. We have to recognise that human flourishing is not a mechanical process, it is an organic process'

assumption is, however, an idealistic view that has been challenged by some authors (Crysler 1995; Yanar 1999; Yanar 2007; Webster 2008). They sustain that, contrary to what we think, an underhanded process of transmission is carried out in the studio that is so embedded in the current process of architectural training that has become invisible (Yanar 2007). This process is not new though. More than three hundred years of history of our discipline would reveal that, at least since its origin in the French academies, architectural training has been a laborious process of transmission, either ideology driven or controlled by spheres of power[12].

What is important in this account is the connotation of an eventual transmission model of education in the studio where students allegedly express and create more freely. Unlike the transmission that takes place in the classroom, the one of the studio has an aggravating component that should not be overlooked. The student here is not a blank screen, on which the educational system could start from scratch, as criticised by Giroux, but something much more problematic in the culture of architects' education.

The novice student, comes with an already rich biography of at least 18 years, experiences, opinions, visions, knowledge, etc. Such knowledge and experience, however, is perceived in our school culture as 'non architectural' or "unsophisticated" (Yanar 2007). To solve this dilemma the metaphor of the vessels still works, but now perversely reversed. Students must first be emptied of their 'non architectural' and 'unsophisticated' knowledge, so that, in this necessary state of emptiness, may become suitable for filling with the relevant one. Students are so led to a "state of intellectual infancy"(Crysler 1995), or

12 L' Ecole de Beaux Arts in Paris emerged as profession system sponsored by French monarchy, as a merger in 1793 of the Académie de Peinture et de Sculpture, founded by Charles Le Brun in 1648, and the Académie d'Architecture, founded in 1671 by Jean-Baptiste Colbert.

"innocent eye" (Varnelis 1998). In this way the experience of first year students who have been living in and around buildings for 18 years, visited architectural spaces, urban realms, consciously or unconsciously have enjoyed the characters of spaces (or places), is unfortunately discarded.

2.3.3 Packaged knowledge

> "The function of the professional school would be 'the **transmission** to its students of the generalized and systematic knowledge that is the basis of professional performance" Everett Hughes quoted by Donald Schon (1991)

> Education "is not the reproduction of the past through cultural **transmission**, but as the formation of new identities that can take its history of learning forward" Etienne Wenger (1999)

The education of architects is not an exception in the transmission model widely implemented in the modern university, except perhaps in regard to the design process that is when students potentially generate knowledge. Excluding the design process, the rest of the curriculum can be seen as a standardized procedure of transmission that occurs within an institution ad hoc: the school of architecture. As in the first French academies, the training of the architect today is governed by professional standards that are safeguarded by the schools. As a result of this, students can receive a set of "standardized credentials" which act as a professional exchange value that can be commerced in the labour market (Woods 1999; Larson 1978).

Essential for the transmission is the construction of a valid canon of knowledge (Kolbas 2001). Knowledge under the precepts of a canon is unequivocal, a corpus of 'the known' in sharp contrast to other pedagogical visions constructed in and through the difference (Kincheloe 2008). Elaborated information is taken up (preserved, disseminated, taught) and confront its **receptors** first as canonical, becoming often an ideology (Guillory 1995, p.30). The canon thus, "not only represents the ideological core, is also an institutional process through which the institutions govern the disclosure of knowledge" (Guillory 1995). Knowledge in this process is formalized, rationalised, transformed into disciplinary knowledge and deposited in the dominant canons of university knowledge as it is categorized and codified (Yerbury & Kirk, 1990). Thus, knowledge that often resists neatness and tidy classification is transformed into compliant academic information. As a result, the appearance of the transmission system is a coherent ensemble, unified by the professional objectivity and the banishment of the difference to a private sphere.

In the efficient management of knowledge, the temporal structure of the curriculum plays a fundamental role. In order to achieve that efficiency, knowledge must be limited to discrete and controllable units, or 'packages of knowledge'. In the process of packaging, reality needs to be decoded and recoded in chunks that are more functional to the time of transfer. "What is worth studying, teaching, talking about (appears as) what can be best parcelled out into fourteen or ten-week format" (Spivak 2008). In other words, the time set by the same curricular culture leads to define much of what should be taught (transferred) and how this process should be carried out, being curriculum structure and canon, reciprocally reassured. In the particular case of architectural studies this is compounded by requirements of accreditation and professional bodies, such as ARB and RIBA, who prescribe packets of knowledge to be delivered in the form of credits that are assigned a certain amount of contact hours and time for student led learning.

The consumption of knowledge, says Crysler, is expected to be correctly applied in the studio, but occurs at a frantic pace in which students are left very little time to develop a critical stance, one that may raise doubts about the premises of their own learning process. Such an atmosphere is certainly conflicting (Crysler 1995, p.212)

In the particular case of architecture teaching, the usual structure of the curriculum works as a satellite system, or clusters of specialised knowledge, in terms of Woods (1999), which hover around the centrality of the studio. This configuration exacerbates the knowledge transfer system, for the studio becomes essentially the place where theoretical knowledge is **received**, particularly that knowledge from areas considered more arcane and extraneous, such as building sciences; or from areas supposedly more familiar, such as Humanities. The studio ends up being a sort of receptacle where knowledge is consumed, applied, and hopefully implemented. The implementation is considered successful when students demonstrate that technical subjects have been resolved according to the information previously delivered. On a closer look, unfortunately, this 'implementation' runs the risk of intensifying the divide, for information just passes by the students, it is not produced by them in their involvement with their main activity, design (Salama 2009).

From the canonical nature of knowledge in academia follows the last point, but no less important given the prominence of creativity in a discipline like ours, that claims to promote it among its students. The inverse relationship between the incontrovertible information, and creativity.

2.3.4 Passivity vs. Creativity

> "Believing that there is one certain truth about (any matter) prunes our imagination, our ability to discern more complex visions. The quest for certainty is an imagination buster". Kincheloe 2008

Referring to the education of the architect, Salama (2006, p.166), sustains that one of the worst scenarios to induce critical thinking is "when educators attempt to offer students ready made interpretations about the physical world in lectures and seminar classes, leading to students' inability to think critically or develop their intellectual skills. This handicaps their abilities to gather, analyse, synthesise, and process different types of information". This seems to be, unfortunately, what usually happens with theoretical knowledge that confronts students as accepted and stabilised body of knowledge or canon.

In the same sense, but referring to general education, educator Paulo Freire (1996) sustained that "since people in the transmission model 'receive' the world as passive entities, education should make them more passive still". In his, criticism of the transmission model, or banking model as he terms it, Freire, while not referring specifically to the teaching of architecture, offers several reflections on creativity and knowledge. The transmission model, with its objectivist basis, tends to reaffirm a passive person, or at best, a person who acts prescriptively, instead of one who questions, or acts on his own. But Freire goes further and suggests an educational ethos that links research, practice, creativity, and transformation.

These are Freire's words in this regard. "Apart from the search, apart from the **praxis**, men can not be (...) in this distorted view of education, there is no creativity whatsoever, neither transformation, nor knowledge. There is knowledge only in the invention, in the reinvention, in the restless, eager inquiry, that men do in the world, with the world and with others" [13] (Freire 1996, p.57) .

Three aspects in Freire´s message are indispensable for a meaningful education and are consistent with an ecological learning approach. First, creativity is not only the expression of the individual genius of the artist who gives to others the product of his brilliance, but the transformation of himself in his very practice, that is simultaneously an act of learning. Students are creative as long as they can transform themselves, and this occurs when they can act on their own initiative. Moreover, quite in accord with an ecological approach, his conception of learning is inseparable from acting. By failing to act on their own initiative students themselves are not transformed, they stop being. The act of learning as such is an act of self-transformation while acting, which goes hand in hand with a state of restless search, as Dewey foreshadowed more than 50 years ago. Second. The acting of man is in the world and with the world, an issue that could be interpreted in our case as an acting 'in the environment' (physical and social). Third, the creative act of knowing is not an individualistic one, but emerges from the interaction of the individuals and their environment of practice.

2.4 Conclusions Chapter 2

The three topics discussed in this Chapter are closely related and their

13 Author´s traslation. "Al margen de la búsqueda, al margen de la praxis, los hombres no pueden ser... en esta visión distorsionada de la educación, no existe creatividad alguna, no existe transformación, ni saber. Sólo existe saber en la invención, en la reinvención, en la búsqueda inquieta, impaciente, permanente que los hombres realizan en el mundo, con el mundo y con los otros".

boundaries blur, as if they were only facets of the same phenomenon. The first, about how knowledge is conceived in a positivist light and how, despite being discredited in the philosophical and scientific realms, is still central in education. The second, about technical rationality that separates practice from knowing. And third, the transmission model of education which, despite a permanent criticism from educators, remains the dominant pattern in education, perhaps as Kincheloe suggests, because it is a system that best accommodates an efficient data transfer that a profitable education model requires. The central dichotomy of positivism -knower from known- resonates in the three topics. A dichotomy that sees knowledge as an integral and self-sufficient substance, theoretically independent of the situations in which is generated.

The relevant aspect of this dichotomy in the context of this thesis is that it implies a separation between knowing and doing. This separation is reproduced and deepened by the curricular structure of our discipline. In almost all schools of architecture, theoretical modules orbit the centrality of the studio delivering packaged knowledge, loosely connected with its implementation in the studio (Gelernter 1988). The studio, consequently, becomes the place where such knowledge is only applied, not generated, replicating the dichotomy between knowing and practising that Donald Schon criticizes of technical rationality.

Finally, the transmission model of education seems to exert a negative effect on students' creative process. While fragmentation freezes the creativity of an active student, objectification and detachment neutralize them as producers of knowledge. This is in sharp contrast with an ecological approach to learning, in which learning occurs and become meaningful in the context of practice (Barab & Roth 2003).

Chapter 3. Void vs. Medium

Integrating environmental attributes in the design process of students is often a challenge for educators in architectural training. One of the reasons for this is the fact that environmental phenomena are generally invisible. In addition, the practice of architectural design has developed within a predominantly visually oriented, or *ocularcentric* culture (Pallasmaa 2005). Being invisible is often equivalent to simply 'non being'. Such circumstance is reinforced by the idea of space as equivalent to void that is communicated to students in the initial years.

In 2003 the author of this thesis published the article 'Visualidad e Invisibilidad' (Martinez 2003) in the journal of the School of Architecture of the University of Santiago, 'Arteoficio'. That article suggested the metaphor that architectural space should be treated as the liquid *medium* of a fishbowl, and that the architect should be as concerned for the quality of this medium as the owner of the fish normally is. This characterization of space as medium inspired various studio exercises developed at that school of architecture, in particular some assignments related to natural convection, and wind flow.

This Chapter discusses the concept of space as medium through the description proposed by James Gibson(1979), in opposition to the concept of space as void that prevails in schools of architecture. A reflection on the implications that both have in the incorporation of environmental phenomena in the design process is offered. The concept of space as void, it is argued in this thesis, has lead architects to an oversimplified understanding of the terrestrial environment that complicates the incorporation of environmental phenomena in the design process. The concept of space as void neglects the dynamic nature of the atmospheric plenum in which the architect has to operate. This is relevant in terms of learning, because the kind of environment that is shown to students determine the way they act upon it. If the terrestrial environment is described to them as *bodies in space*, and if in addition that space is described as a homogeneous *void*, it is not surprising that environmental phenomena, other that visual, are neglected.

3.1 Void Space

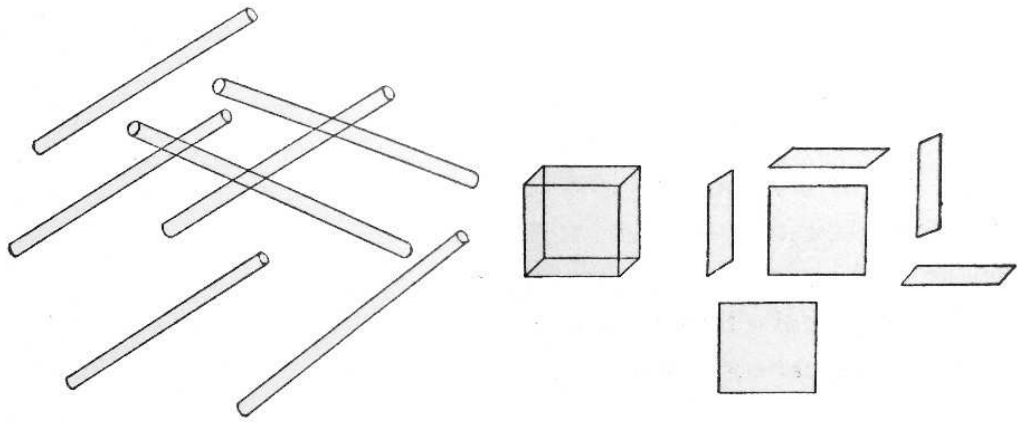
> "Architecture has the monopoly of Space... it can surround us with a void of three dimensions" Geoffrey Scott
>
> "Buildings that have a strong impact: always convey an intense feeling of their spatial quality. They embrace the mysterious void called space in a special way and make it vibrate.(Zumthor 2010, p.22) .

Among the *knowledge* students are expected to acquire in their first year in most schools of architecture is the language of space that is accompanied by the actual manipulation of bodies in space. For many this is viewed as a basic skill of an architect. Students must learn to shape space, delimit it, and divide it. This manipulation does not only concerns the floor space, but the three basic dimensions of Cartesian space that is by definition isotropic and homogeneous.

Students must be able to anticipate, in their minds, its basic classic attributes of 'form' and 'extension'. With practice this turns into an indispensable skill, essential for their current and future practice. This happens for a reason. Designing in architecture is, but obviously not exclusively, distributing space in three dimensions to accommodate objects, people and activities.

In this discussion, it is worth recalling briefly how 'space' was conceived when it entered the realm of architectural education, in Germany, in the 1920s. At that time Laszlo Moholy-Nagy, in charge of the influential Bauhaus, made of space the focus of its curriculum. This episode is important because it is also a moment of rupture between visions of architectural space, that later spread from Germany to other schools over the world. German architects at the time, adhered to the idea of space as 'enclosure', a somehow environmental oriented concept, postulated by Gottfried Semper. The new idea, promoted by Moholy-Nagy and others, posited instead the idea of space as a compositional element, departing drastically from Semper's view. The generation of space is described by Moholy Nagy in these terms: "if the side walls of a volume are scattered in different directions, spatial patterns, or spatial relations, originate,"(Moholy-Nagy 1947, p.92), so that "in the voids between them is created a continuum of space that runs through buildings and connects the inside with outside" (Forty 2000, p.267).

This conception of space, Forty suggests, has nothing to do with materials, in the plural, but with one generic material, as if steel, timber, stone, or any other could be replaced by a single substance, of which its delimiting capacity of the void is the only requisite to participate in the compositional play of spaces . In this way, the elements to be manipulated become of two unique kinds. The mentioned generic material on the one hand -geometrical planes and lines that will be assigned a name and nature at some point in the design process- and a generic space, or void, as Forty denominates it, on the other.



34. Space relationship created through the position of rods.

36. Volume and space relationships. If the side walls of a volume are scattered in different directions, spatial relationships originate.

Figure 1: Diagrams of space relationships from Moholy-Nagy's influential book The New Vision.

It is important to remark that this new concept of space, as Forty suggests, derails a line of thought that made emphasis in the environmental distinctiveness of interior space, the 'enclosure' of Semper, and underscores instead the indistinct continuum of void space both inside and outside buildings.

Eight decades have passed since, and though not with the mystical force it had, the word 'space' has become ubiquitous in schools of architecture, multiplied in expressions, such as, private space, public space, generic space, interlocking spaces, positive space, negative space, cellular space, fluid space, etc. to name a few from the illustrated guide to architectural design terms, 'Archispeak' (Porter 2004a).

Among these terms, there is a group of cognate ideas that are used interchangeably as rough equivalents to the idea of space as the absence of material. These are referred to in various books for students of architecture as, 'void' or 'emptiness', and sometimes as 'negative space' [14].

In the comprehensive history of the evolution of concept of space in architecture by Van de Ven (1987), the dialectics of solids and voids (or volumes and voids, or masses and voids) recurs periodically from the thinkings of ancient Greeks, through the modernist period, and presumably to this day. As various other authors, he resorts to an old poem by Lao-tzu[15] to explain how important the void is. The following translation of the poem appears in the still popular book for students of architecture, 'Architecture: form, space, and order'.

> "We put thirty spokes together and call it a wheel;
> But it is on the space where there is nothing that the
> utility of the wheel depends.
> We turn clay to make a vessel;
> But it is on the space where there is nothing that the
> utility of the vessel depends.
> We pierce doors and windows to make a house;
> and it is on these spaces where there is nothing that
> the utility of the house depends.
> Therefore, just as we take advantage of what is, we
> should recognize the utility of what is not"[16]
> (Lao-tzu in Ching 2007, p.91)

Van de Ven (1987) sees in this poem a rudimentary description of the two ways in which architects *make* space: by stereotomics, represented by the hollowing

14 (See for examples Porter 2004a; Ching 2007; Cooper 2007)

15 Lao-tzu was a mystic philosopher of ancient China (6th Century BCE), best known as the author of the Tao Te Ching, of which the poem often quoted in books of architecture appears in Chapter 11. The void in the Taoist tradition represents, among other things, "infinite possibilities" (Chapter 4, Tao Te Ching).

16 This is the slightly different translation of Lao-tzu's poem in Van de Ven's book: "Thirty spokes converge upon a single hub; It is on the hole in the centre that the use of the car hinges. We make a vessel from a lump of clay; It is the empty space within the vessel that makes it useful. We make doors and windows for a room; But it is in the empty spaces that make the room livable. Thus while the tangible has advantages; It is the intangible that makes it useful"(Van de Ven 1987, p.17).

of the vessel; and by tectonics, represented by the assembling of the pokes of the wheel[17] . The poem, in the view of Van de Ven, also alludes to the central task of architectural design that is to establish a transition between the internal space and the external space, which in his description are, internal and external *emptinesses* respectively. For Van de Ven, Lao-tzu's poem expresses a polarity between "being and non-being", which in his opinion is a notion that "has proven vibrant throughout the entire development of the entire civilization". It is also evident, through his remarks, that emptiness is superior to mass. The poem reveals, for him, not just a "principle of two opposing elements... it reveals the superiority of the contained, the space within. The non existent is the essential..." (Van de Ven 1987, p.3).

Architectural space, Van de Ven remarks, is not equivalent to the Cartesian notion of space. While both share the three dimensions, the Cartesian extension does not discriminate solid from emptiness. In architecture, Van de Ven reminds us, this distinction is essential because it is only in the emptiness between the solids, where architectural space exists. The emptiness is what endows architecture with value, thus emptiness is superior to matter.

While Van de Ven's view of empty space emphasises the importance of an invisible element, usually neglected in the visually oriented design culture, his equally emphatic remarks on the equivalence between this element and *non-being*, or *non existent*, can make us construe the idea of space as devoid of any quality.

In the Taoist tradition, to which Lao-tzu's poem belongs, the term emptiness can

17 Such description coincides with Arnheim's : "A building is thought of either as a closed container, into which holes are punched as needed, or it is a set of units –boxes, boards and posts– added to one another until the space is sufficiently closed. Every architectural design dwells somewhere between these two extremes"(Arnheim 1969, p.152)

be interpreted in multiple and inspiring ways, for instance, as potential for endless opportunities[18]. But once transferred into the world of Western students, immersed in a disembodied ocularcentric culture (Pallasmaa 2005), its meaning can descend to levels considerably less sophisticated. Till (2009) suggests that students associate the idea of space, not with an endless potential, but with blank spaces in their drawings. Till recalls a student describing a public space in his drawing " 'Look', says the student, pointing at the drawing, 'there is the public space'. An then touches the white stuff, just to reinforce the reality of that space" (Till 2009, p.118). This association of space and blank areas, nonetheless, would not be so unjustified, taking into consideration the use of the word 'space' in everyday parlance[19], and most importantly the meaning of the term 'negative space' that is presented to students as part of a the large armoury of 'spatial terms' they acquire during their initial studies.

Negative Space is not exactly the same as 'void' or empty space, but they are closely related. It is usually conveyed as a basic compositional concept in first year. Porter states that "within design education philosophies, concepts of space and form are usually separated and regarded respectively as the negative and positive of the physical world, a world where objects reside, and void (the mere absence of substance) is a surrounding or contained atmospheric emptiness" (Porter 2004a, p.31) .

The lineage of the expression 'negative space' is eminently visual and related to positive and negative elements, as they are commonly used in pictorial design. Here, positive elements dominate and appear nearer the eye, while negative elements appear passive and receding. According to Porter, this idea has been

18 In the Taoist tradition, emptiness can also mean, having no fixed preconceptions, preferences, intentions, or agenda; or the existence of a potential for something to emerge (Dyer 2008).

19 Distance between two objects, blank area on which to write in a form, a time interval, an empty floor area, etc. (source: wordnetweb. princeton. edu / perl / webwn)

adapted in architectural design, in the guise of positive and negative spaces, not just in the bi-dimensional representations on paper, but in the three Cartesian dimensions. “Positive refers to the space that is materially occupied as distinct from the areas of unoccupied space that are shaped by the positive areas (...) negative space, refers to the empty space surrounding and defining positive elements” (Porter 2004b). It is worth noting that, in this interpretation, whether in two or three dimensions, negative space would actually be the space we inhabit.

The expression 'emptiness' is often mentioned as a necessary element of architectural composition. Buildings, observe Jacobson et al. (1991), “consists of an interplay between something -a physical material, object or area of information- and nothing -the emptiness and space in between” (p. 40). Jacobson clearly equates contained space and emptiness, and something even more unsettling: nothing.

Cooper (2007), in his book 'Drawing and Perceiving, for students of architecture and design', argues that the difficulty in depicting architectural space rests in the fact that “empty space provides little to no sensation. It's empty. Only the solids provide sensation. Solids are the part the radar bounces off” (p. 57). He gives the example of Siena's Piazza del Campo to illustrate the case of an empty space that is visualised only thanks to the solid masses that make it exist. Cooper correlates being visible, and being existent. Space becomes a thing because its boundaries make it visible. He then suggests that space may take on the quality of a solid form, “where the shape of a space is so distinct that it can be compared to a solid, empty space takes on a peculiar quality. Though it can not be sensed as a thing, we nevertheless understand it as a thing in its own right. In a true figure-ground reversal, we understand it as a solid's inverse” (p.58).

Some architects and artists have represented this solid's inverse in three dimensions, substituting mass for void. Thus, they have made empty space, or 'negative space', visible without the delimiting mass. A good example is the series of plaster casts of historic buildings of Rome by architect Luigi Moretti (1907-1973). Moretti made these models of internal space of historic buildings in Rome for his studies of spatial sequences, continuities and discontinuities, published in 'Spazio' (Space) in 1952 (Bucci & Mulazzani 2002). More recently artist Rachel Whiteread produced another particularly clear 'space reversal', this time a domestic one, a full size concrete cast of the inside of an entire Victorian terraced house, both (house and cast) now demolished. Porter (2004b) , commenting on Whiteread's work, affirms that she "plays games with our sensory perception of what is **solid** and **void**" (p. 114).

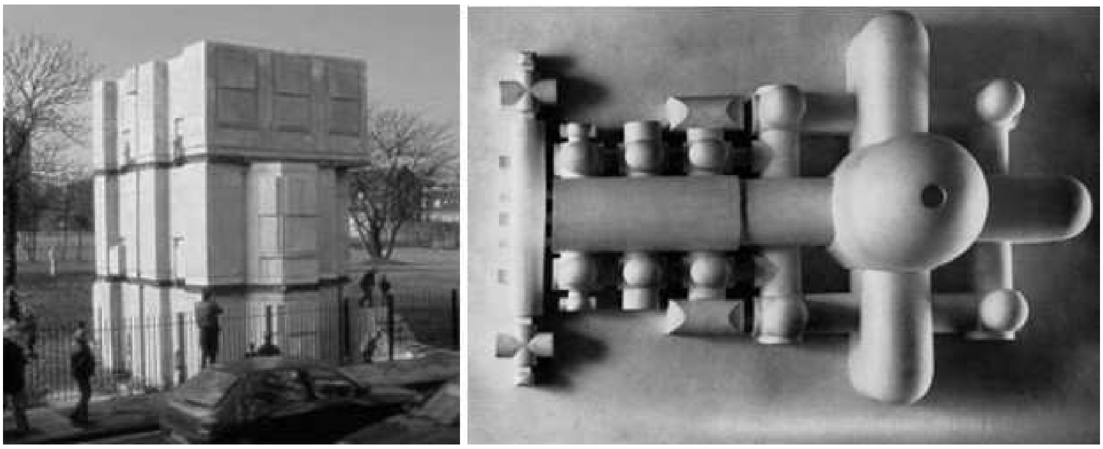


Figure 2: Rachael Withehead's 'House' and Luigi Moretti's plaster model of space.

This representation of space has been also sustained in the field of aesthetics. In a manner similar to Moretti's and Whiteread's substitution of solid for void, philosopher Roger Scruton (1979) suggests the substitution of shape for space. In describing a building, he explains, the word 'shape' can be used instead of 'space', and the description of the building would not be affected. So, if a space is described as curved, for example, what is being described in reality is the curved shape of the matter that delimits that space. Ultimately, the term 'space', in his view, would not be needed to explain a building.

In order to illustrate this idea he compares two settings. On the one hand, Saint Peter's Basilica in Rome; and on the other, an open field. “If I stand in an open field”, he suggests, “then I can have a full experience of all the separate spaces in Saint Peter's basilica in Rome. The only difference is that here the shell which Bramante and Michelangelo constructed around those spaces does not exist, and so does not interfere with the pure unmediated contemplation of the spaces as they are in themselves” (Scruton 1979, p.43) .

Figure 3: The contrast between an open field and Saint Peter's Basilica interior space

As in the models of Moretti and Whiteread -as well as in the descriptions of Ching, Cooper, and Porter- space is equalised to form, but Scruton suggests something more troubling from an environmental perspective. The space inside buildings is the same space outside, idea that can be linked to the concept of fluid space of the Bauhaus, touched upon at the beginning of this section.

This concept of architectural space entails no atmospheric differences, no transitions or gradations. The spatial experience of being under the vault of the basilica, which apparently is the empty reversal of the masses, would be the same as being in a desert at noon. Scruton also suggests that the way of appreciating space is through aesthetic contemplation, making clear that a combination of vision and reason, rather than actual inhabitation is needed in order to appreciate space conceived in this way. The sensual experience of the environmental dynamics is not part of his understanding of space, though in reality they contribute toward making the Basilica such a distinct setting.

In this aesthetic understanding of space, the internal atmosphere does not play any role. It is only under this homogenised view of architectural space, in which the alluded basilica is devoid of sounds, smells, light, temperature, that Scruton can be justified in seeing the internal space as being equivalent to an open field. It has to be emphasised however, that this is the kind of aesthetics usually linked to vision exclusively. Architectural Space can be described as a form, either occupied by mass or empty, in a context in which vision is the predominant sense. It can be considered empty because its environmental contents are not visible, yet invisibility can not be equated to non existence.

Of course, architectural space as the empty reversal of solids is a limit case. Others have questioned this possibility. Evans (1995), for example, observes that "Scruton's substitution of space for shape does not always work, like Moretti's plaster models do not always work either. The word space, says Evans, "is as much about intimation as it is about surveyable dimensions. An intimation cannot be made of plaster, nor can it be described as a shape, nor can it be easily located as a portion of the one universal space" (p.158).

3.2 Space as Medium

This section introduces James Gibson's description of the terrestrial environment, which in many respects, is akin to the implicit conception of architectural space of the DML.

At the end of the 1970's Gibson published his book 'An Ecological Approach to Visual Perception'. In order to substantiate his assertions in this field of psychology, he devoted the first part of his book to formulating a description of the terrestrial environment (Gibson 1979). This description comprises an understanding of space very different of the idea of space as void.

In his description, Gibson rejects the idea that the terrestrial environment consists of bodies in space. That description seemed to him an inadequate way of accounting for the richness and complex relations between a perceiving agent and the environment[20]. Instead, he suggested that the terrestrial environment consists of three kinds of things. A Medium, Substances, and Surfaces.

Gibson explicitly rejects the notion of Space, and does so in two levels. First, he rejects the Kantian notion of space, as an *a priori* intuition that Man imposes upon the world to endow it with order. Instead, he argues the opposite. The world - the environment- has structure, and this structure provides information. The agent in the environment has just to detect it. Second, Gibson challenges the Cartesian notion of space, and the inherent abstraction it implies. Geometry, that is central to Descartes' account of space, and to architectural training, is for Gibson a 'ghost of reality' [21]. Gibson mentions the notion of space as void, and the conceptual opposition between this idea and his ecological description. In his framework, emptiness, or void, is not conceivable.

20 While Gibson's greatest concern relate to visual perception, his description encompasses a variety of other environmental phenomena beyond the visible.

21 Gibson refers insistently to geometric elements as ghosts of reality. A line, for example, is a ghost of a fibre, or of a border. (See Gibson 1979, p.35) “Planes are transparent ghosts” (p. 33)

"According to classical physics", he states, "the universe consists of bodies in space. We are tempted to assume, therefore, that we live in a physical world consisting of bodies in space and that what we perceive consists of objects in space. But this is very dubious. The terrestrial environment is better described in terms of medium, substances, and the surfaces that separate them" (Gibson 1979, p.16).

This description is, however, not novel, as Gibson himself acknowledges, but it has never been explicit. Like the ancient Greeks, he sees the terrestrial environment as comprising matter in different states. The first one -Medium- is the gaseous state, the second one -Substances- are the solid, semi-solid, or liquid state; and the third element in this triad -Surfaces- is not a state itself, but an interface, or 'film' that separates the different states of matter.

3.2.1 Medium

In his previous book, 'The Senses Considered as Perceptual Systems' Gibson (1966), suggested that what we call 'space' is nothing less than the 'air'. Thirteen years later he reviews this analogy and replaces the term 'space' for the term 'medium'. Space for him is a too abstract term, a human construct that does no capture the qualities of the medium in which animals live. For him, the medium, that for terrestrial animals is basically air, has the following properties:

1. It is "insubstantial", this is, "a detached solid body can move through it without resistance", and thus it "affords locomotion to an animate body". The medium is generally transparent, transmitting light. Thus, it affords vision. A terrestrial medium is a region in which light not only is transmitted but also reverberates. For this reason, it can be said that light

"fills the Medium".

Figure 4: The medium affords locomotion and vision

2. The medium transmits vibrations or pressure waves out of a mechanical event. It permits listening to the vibratory event. The Medium, then, makes possible hearing of what we call sound. In strict sense air can not be said is insubstantial for it could be not be able to transmit vibrations like light or sound. The term "insubstantial" in Gibson's nomenclature refers to its lack of resistance to be penetrated. Gibson intends to make clear the difference between the gaseous nature of air and the solid or semisolid state of other matter.

3. The medium allows a rapid chemical diffusion. "It permits molecules of a foreign substance to diffuse or dissolve outward from a source whenever it is volatile". In this way the medium affords smelling of the source, at a distance.

Gibson emphasises that the latter three properties of the Medium are related to the detection of information. That is, they make sense when there is an agent in the environment that can perceive them. The agent perceives or knows [22], the

22 "Perceiving is the simplest and best kind of knowing". (Gibson 1979, p.263)

environment and the objects in it, through seeing, listening, and smelling. Inexplicably, Gibson does not consider the transmission of heat through the Medium, which for some organisms in the environment can be essential to their survival.

Figure 5: The medium affords listening and smelling

The Medium has two other important properties, which make the interdependence between agent and environment even more evident.

4. Our medium contains oxygen and permits breathing. "This ceaseless chemical exchange of substance", says Gibson, "is truly the 'flame of life'. The animal must breath everywhere it goes, for this reason, the medium needs to be relatively constant and relatively homogeneous."

While Gibson characterises the Medium as being relatively homogeneous, this homogeneity depends on the portion of medium observed. If we observe the Medium in a small room, it may appear as highly homogeneous, whereas the terrestrial atmosphere may appear as highly diverse. "Rain, wind, snow,and cold... prevent the air from being perfectly homogeneous, uniform, and unchanging "(p.19). What Gibson wants to make clear is that the Medium is homogeneous in comparison to the diversity of substances that we can find in the terrestrial environment.

5. Finally, for terrestrial animal life the Medium has an intrinsic polarity of up and down. It is not isotropic along the vertical axis. The medium is more dense at sea level than it is in the mountains. Even in the two horizontal axes, assuming Cartesian coordinates, the Medium is not homogeneous or arbitrary, "for they depend on sunrise and sunset".

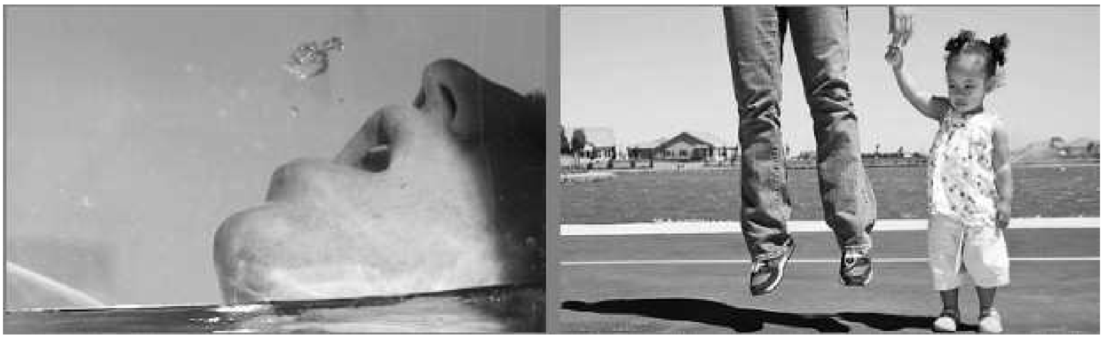


Figure 6: The medium affords breathing and is not isotropic along its vertical axis.

As Gibson himself shows, the idea of medium is not equivalent to the idea of space. In particular it is not equivalent to the idea of space as void, which is by definition devoid of environmental phenomena. To the concept of Medium, Gibson adds two more, namely, substances and surfaces. These are particularly important since much of what the Medium is, in terms of environmental attributes, depends on them and the way in which they interact.

3.2.2 Substances

The substances of the environment are matter in the solid or semi-solid state. Raw materials like "rock, soil, sand, mud, clay, oil, tar..." are substances. Seen from an architectural perspective, substances are also those materials which architects specify for their buildings, like stone, timber, glass, concrete, ceramics, acrylic, different alloys, etc. Unlike the Medium, that tends to be homogeneous, Substances differ in a varied sort of ways. Again, is good to read the following adaptation of Gibson's description of the properties of Substances, bearing in mind the materials of which buildings are made.

Substances are more or less resistant to deformation, or more or less impenetrable by solid bodies, and more or less permanent in shape, hence they vary in hardness or rigidity. They posses more or less mass per unit volume, hence they vary in density. They vary in cohesiveness or strength, this is, they are more or less resistant to brake. They are more or less able to regain the previous shape after deformation, this is, they vary in elasticity. They also vary in plasticity, i.e. they are more or less able to hold the previous shape after deformation. They are more or less resistant to flow, i.e. they vary in viscosity. "Substances considered as compounds differ in their susceptibility to chemical reactions, degree of solubility in water, degree of volatility in air, chemical stability or resistance to chemical transformation and degree to which they absorb light". Substances change at an ecological scale, they decay in time, "metal rusts, and even the hardest rock eventually disintegrates into soil"(Gibson 1979, p.17)

The image of substances that Gibson presents to us is varied in the extreme. They are numerous, and their combination makes them virtually unlimited, even more if we consider organic substances. They can be found as raw material in the environment, but they are also the elements that students must learn to manipulate in order to set up spaces for human inhabitation. In a sense, the substances of the environment are alive, and, in conjunction with the surfaces, have the ability to modify the Medium. The acknowledgement of this principle, as architect Zumthor recognises, is central to the deliberate design of an architectural atmosphere.

3.2.3 Surfaces

Surfaces are not a state of matter, but an interface between states of matter. Between the medium and substances there is an interface. For example, a surface exists between our body and the air; there is a surface also between the wall and the surrounding air of the building, or between the same wall and the contained air of the room.

Surfaces are of the utmost importance, because, it is there "where most of the action is", and they are the interface that we normally see. "The surface is where the light is reflected or absorbed, not the interior of the substance", hence, they play a fundamental role in visual perception, and by extension in the visual experience of an architectural space. An interesting example in this regard is the the role of 'specular surfaces' in the experience of Giuseppe Terragni's Casa del Fascio, by Marie Anne Steane (2004)

Gibson stresses that there is a rich reciprocation between surfaces and the medium. There is a 'give and take' between 'less alive' surfaces and the Medium, but of course this reciprocation is maximum between organic surfaces and the medium, of which the interaction between the human skin and the medium is particularly evident.

Yet surfaces have other important functions that exceeds the visual. "The surface is what touches the individual[23], not the interior". The surface of timber, steel, or stone, for instance, not only provides optic information, but tactile. Besides, "the surface is where chemical reaction mostly takes place. This means that the surface "is where vaporization or diffusion of substances into the medium occurs". Surfaces and substances absorb odours along time, odours that "lend

23 "Animal", in the original.

character to objects and places, making them distinctive, easier to identify and remember" (Tuan 1977, p.6). Thus the contribution from the surfaces and substances can be olfactory , as well, endowing the experiences of places with lasting sensory memories.

Gibson uses an additional expression, "substantial surfaces", implying that texture and layout of surfaces depend greatly on the internal structure of the substances, of which they are the visible face. For this reason they have the capacity of modifying the medium. A surface "is where vibrations of the substances are transmitted into the medium", and where vibrations travelling in the Medium bounce back, so, depending on the density, texture and flexibility of the substances and surfaces, sound behaviour can be attenuated, or lengthened. So, as polished marble can increase the reverberation time in a church, a thick carpet can attenuate noise in a restaurant.

An additional understanding of architectural space

Gibson states that the entities of geometry are "ghosts of reality"[24]. In architectural education, however, such entities are actual elements of the students' learning setting. Students learn to see lines and transparent planes as a future reality of the built environment. They draw them on paper (or screen), and translate them into tangible three-dimensional models. Geometry, in this sense, is part of the "virtual world" that students need to construct in order to establish a "conversation with the situation", as Schon characterises design (Schon 1991). In this sense, the view of space as medium should not be understood as supplanting the notion of space as geometrical extension, but as an additional and necessary way of understanding the space of human inhabitation, in order to situate environmental phenomena from the start of the design process.

3.3 Conclusions Chapter 3

The aim of this Chapter was to interpret a vision of the terrestrial environment that is different of the vision of the terrestrial environment that is usually presented to students in architectural education. From an ecological learning perspective this is relevant because students operate according to the vision of the environment that is shown to them.

While it is widely accepted that simplifications of reality are necessary in pedagogy, some educators have warned that simplifications may unintendedly become distortions, which can jeopardize a further understanding of the reality

24 In nature, Gibson sustains, none of these elements exist. There are no abstract lines. Instead, there are edges, filaments, hair, etc. Neither are there planes, equal on both sides, but surfaces which have one side exposed to light, and one side hidden toward the substance. Nor are there bodies in space, made of a generic material, but substances of varied forms and natures.

they intend to simplify (Taber 2000). It is sustained in this thesis that the notion of 'space as a void delimited by masses', and the fact that this idea is usually conveyed at the start of architectural training, sets a reductionistic understanding of the environment in which architectural design unfolds for students.

As medium, architectural space can be described not only by the properties of shape, as it is usually done in architecture, but also by the attributes of the enclosed atmosphere, that tend to be neglected. As shape, an architectural space can be curvaceous, boxlike, vertical, narrow, etc. As medium, these adjectives do not seem appropriate. However, 'cold' or 'warm' seem to be fitter terms. Architectural space, conceived as medium, turns intrinsically dynamic, even if the container is 'boxlike'. A concert hall, for example, modified by the qualities of surfaces and substances, can be described as 'alive' or 'dead', depending on its reverberation time. The combined effects of geometry, surfaces and substances provide an immense number of sonic experiences (See Augoyard & Torgue 2005).

As medium, space can be scented and humidified, and its temperature can be domesticated in hot and dry climates. Vernacular architecture has done this for long time. Conversely, in cold climates, the medium can be warmed up, and in appropriate quantities, some substances surrounding it can help to keep its comfortable temperature during a cold night.

Space as medium can flow. Not metaphorically, as modern space was understood to flow, but in reality[25]. By the same token, space can 'leak', and a warm space

25 In strict sense the modern concept of fluid space, embodied in Gerrit Rietveld's Schroeder house, or Mies Van der Rohe' German Pavilion, is as static as the concept of space as 'enclosure' of Semper. It is true that in 'fluid space', users could enjoy an unprecedented freedom of movement, and thanks to advances in construction techniques and glass technology, the visual connection between inside and outside became almost unlimited, but in neither case space is conceived as an

can become a cold space, though the geometry of the container may remain the same.

Defining space as medium inhabited by physical dynamics, rather than an extension devoid of atmosphere, sets a demanding task for students, however this definition of the terrestrial environment is an inevitable precondition to promote the factoring of environmental attributes from the beginning of the design process, instead of adding such attributes at a later stage. Working with the actual phenomena has, as we will see in the Chapter, a great importance in terms of ecological learning.

actual fluid. In defining 'interpenetrating space', Porter reports that flowing space "can result when the corners of floor and wall planes are deconstructed, literally pulled apart to release the flow of space and light ... or when wall, ceiling or floor planes are projected through a plane of glass with a continuity that connects interior to exterior". The fluidity through a plane of glass is clearly only optical.

Chapter 4. Understanding ecological learning

"It is hard to draw the line at what is intelligence, and what is environmental interaction. In a sense it does not really matter which is which, as all intelligent systems must be situated in some world or other if they are to be useful entities. The key idea from intelligence is: Intelligence is determined by the dynamics of interaction with the world" (Brooks 1991a).

"Knowledge of the world is gained by moving about in it, exploring it, attending to it, ever alert to the signs by which it is revealed. Learning to see, then, is a matter not of acquiring schemata for mentally *constructing* the environment but of acquiring the skills for direct perceptual *engagement* with its constituents". (Ingold 2000d, p.55)

Chapter 3 described the vision of space as medium, as a underlying concept on which environmental phenomena may be given access to participate in the design process.

After Donald Schon, it can be claimed that *design* represents the antithesis of the positivist epistemology of practice in which *knowing* is separated of doing. In fact, in any studio, knowing and doing are tightly intertwined. Knower and known -the student and the materials of the design situation- are also deeply interconnected. Yet, a doubt still persists. Is designing an instance of knowing and learning that justifies dispensing with the method of transmission/application?

The current Chapter sets out to introduce an ecological approach to learning that differs profoundly from the transmission model described in Chapter 2 (p. 19). It is argued in this thesis that this approach to learning is linked to a conversational model of design and both can be considered as didactic underlying strategies in order to implement environmental design in the studio.

Expressed in simple terms, the ecological approach to learning assimilates human learners to animals (agents-in-the-environment), or to be more precise, assimilates the relationship between animals and their environments to the relationship between human learners and their learning environments. Centuries of hegemonic anthropocentrism make this analogy appear improper, but this is precisely the relationship on which the ecological approach to learning rests. What happens to an animal in its particular environment is analogous to what happens to a human learner in his learning environment. The use of the words 'animal' or 'organism' in this Chapter, therefore, also refers to a human learner. The word 'agent', more akin to artificial intelligence, will be also used. The animal of this Chapter is the student of architecture[26], so it is important to bear in mind that this animal performs a particular practice: Design

The ecological approach to learning defers from the transmission model in various respects. If we reckon cognition in its most basic sense, as a process by which a person knows and learns, these differences are cognitive. While for the transmission model the learner is a passive recipient by definition, for the latter is a purposeful obtainer of information. Thus, if information is scarce, the ecological learner engages in activities that yield more information. It is in fact the actual engagement with the meaningful constituents of their activities what keeps learners and their learning environments epistemically linked (Ingold 2000b).

But there is a second difference also important, concerning the concept of learning. Far from being just an internal process of accumulating and processing information in the mind, learning in the ecological framework also occurs 'outside', in the physical side of reality, as an ongoing process of perceptual attunement of the learner to his environment of practice. For the environmental designer this is coincidently an attunement to his practice, and by means of it, an attunement to the environmental variables of the spaces he is designing.

The ecological approach to learning does not deny that information can be communicated by means of propositions, of which lecturing is an emblematic example. But the accumulation of information in the head of the learner, taken as self-contained abstract entities, does not make him more 'knowledgeable'. Such information while remaining in the head of the learner, is "inert", as

26 This is not the first time that a thesis assimilates students of architecture to animals. Nick Dunn (2007) developed an insightful research on the ecology of models in architectural training, based on Gibsonian principles.

Whitehead (1929) refers to information disconnected from practice. And that information remains inert unless the learner can situate it in an actional context, in which he can actively participate (Hanks 2009).

As for the surgeon the main actional context is the operating theatre, and for the mechanic is his garage, for the student of architecture this actional context is the studio. What the operating theatre, the garage, and the studio share - with a vast number of other actional contexts- is that they are the place in which knowledge can be situated. However, situating a knowledge, in the ecological framework that is discussed here, does not mean that a 'body of knowledge' can be forced in -as often occurs in a transmission model of education - but that knowledge can emerge from the action that takes place there.

The 'action' in our discipline is, since the Renaissance, design. Design, however, can be understood in very different ways. Of the many descriptions we can find in the literature, one is particularly relevant to this thesis: Schon's description of design as a conversation with the materials of a situation. If we share his vision, as Nigel Cross and Brian Lawson do, architectural designers are always acting under the premises of ecological learning, that is, while designing they are always refining their perceptual systems in their setting of practice.

This is important since it shifts our concern from integrating knowledge, often prefabricated outside the studio, to situating knowledge within thge main activity of the studio: design. Though the difference between 'integrating' and 'situating' could appear as a language nuance for the reader, they stand for two different pedagogical agendas. Situated in its basic sense means that the production of knowledge occurs in a specific time and space, but in a deeper sense it means that it is embedded in practice.

This Chapter in particular, is inspired in the seminal work of American psychologist James Gibson (1979), but also incorporates the view of contemporary education theorists who advocate a fundamental role of the environment in the learning experience. While Gibson's work focused mainly on perception and did not address education specifically, theorists have brought a number of his concepts into the educational realm, shedding new light on learning in the present day.

The aim of this Chapter is to sketch a definition of ecological learning relevant to this thesis. This is, from a vast literature on ecological psychology and situativity, only a few concepts have been taken. Those which best resonate with the pedagogical experiences shown in Chapter 6, p.162.

The Chapter comprises 5 sections. The first introduces the concept of animal-environment coupling, which is a basal idea of ecological learning. It also provides an illustration of cognitive coupling in our own learning environment. The second section deals with the operation of the animal- environment coupling and introduces the concepts of perceptual systems, affordances and effectivities. The third section incorporates the idea of the intertwining between knowing and action (either as explorative movement or explorative manipulation). The fourth section addresses the concept of learning seen as an attunement between learners and their environment of practice. The fifth section touches upon a portion of the environment that is little mentioned in Gibson´s theory, but is relevant in an account of human learning: the social setting.

4.1 Animal - Environment coupling

It is now a consensus in education that the environment plays a fundamental role in the learning process (Jonassen & Land 2000). This consensus did not appeared overnight, but has been built over the last decades, with the contribution of many people. One of these is the prominent educational reformer John Dewey (1938a) in the first half of the last century. Dewey acknowledged a key role to the 'transactions', as he termed the relationship between the learner and the learning environment . In his words,

> "An experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his environment, whether the latter consists of persons with whom he is talking about some topic or event, the subject talked about being also a part of the situation; or the toys with which he is playing... or the materials of an experiment he is performing. The environment, in other words, is whatever conditions interact with personal needs, desires, purposes, and capacities to create the experience which is had. Even when a person builds a castle in the air he is interacting with objects which he constructs in fancy". (Dewey 1938a, p.44)

Later on, Dewey mentions explicitly the "objective conditions" of the learning environment, in which he includes "equipment, books, apparatus, toys, games played ... the materials with which an individual interacts. He also emphasises that, "(the) most important of all, (is) the total social set-up of the situations in which a person is engaged" [27] (Ibidem p. 45).

27 In the context of this thesis is particularly relevant the portion of that social environment that Wenger (1999) in our time has termed 'communities of practice'. For the student of architecture these are a set of several nested communities. (S)he belongs simultaneously to the studio community, to the school community, to the broader academic community, and finally to the professional community. The importance of communities of practice, as we shall see later, is that they hold particular world views that in turn determine their own ways of acting upon it, and learning.

In this brief text, Dewey condenses a philosophy of learning environments that still echoes today in pedagogical undertakings. It is clear that for him, as for several contemporary educational theorists, learning is the achievement of an individual embedded in a learning environment. This concept is kin to the ecological approach to learning, however in this framework this idea is pushed further. The learner is not just embedded in the environment, but both -learner and environment- are mutually constituted, as animals and their niches are. This is a contested idea, but captures the deep engagement of the student of architecture with his learning environment during the activity of design.

As expressed in the general introduction (Chapter 1, p.6) the ecological approach is characterized by its essentially antidualist stance before dichotomies deeply rooted and still standing in Western culture, like the mind-body dualism or the objective-subjective dualism. But perhaps what best distinguishes it, is its rejection of the animal-environment dualism (Turvey et al. 1981). Ecological theories do not only assume that organisms develop their life in a rich sea of information about their environments, but that these organisms and those rich seas of information have evolved in conjunction. Consequently, it is logically assumed that the structure and function of perceptual systems have become 'tailored' to the information available (Michaels & Carello 1981).

Furthermore, "it is claimed that the two -the animal and the niche- cannot be disjointed logically since each owes its very identity to the other... an animal is what it is, given that its niche is what it is... Thus, just as the structure and functioning of an animal implies the environment, the particulars of the niche imply the structure and activities of its animal", and arguably, "it is this niche that the animal knows" (Michaels & Carello 1981).

The central question that arises is whether an animal and its environment must be considered as logically independent. In the context of this thesis the question can be rephrased as whether students of architecture and their learning environments must be considered as logically independent. The ecological position, in both cases, is that such independence is not justified in the light of the theoretical and practical problems it causes.

It is true that the environment has been incorporated in the conventional (non ecological) analysis of the processes of cognition. However, it has entered the discussion as a set of standard conditions that tend to erase the different meanings of particular environments -niches- for different actors. This neutrality is for ecological psychologists the most obvious manifestation of the dualism of the animals and the environment that permeates the conventional perspective to cognitive processes, which they consequently reject (Michaels & Carello 1981).

The term 'environment' is used in this perspective as the constituents of the learners' surroundings with which they can actively engage. It is not the impersonal representation of the global environment, as we tend to use the term. What the ecological approach claims is that there is little sense in saying that a learner knows 'the' environment, as if its description was the same for the different inhabitants of the planet. Rather, plenty of examples among animals[28] suggest that it is more sensible to suppose that what a perceiving agent can know (perceive) is as specific to its niche as its body is.

Transferring these concepts from pure ecology to the realm of human education,

28 This example provided by Michaels and Carello is clarifying. 'If a small mammal is hiding in a room, the heat it radiates will identify its location. That is, the thermal structure of the room specifies the location of the animal. This energy pattern is not information to human beings because biologically we are not equipped to detect it...(but) rattlesnakes are sensitive to such information...their “pits” are directional, temperature-gradient sensing devices that permit them to detect...warm-blooded creatures upon which they prey'(Michaels & Carello 1981, p.38).

they represent a radical shift of what the unit of analysis of the knowing and learning experience should be. Customarily the favoured unit has been the learners, and in some cases just their mind. Implicit in this restricted choice is the idea that the environment, though very important, is still independent of the process of learning. Cognition is customarily thought to occur just in the cognizer's mind, following a dualistic Cartesian tradition. The ecological approach, however, offers an alternative view on this respect: It is suggested that cognition -that is knowing and learning- should be the study of the animal-environment system (Turvey & Shaw, 1979). In other words, if the animal is the knower and the environment is the known, 'a full accounting of knowing can not be had by analysing only one' (Michaels & Carello 1981). Indeed the expression learner-in-the-environment sets up a new unit of analysis or 'minimal ontology for describing knowing and learning' (Barab et al. 2007).

The nature of the coupling of animal and environment is cognitive, and that is why it is so important in a formal learning environment. Next, this idea is explained, and some examples provided.

4.1.1 Cognitive Coupling

> “There is no genuine feedback from the world during the problem-solving session, it must be simulated or generated by the designer during the problem-solving session. Feedback from the world comes only after the design is completed and the artifact is constructed and allowed to function in its intended environment. But, of course, at this point, the feedback cannot influence the current project, only the next 'similar' project.” (Goel & Pirolli 1992, p.402)

> "... mind is immanent in the larger system—man plus environment. In principle, if we desire to explain or understand the mental aspect of any biological event, we must take into account the system...Consider a man felling a tree with an axe. Each stroke of the axe is modified or corrected, according to the shape of the cut face of the tree left by the previous stroke. This self-corrective (i.e., mental) process is brought about by a total system, tree-eyes brain-muscles-axe-stroke-tree; and it is this total system that has the characteristics of immanent mind." (Bateson 2000, p.230)

The epigraphs at the beginning of this section represent two different views about the cognitive relationship between an agent and the environment. While the first deals with design as problem solving, and the second with tree felling, they illustrate these two stances. For Goel and Pirolli (epigraph 1), the whole process of solving a problem occurs in the mind of the solver. The world (environment) is not able of providing feedback to the problem solver. Feedback only happens when the process has finished.

Gregory Bateson (epigraph 2), suggests an alternative cognitive mode instead. The world (environment) not only provides the man with information that guides the process of cutting the tree, but it forms a system with him. The information from the world (feedback) flows, unlike what Goel and Pirolli suggest, simultaneously to the action, not after. The ecological approach tend to align with Bateson's proposal.

It has been sustained that the animal does not couple with an undifferentiated environment, but with some entities in its particular niche (Gibson 1979). In analogous way, ecological learners couple with certain portions of the environment that are meaningful to them in order to know.

There is a growing consensus across a number of contemporary learning theories in acknowledging a cognitive role to objects in learning environments[29]. Artifacts mediate and alter the nature of human cognition (Jonassen 2000). ' Artifacts can scaffold new capabilities while individuals make use of them. That is, aspects of cognitive work can be off- loaded onto the artifacts in ways that afford new types of reasoning than what is possible without use of the artifacts. Such systems can be said to augment our capabilities. Individuals might also internalize aspects of these artifacts as they make use of them and thereby the use of an artifact can leave some sort of cognitive residue with the individual. (Bell & Winn 2000, p.140)

The idea of off-loading, by which part of the cognitive coupling is enabled, can be explained as follows. Rather than attempting to mentally store and manipulate all the relevant details about a situation, we physically store and manipulate those details out in the world, in the very situation itself. In the much cited case of the cottage cheese[30] of Lave, for example, the elements being manipulated do

29 Two of these theories are Distributed Cognition and Activity Theory. Distributed cognition is a psychological theory developed in the mid 1980s by Edwin Hutchins that emphasizes the social aspects of cognition. It is a framework that involves the coordination between **individuals, artifacts and the environment**. The premise of **activity theory** is that a collective work activity, with the basic purpose shared by others (community), is undertaken by people (subjects) who are motivated by a purpose or towards the solution of a problem (object), which is mediated by tools and/or signs (artefacts or instruments) used in order to achieve the goal (outcome). The activity is constrained by cultural factors including conventions (rules) and social organisation (division of labour) within the immediate context and framed by broader social patterns (of production, consumption, distribution and exchange). Activity theory provides a conceptual framework from which we can understand the inter-relationship between activities, actions, operations and artefacts, subjects' motives and goals, and aspects of the social, organisational and societal contexts within which these activities are framed.

30 Lave (1988) provided this example from her research on a particular community of learners, weight watchers: "Dieters were asked to prepare their lunch to meet specifications laid out by the observer. In this case, they were to fix a serving of cottage cheese, supposing that the amount allotted for the meal was three-quarters of the two-thirds cup the program allowed. The problem solver began the task muttering that he had taken a calculus course in college. Then after a pause he suddenly announced that he had 'got it!' He filled a measuring cup two-thirds full of cottage cheese, dumped it out on a cutting board, patted it into a circle, marked a cross on it, scooped away one quadrant, and served the rest" (2009, p.165). This is one of the most quoted examples to illustrate how an agent couples to particular parts of the environment (the problem's

not serve as symbols for anything but themselves, and their manipulation does not so much yield information about a solution, as produce the goal state itself through actual doing. In contrast, actions such as drawing a preconceived plan on paper represent a quite different use of the environment. Here, the cognitive system may be said to impose meaning on external resources.

In the same manner as Bateson in the second epigraph at the beginning of this section, Clark and Chalmers (1998) have developed a thesis they call "extended mind" or "active externalism". They compare cases of people who undertake cognitive tasks with and without the help of external objects (computers, calculators, books, paper and pencil, models, etc.) and claim that these objects, situated in the environment, participate in the cognitive task on a par with internal cognition. In coincidence with Bateson, they affirm that these objects extend the limits of the internal mind, playing a causal role, therefore, creating a system. The "human organism is linked with an external entity in a two-way interaction, creating a coupled system that can be seen as a cognitive system in its own right". If we remove any of the external components of it, they say, "the cognitive performance will drop in the same way as it would if part of the brain was removed".

As illustration they provide various examples. The old engineer with a slide rule hanging from his belt wherever he goes, in which case both constitute an almost permanent coupled cognitive system. Or more quotidian examples, like the use of pen and paper to perform long multiplications, or "the general paraphernalia of language, books, diagrams, and culture". In all these cases the individual

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brief, the cutting board and cup) to create artifacts (the patty of cottage cheese) avoiding to resort to formally-learned knowledge. Lave (1988) reports that at no time the procedure was checked against a paper and pencil maths operation [3/4 x 2/3 = 1/2]. "Instead, problem, setting, and enactment were the means by which checking took place" (p. 165).

brain performs some operations, while others are delegated to manipulations of external media. “Many of these activities are both situated and spatial, in the sense that they involve the manipulation of spatial relationships among elements in the environment. The advantage is that by doing actual physical manipulation, rather than computing a solution in our heads, we save cognitive work” (Clark & Chalmers 1998).

4.1.2 A close example of cognitive coupling

Of the many examples of this agent-environment cognitive coupling, expressed as an interaction between cognizers and artifacts, models utilised in architectural training may be one of the most paradigmatic ones. Recently, Nick Dunn (2007) has conducted an insightful research on the affordances of models in the teaching of various disciplines, with emphasis in architectural education. He classified models in four types[31], of which two are strikingly different in terms of cognitive functions: The descriptive model on the one hand, and the explorative model on the other. The descriptive model, also known as 'presentation model', is typically a literal representation of the proposed work of architecture at a reduced scale, made for clients in practices, or for final crits in schools. As Dunn notes, its function is “to communicate the end of the design process” (p.66). In contrast with the explorative model, the descriptive model consolidates all decisions that have been taken in advance, prior to its actual fabrication. Thus, in spite of being a powerful instrument for selling ideas to clients, its participation in the cognitive process is arguably very reduced.

31 Dunn's taxonomy of models include: 1. The Descriptive model, typically a literal representation of the proposed work of architecture at a reduced scale made for clients; 2. The Evaluative Model, built, with mock materials, at the same scale as the work they intend to represent and used to 'perceive' qualitative data; 3. The Predictive model, to be tested in wind tunnels, heliodons, etc. used to measure quantitative data, rather than perceive qualitative ones; and finally 4. The Explorative Model, typically found in the studio during the design process.

The explorative model instead is ordinarily found in the studio during the design process, and often has an unfinished look. This is so because of its intrinsic dynamic function that is “to discover other realities by speculation... involving a systematic variation of parameters” (p. 76). It is worth noting that variation of parameters is central to the act of perception, hence of knowing.[32]

As its name suggests, the explorative model is supposed to be a means rather than an end in itself, however from a cognitive standpoint it constitutes quite an accomplished example of active externalism. By changing parameters, an extensive range of ideas regarding structure, shape, geometry, construction methods, environmental variables, and so forth, can be tested out. This is not to say, however, that this is a one way routine of the designer who performs the testing upon an inert object. Rather, the model is said to talk back to the designer, giving way to a conversation between him and the model (Schon 1992a; Lawson 2006)

This reputed 'talking' ability of the model is a way of attributing a cognitive role to it. The conversation between the model and the designer, then, becomes a distinguished representative of an extended cognitive system. If we remove the external component of this system, as Clark and Chalmers(1998) suggest, the cognitive performance will drop in the same way as it would if part of the brain was removed.

After illustrating the idea of cognitive coupling in which the agent and portions of the learning environment (objects, artifacts or tools, in this case) become a cognitive system, we turn to three concepts that are essential to understand the

32 The key factor to be detected in a perceiving acting cycle is **change.** 'Change is an essential element, the essence of a dynamic system. Change (variance) and stability (invariance) are critical information to be detected and acted on' (Young).

operation of this system. Sensory exploration, Affordances and Effectivities.

4.2 The operation of the Animal-Environment coupling

4.2.1 Sensory exploration

As mentioned at the beginning of this Chapter, the attitude of the ecological knower is of a permanent search for information in order to act. But, although information is available in the environment, it must be obtained, or sensed, to be considered as such. From this follows that the agent must implement a mechanism to do this. This idea, that is central to the development of the perception action cycle explained later, is closely related to the concept of senses as perceptual systems that Gibson(1966) developed prior to his more radical ecological ideas.

Unlike to what was being done to that date, focusing exclusively on the receptor organs, his proposal of a perceptual system considers a set of organs involved in perception. These organs, in coordination, attend or explore the environment, and detect several kinds of information. Gibson (1966) identified five perceptual systems. The basic orienting system, the auditory system, the haptic system, the taste smell system, and the visual system.

But Gibson's contribution was innovative in another way that is relevant to ecological learning. Each system includes perceptual exploration activities that provide information beyond what is traditionally accepted as received by the organism. These exploratory activities include, sniffing, feeling, hefting, neck craning, etc. Gibson's contribution in this area, render perception (knowing) as deeply active, in contrast with the common idea of sensing, as simply receiving stimuli.

The most obvious cases of exploration occur in the visual system. In the traditional approach, the eye is usually studied in isolation and assimilated to a static camera that receives patterns of light, or luminous stimuli. The problem with this analogy is that it neglects the context of the receptor organ. The eye is located in a head that can pivot in multiple directions, and the head in turn, is strategically located in a body that moves backwards and forwards, or around the observed object, or even can manipulate it. The eye is part of an organism. In the language of ecological psychology "The head and the body movements... induce transformations in the optic array (patterns of light arriving at the eye) that are reliable specifiers of the relative positions of objects and surfaces in the field of view (motion perspective)" (Michaels & Carello 1981, p.39).

Michaels and Carello provide another example, this time of the haptic system. "Consider, for example, the texture of cloth. As the cloth is held in a perceiver's hand, crude information about its texture is available. If the perceiver engages in the exploratory activities of feeling (rubbing, fingering, touching) more detailed information about its texture is yielded. In this example, the perceptual system is the haptic system, the primary organ is the hand (including muscles, joints, and skin) and the mode of attention is feeling. The new information includes the patterns over time of deformation of the skin, skin-to-cloth friction, etc." (Michaels & Carello 1981, p.39).

All exploratory activities add information to the act of perception that a static agent can not obtain. But something else can be conjectured, much of the information in the environment does not exist as such until the agent can perceive it by exploration, and this occurs by getting physically involved in the act of perception.

At a small scale, the only thing that the agent perceives is change or persistence, also referred to as variants and invariants (Gibson 1979), but for the animal, change or persistence becomes meaningful information because it specifies possibilities for action, or affordances, to which we now turn.

4.2.2 Affordances

The concept of affordances was not initially conceived to be applied in an institutionalised learning environment, but to the study of perception of the environment in general, however it has become important in education since a learning environment inevitably involves affordances, whether for the benefit of the learning experience or not. As for animals their environments can be seen as a set of affordances to be detected and acted upon, a learning environment for humans can be seen as a set of affordances to be detect and acted upon. The relevance of this relation between learners and affordances is that the affordances of a designed learning environment can be deliberately orchestrated.

In order to illustrate the role of the affordances in a traditional learning environment let us consider the following simple experience: a child in the process of learning how secondary colours can be produced out of primary ones by painting. Let us think of three possible settings. In the first one the child is lectured the theory of how the primary colours mixed in some way yield the secondary ones. In the second one, the child is shown how this is done through a practical demonstration carried on by the teacher. In the third one the child is given the actual three basic colours of soluble paint, paper and brush, and is allowed to explore combinations in a semi guided form, until the point in which he is able to produce the secondary colours.

The epistemic relations afforded in the three cases are wholly different. The first case affords archiving that information in the learner's mind for later application (as in Freire's banking model of education cf. Chapter 2, p. 38). The second one affords imitation and a potential involvement, in an apprenticeship manner. Albeit demonstration is a powerful teaching practice and much learning rests on it [33], it is still incomplete in terms of embodied learning. It is only in the third instance, when a more complete set of affordances was made available to the child, that he can engage in an actual explorative activity, and when the system may be said started to know , but not yet to learn (Bateson 2000).

Provided by the set of tools, the mixable paints and white paper (not to mention the furniture, and the very classroom in which this activity occurs[34]), the affordances have been orchestrated by the educator for the learner to experience an actual engagement with the material to be learned. Paraphrasing Bateson, this becomes a self-corrective (i.e., mental) process (that) is brought about by a total system, paper-eyes-brain-muscles-brush-paint-stroke-paper; and it is this total system that has the ability to know.

The affordances 'of' the environment, as this simple example shows, are opportunities for action and such action yields information about the learning environment in a circular way. When learners are allowed to act, they are

33 'by using one's body in the same way as others in the same environment one finds oneself informed by an understanding which may then be interpreted according to one's own custom or bent' Michael Jackson quoted by (Ingold 2000g)

34 A revealing example of how furniture makes a difference in learning environments is reported in a pilot study comparing students' behaviour when equipped with traditional static and non-adjustable furniture against another group of students equipped with ideal ergonomic standards. Continuously height-adjustable chair-desk combinations, inclinable tabletops, and rolling/swivel chairs with rocking mechanisms. The more adjustable the furniture was, the better levels of students' performance was observed. (OWP/P Architects et al. 2010, p.86)

allowed to know; when they are allowed to know, they are allowed to act.

Affordances are opportunities for action

> The 'affordances of the environment are what it offers animals, what it provides or furnishes, either for good or ill' (Gibson 1979).

This is the simplest definition of affordances provided by Gibson, but certainly it involves more than what is seems [35]. Two of its facets are relevant to this thesis. The first one is that they are tied to action, and the second one is that they emerge in specific situations.

The affordances always refer to action. Something affords acting upon. Greeno (1994) has described them "as properties of the environment" that permit certain activities. Michaels and Carello (1981, p.42) , defined them as "acts or behaviours allowed by objects, places and events", highlighting the actional variable. Concisely, affordances are possibilities of action that the environment offers to an agent. Examples frequently given of affordances in the built environment are, chairs, benches, stools that afford seating on, or ladders that afford climbing, or objects with handles that afford grasping, etc. Detecting affordances then, does not refer to the mere register of stimuli, either visual, acoustic or other, but to the detection of a possibility of action. The affordances provide information, and this is useful when they "specify what those objects mean to us as perceivers, in terms of what we can do with them", when the individual not only perceives them, but when sooner or later they have consequences on the acts the individual executes (Michaels & Carello 1981).

35 The richness of the term was difficult to explain even for Gibson himself. Elsewhere he provided more complicated descriptions of the following type: 'An affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective–objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer' (Gibson 1979, p.129).

In this same sense, but with emphasis in the operation of designed objects, the concept of affordances has been used by Don Norman (2002). The term “affordances”, he writes, “refers to the perceived and actual properties of (a) thing, primarily those fundamental properties that determine just how the thing could possibly be used. A chair affords ("is for") support and, therefore, affords sitting. A chair can also be carried. Glass is for seeing through, and for breaking. Wood is normally used for solidity, opacity, support, or carving. Flat, porous, smooth surfaces are for writing on. So wood is also for writing on... Affordances provide strong clues to the operations of things. Plates are for pushing. Knobs are for turning. Slots are for inserting things into. Balls are for throwing or bouncing”. For Norman the affordances are relevant in design of objects, because when the designer works with them in mind, the manipulation of those objects turn obvious to the user[36]. “When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction is required” (Norman 1988).

Affordances emerge in a situation

Though several authors, including Gibson, referred to the affordances as 'of' the environment, it is clear that they are not universal or standard features, always available to all. On the contrary, while the environment makes them available, it does not 'possess' them. The affordances are detectable features of the environment “for a specific agent acting within a specific space-time, not all agents, or for all times” (Young et al. 2000). Chemero (2009) coincides with this relational character of affordances and defines them as “relations between abilities to perceive and act and features of the environment”. The affordances,

36 While for Norman, and for most of design theorists, affordances are important for the user while operating designed objects, for the purpose of this thesis the affordances are important as key constituents of learning environments.

then, emerge from a very close relationship between an agent and the environment in a situation. In a temporal and physical sense, the affordances are situated[37].

Pea (1993) illustrates how different contexts make different affordances emerge. A chair affords ('is for') sitting on, at least that is its intended function, and an agent in normal circumstances will appreciate it. But It is likely that this affordance will not be detected in a different context, such as the agent being isolated in the mountains caught in a blizzard without power and freezing to death. In which case the detected affordance will probably be the 'burnability' of the wood of which the chair is made of.

This means that the affordances do not emerge by chance, or are disconnected from the agent, but they become visible in situations in which agents having goals (or needs) make contact with meaningful environmental features for them. This point is worth emphasising for, in a learning environment, a learner will not detect any affordances, having no objectives toward which to move.

Meaningful does not refer here, of course, to an 'internal ordering' that must be imposed on an otherwise meaningless environment, as a Kantian view would posit [38]. On the contrary, since one of the premises of the ecological approach is that the environment provides information complete and structured, the agent does not need to inscribe meaning in the physical environment. It is suggested instead that the meaning emerges from the agent's goals and the very activity in

37 Situated may be understood at least in two senses. As the actual physical and temporal location of an activity, and in a broader sense as a professionally and socially situated activity (J. S. Brown et al. 1989; Lave & Wenger 1991).

38 In the influential philosophy of Immanuel Kant (1724 - 1804) the sensory experience of the world 'outside' - what in modern language we call 'the environment'- is one of the two sources of knowledge, yet he assigns a major role to the mind 'inside', which processes this information about the world and endows it with spatial and temporal order, enabling us to understand it.

which he is engaged. To be considered as such, affordances must be able to specify an action that leads, in turn, to achieve a goal. In Pea's example the 'burnability' of the wood specifies the action (to burn), leading to the goal (to heat).

While the affordances of the environment may be there to be perceived by the agent, in order to actualize them the agent must correspond with certain abilities. Such abilities of the agent have been termed, effectivities (R. E. Shaw & McIntyre 1974).

4.2.3 Effectivities

Effectivities are an expression of the corporeal coupling between organisms and their environments. This is particularly evident when the physical characteristics of an animal are listed, since in doing so we implicitly describe the environment. This also occurs in reverse. When describing an environment it is possible to conjecture the characteristics of the organism that lives in it. If an animal has gills, if it excels in nocturnal vision, if it has membranes between its fingers, or if it is able to detect the heat of its prey in the dark, we are immediately reminded of the type of environment it inhabits. Consider the soles of a mountain goat on the ground of its habitat. 'The toes of the 2-toed goat hooves are used individually for support and to attain footholds in small and uneven places (and) while horse hooves are concave and the animal essentially walks on the 'rims' of its toes, goat hooves have a protruding pad with rough surface texture that provides considerable friction, yet is pliant enough to conform to surface irregularities' (Oricom Technologies 2004). This feature, combined with a complete set of other effectivities, make the goat fit perfectly in its environment as a piece of a puzzle. While for people with average human effectivities a steep mountain affords falling off, for the goat it affords climbing[39].

The coupling affordances-effectivities, which in animals appear very obvious to us, occur in a similar manner between humans and the built environment. A stair, for example, requires certain effectivities as bipedalism. A bicycle also requires a bipedal operator, but additionally he must have hands with grasping capacity. A chair requires an animal with buttocks and vertical torso, a keyboard requires hands with fingers, etc. All these designed elements, and what they afford, have not appeared in the built environment as independent from human effectivities, on the contrary their have been tailored to them.

Figure 7: Examples of the coupling affordances/effectivities in humans

In formal education, a correct identification of effectivities can foster a good learning experience by defining which affordances can be entered in the design of a learning environment. By the same token, a wrong diagnosis can make a

39 For an extra illustration Clark and Chalmers (1998) provide the following example of animal-environment coupling. The extraordinary efficiency of the fish as a swimming device is partly due, it now seems, to an evolved capacity to couple its swimming behaviours to the pools of external kinetic energy found asswirls, eddies and vortices in its watery environment. These vortices include both naturally occurring ones (e.g., . where water hits a rock) and self-induced ones (created by well-timed tail flaps). The fish swims by building these externally occurring processes into the very heart of its locomotion routines. The fish and surrounding vortices together constitute a unified and remarkably efficient swimming machine'.

learning experience difficult (An obvious example: standard printed books would offer a poor ensemble of affordances to students with impaired vision).

Yet in a wider sense, in conjunction with affordances, effectivities have become relevant to ecological learning because they are the means by which animals interact with the world. To be more precise they are the means by which animals can engage in activities that yield information meaningful to them. They determine the way the animal can explore. As for an eagle its way of exploring is determined in part by its remarkable visual system, it is also determined to a great extent by its effectivity of flying.

For humans there is a range of exploration modes, associated with their effectivities, but are rarely resorted to in formal learning settings. We rarely see, for instance, a student exploring and perceiving a space by knocking at walls, or clapping hands, or sensing temperature gradients. Seen from this point of view, the effectivities may be considered not so much as a restriction on the type of affordances that may or may not be orchestrated in a formal education setting, but as a challenge to open up the range of possibles explorations.

In the case of humans, and some animals, effectivities can be increased or extended by means of prosthesis, and tools (Michaels & Carello 1981). But this is a controversial point that needs more attention. Interestingly, animals using tools do never weaken effectivities, or put them in risk of disappearing. For humans, however, some tools may take over the effectivity, or replace it. This displacement of effectivities has been seen as a displacement of the agent himself to the periphery of the cognitive activity. Or even worse, the agent may be displaced to the periphery of social relations(Ingold 2000g).

In this sense, the use of tools like computers needs to be reviewed. Though it is beyond the scope of this research, a pertinent question is to what extent these tools are enhancing effectivities, or, to what extent they prevent a better coupling of the learner and the environment.

A last remark regarding effectivities and the role of the body in the act of knowing and learning. While the ecological approach to learning is not an explicit theory of embodiment, the concept of effectivities, in particular, brings the body of the agent to the central stage of cognition. Accounts of embodiment and experience are not rare in architecture, but most of them focus on the experience of the user in buildings, and a few on the embodied experience of designing (Malnar & Vodvarka 2004; Pallasmaa 2005; McCann 2003). Embodied learning, however, has been given nearly no attention. However, as has been shown throughout this Chapter, most of the concepts of ecological learning necessitate an embodied agent to be fully understood.

The embodied agent implies a sentient agent, but also an agent that is active. The term 'action', appears many times in this thesis, and for a good reason. Knowing and learning in the ecological learning cast is developed within an activity.

4.3 Knowing unfolds in activity within an environment

> "Situated activity is not a kind of action, but the nature of animal interaction at all times... This is not merely a claim that context is important, but what constitutes the context, how you categorize the world, *arises together* with processes that are coordinating physical activity. To be perceiving the world is to be acting in it -not in a linear input-output relation (act-observe-change)- but dialectically, so that what I am perceiving and how I am moving co-determine each other" (Clancey 1993)

In our discipline there exists a long tradition that separates intellectual activities from those of actual making that may be traced back to the written work of two important exponents. Vitruvius (25 AD /1826), who declared that the arts are composed of two things, eius rationale and ex-opera (craftsmanship and theory); and later during the Italian Renaissance, the figure of Alberti (1987) who proposed a sharp separation between *lineamenta* and *structura* (design and construction). "It is quite possible, Alberti sustained, to project whole forms in the mind without any recourse to the material, by designating and determining a fixed orientation and conjunction for the various lines and angles. Since that is the case, let lineaments be the precise and correct outline, conceived in the mind, made up of lines and angles, and perfected in the learned intellect and imagination" (Alberti quoted in Lang 1965).

Alberti is considered the initiator of design as a discipline, and this particular postulate is still invoked to define the designer (Goel & Pirolli 1992). Design is seen, in this view, as an internal processing of abstract symbols (geometry), an essentially intellectual task, that can be carried out within the confines of the individual designer's mind, not only separate from the environment in which the building will be erected, but from the environment in which the designer is during the design process. The Albertian paradigm of design is, therefore, distant from an ecological creative process.

The mental self-reliance may be true in initial stages of the design process, however even in these cases it is dubious that the design process proceeded just in the designer's mind. At some point the designer had to resort to the environment in the form of paper, pens, ink, models. The designer had to 'off load' an initial design by hand drawing or other technique. In other words, he transferred the geometry from his mind into the environment. He was then able to test out different configurations, and while doing this he was able to perceive the backtalk of the drawing in a similar way, but probably in a different scale of time, as the man who fells the tree in Bateson's example. Action and perception became somehow intertwined.

This paradigm is also known as motor cognition and, as its name suggests is grounded in the notion that cognition is embodied in action. This means, in turn, that the motor system participates in what is usually considered as purely mental processing. The fundamental unit of the motor cognition paradigm is action, defined as the movements produced to satisfy an intention towards a specific goal, or in reaction to a meaningful event in the environment.

4.3.1 Perceiving Acting Cycle

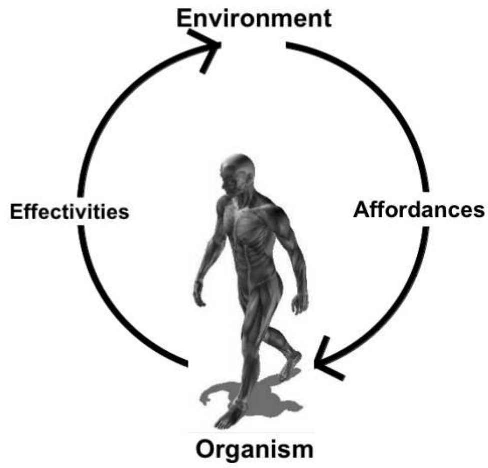

Figure 8: Perception-action cycle including the terms affordances and effectivities

When Gregory Bateson, referring to a man who fells a tree, says that "each stroke of the axe is modified or corrected, according to the shape of the cut face of the tree left by the previous stroke (is a) self-corrective mental process (that) is brought about by a total system, tree-eyes brain-muscles-axe-stroke-tree", he is suggesting a particular cognitive mode. An extended cognitive system. While the description of Bateson may indicate that the components of the system blend into one undifferentiated aggregate, the reality is that both retain quite different but complementary functions. The environment's task is to provide information, and the agent's task is to act upon that information provided by the environment, giving rise to an information loop. This information continuum is known as perception action-cycle and has been used to describe how action and perception intertwine. Perhaps the most important feature of this description is that action is not subordinated to perception, but both unfold in conjunction. This distinction, as we shall see later, is relevant in terms of how learning can be described in the ecological approach.The perception-action cycle can be described as a circular flow of information that takes place between the agent and its particular environment in the course of a goal oriented activity. It involves an agent who perceives affordances of the environment, and responds thereby transforming the environment so that new affordances can be perceived and acted upon. In other words, detection of information tailors the agent's actions to its environment, and the agent's actions tailor further perception. Perception and action are, therefore, co-implicative.

Action plays a fundamental role in terms of the agent's ability to explore the environment which in turn lead him to be in a better position to detect affordances. "It has been shown that if the individual is not given ample opportunity to engage in action (e.g. restricting head or body movement), then detection of environmental affordances is extremely limited even when looking at the same environmental information" (Warren & Wang, 1987 quoted in Young). This idea is related to Gibson's conception of explorative activities of the perceptual systems, and the effectivities of the agent. For example, when a sculptor wanting to appreciate a work in progress walks around it, he is resorting to an explorative activity of the visual system. The whole organism, while 'transporting the eyes', is participating in the visual exploration. Thus, action is important in the first place, in terms of mobility.

However, action is also important, in a sense that is relevant to an animal who designs. This is, in terms of the agent's ability to manipulate and modify objects in the environment. Consider again, the student of architecture while manipulating an explorative model, testing out new possible configurations. It may be said that student and model constitute a cognitive system of the type Clark and Chalmers (1998) describe, in virtue of the perceiving acting cycle.

So far, a number of concepts have been introduced with a focus on perceiving, which for Gibson is the simplest and best way of knowing, as well as on the circumstances surrounding the animal that knows. But little has been said of the process of learning. This process, as mentioned above, is different from what we customarily assume as such in the context of the modern university. How learning is done in the ecological cast is very similar to what popular wisdom says. Learning is done and enhanced by practising. Though this could sound very similar to 'learning by doing', there is a not so obvious but important distinction. Doing or experiencing something once is not enough to be considered learning. The emphasis is placed instead on the reiteration of the experience, and how from this reiteration, a process of learning emerges. To understand this, is necessary to address some previous concepts.

4.4 Learning as increasing attunement

4.4.1 Detection

At the end of Don Norman's paragraph quoted in page 92 he sustains that when a design is good “no picture, label or instruction is required” to use it. The user simply detects how the object can be used, being this an essential feature of the epistemic activity of an ecological agent. The affordances of the environment are not mentally processed, but are directly perceived, or as ecological psychologists would prefer to say, they are detected.

Detection is something on which there is not much agreement, though. The traditional and most widely accepted view (information processing perspective [40])

40 The information processing perspective or cognitive science 'emerged as an alternative to

sustains that information must be processed in the brain of the agent. This processing includes collecting, storing, and retrieval of information for later use (these are the pillars of a transmission model of education). Though an additional step is needed: information must be embellished at some point. Embellishment is necessary because this model is based on the assumption that the information in the environment is incomplete and unstructured, just data. Then, if an accurate picture of the world is needed, embellishment in the brain of the agent is indispensable.

The cornerstone of this model in terms of learning is memory. Information, it is assumed, can be stored in memory and can be transported to different contexts. Transfer of information is considered a proof of learning. Consequently, the information processing perspective sees the learner's brain as a storage of information, and also as a sophisticated data processing centre.

The ecological approach does not share this view. In the first place because the environment is an inexhaustible source of information, and this information is complete and structured (Michaels & Carello 1981; Gibson 1979). This means that it needs not to be embellished or corrected in our brain to get a proper picture of the world. What the agent does is to detect -without mediation of mental processes- salient features of the environment. For this reason the ecological approach to perception is also known as direct perception, i.e. the learner does not resort to 'mental gymnastics' to perceive the world (Chemero 2009).

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behaviourism in the 1950s, alongside the development of the digital computer. Its founding axioms are that people come to know what is 'out there' in the world by representing it in the mind, in the form of 'mental models', and that such representations are the result of a computational process working upon information received by the senses. The functioning of the mind, then, can be compared to the operation of a computer program, and the relation between mind and brain to that between the program and the 'hardware' in which it is installed' (Ingold 2000a, p.163)

Since for Ecological Psychologists, people are not processors, but sophisticated detectors of information, they prefer to use an alternative metaphor that, consequently, emphasizes the detection of salient features of the environment (objects, events). Gibson (1979) proposed the metaphor of a radio to explain the phenomenon of detection and it is worth pausing for a moment in it, since it involves some concepts that will help us to further understand what learning for an ecological agent is [41] .

The radio metaphor. The reception or detection of radio waves is based on principles of resonance of an electric current, by which a frequency-sensitive circuit selects a particular signal. Due to the existence of a large number of radio stations (frequencies) the receiver is reached by the same large number of signals, but a "proper tuning of it causes a current in it to resonate in response to one of the incoming signals, and not others'. The information in the environment and the multitude of signals transmitted by an equal number of sources works similarly. 'In the case of vision, electromagnetic radiation (light) is modulated by reflection. This is one way in which the environment 'broadcasts' information; the structuring of acoustic patterns is another. At a small grain of analysis 'What people detect are 'invariants' or persisting features of the terrestrial environment over time and space, at a larger scale the agent detects affordances. (for a comprehensive account see (Michaels & Carello 1981)

4.4.2 Genetic attunement and learnt attunement

While the analogy of the radio is limited, it is clarifying of the phenomenon of resonance as the basis of an ecological knowing. Places, events, and objects

41 In order to explain the same phenomenon of detection in the field of education, Young et Al. (2000) suggest the analogy of 'control systems like thermostats'. Thermostats are simple signal detectors that can be tuned to detect different temperatures. People, they sustain after Gibson, 'are information detectors that can be tuned to detect different types of information in the environment'.

transmit “structured distributions of energy” (e.g. light or sound) and some of these distributions are massively available in the environment. As the environment in which an intelligent human being unfolds is infinitely multiform and dynamic, the perceptual system must pick up information that is relevant in a particular circumstance. The agent detects this information on the fly, by resonating to particular environmental stimuli, and, like the radio, the perceiver can be attuned. However there is an important distinction between two types or categories of attunement to information from the environment. A genetic preattunement on the one hand, and a learnt attunement on the other.

Genetic preattunement is a logical consequence of evolution. Ecological theories do not only assume that organisms develop their life in “rich sea of information about their environments, but that these organisms have also evolved in those rich sea of information” (Michaels & Carello 1981). Consequently, it is taken for granted that the structure and function of perceptual systems have become 'tailored' to the information available. This genetic preattunement has been refined in the same evolutionary process of the species in conjunction with the environment in which the agent lives.

The kind of information to which this genetic preattunement attends is universal and available to all members of a species. An example in the case of ours is the ability to distinguish speech in childhood (Michaels & Carello 1981). Other preattunements are shared over humans and animals. Examples are our immediate reaction of defence, or escape, from attack, or the detection of the direction of gravity.

However there is also another category of attunement that in the context of this thesis is more relevant: the learnt attunement. We all perform it in the course of our lives, and, since it is not 'prewired' in us, gaining it requires an effort. Thus, the similarity between the radio and the agent ends here. The difference in the first place is that the living organism is a self-tuning devise. By contrast, the radio must be attuned by an external agent, and of course, can not improve the tuning in the course of its 'life'. This inability to refine the detection and tuning is, in the ecological framework, an inability to learn. Learning, then, is learning to tune the perceptual systems of the agent and this is a prerogative of living organisms.

As mentioned above, the emphasis of this approach is on practice rather than on simply doing. In humans, examples of perceptual refinement through practice are evident in craftsmen and artists. A sculptor, for instance, when rubbing the surface of one of his works in progress, is acting as a perceptual system attuned to detect texture[42]. However this attunement is not a privilege only of artists. It also occurs in activities that we consider more mundane. For instance, when a mechanic detects a particular type of fault in a car just by listening to it, or when a blind person detects acoustic invariants while he walks around in the city. And it is remarkably clear when a professional wine taster detects all kind of nuanced flavours in the wine, thanks to his highly attuned taste and olfactory system.

This attunement is closely related to craftsmanship, because is refined by reiteration, but it is not exclusively circumscribed to manual or physical activities [43]. A lawyer is a craftsman in his/her particular trade, who refines his/her perceptual systems every time that he/she litigates in the courts. The same happens to an architect every time that he/she estimates the length or height of

42 Referring to this capacity the Finnish master craftsman and designer Tapio Wirkkala says 'if eyesight fails, my fingertips see the movement and the continuous emerging of geometric form' (Pallasmaa 2009, p.54).

43 Richard Sennett (2009) sustains that 'craftsmanship is poorly understood...when it is equated only with manual skill of the carpenter’s sort'

a room, until reaching a moment when his/her visual system becomes a precise measuring devise.

In all these cases, learning is not conceived as memorization of information, but as an increasing refinement of the learner's ability to detect environmental information. The learning process for these individuals requires recurrent attempts, trial and error, continual testing. From this follows that learning implies for the agent to be in a continuous epistemic contact with the environment of practice, and the tools and artifacts of the trade. In this contact, agents, turned now into practitioners, learn to tune in their perceptual systems during a maturation process over their lifetimes. The result of this process of tuning is an agent with “an improved ability to know” (Michaels & Carello 1981, p.15), better prepared to act in each new situation, not because they 'have a knowledge' in their heads, but because they, as entire organisms, involving perceptual systems and effectivities, have become better detecting devises, and this occurs by means of actual reiterated experiencing.

4.4.3 Learning within a community

While Gibson's work primarily addressed issues of perception, his ecological coupling of agent and environment is consistent with current trends of cognition as situated (Lave & Wenger 1991; J. S. Brown et al. 1989; Wenger et al. 2002; Wenger 1999; Bredo 1994b; A. Watson & Winbourne 2008; Vanderbilt & Cognition and Technology Group at Vanderbilt 1990; Payette 2008).

The 'situativity'[44] of Gibsonian concepts is both implicit and explicit. Affordances, and the active responses by means of effectivities, must proceed in a particular

44 Situativity is the term used to unify a series of appellations, like Situated Cognition, Situated Learning, Situated action.

occasion and place. They are intrinsically situated. However, in Gibson's theory there is little mention of the social setting in which learning occurs, that was so important to Dewey(1938a) and to contemporary scholars (Bourdieu 1992; Lave 1988).

Situativity in coincidence with the ecological approach to learning, describes "Knowledge as fundamentally situated (knowing about), emerging in context and spread across activity, content and context. It becomes impossible and irrelevant to separate the learner, the material to be learned, and the context in which learning occurs" (Barab et al. 1999)

Advocates of these trend are more concerned with the interrelationship between the learner and the social and physical environment, rather than with the learner as an isolated individual. It has been suggested that learning is always situated and progressively developed through activity. In their seminal paper, "Situated cognition and the culture of learning", Brown et al. (1989) suggest that concepts such as knowledge understood as a self-contained entity should be abandoned. By contrast, knowledge should be likened to tools that can only be understood through use. The use of tools is not unconscious. It involves building an understanding of the context in which these tools should be used, as a framework that gives sense to such an activity (Ibidem).

Knowing is no longer conceived as a static structure residing in the head of individuals. Instead, 'knowing about' is an activity that is distributed between the knower, that which is known, the environment wherein knowing occurs (including the community), and the activity in which the learner is participating.

Concurrent with ecological psychology, situativity intends to overcome dualisms that infuse traditional pedagogical practices. This perspective rejects a separation between cognition and environment, or between "the learning and its applications" (Lave 2009, p.32). Knowing about, sustains Barab, "is deeply embedded in active participation within the social/material world" (Barab et al. 1999, p.360). Learning is context dependent, and the community in which the learner participates is an essential component of this context.

Crucial to this vision is the primacy of practice, though in a slightly different way of what it has been discussed here. Practice in situativity is a framework of participation. In this framework, the learner is given legitimacy by granting him access to a community of practice (Lave & Wenger 1991; Wenger 1999; Wenger et al. 2002). In such organization, "the individual learner is not gaining a discrete body of abstract knowledge which he/she will then transport and reapply in later contexts. Instead, he/she acquires the skill to perform by actually engaging in the process, under the attenuated conditions of legitimate peripheral participation" (Hanks 2009).

This is an essential concept introduced by Lave and Wenger (1991)denoting a particular mode of learning in which a learner does not need to attend lessons to acquire mental representations that must remain fixated in his memory. In contrast, the unskilled person is accepted in a centripetal social structure of participation (community of practice), and is assigned from the start with tasks typical of that community. At first, the novice occupies a position in the periphery and is involved in the practice only to a certain degree, hence with little accountability. As time progresses and he/she becomes more skillful and gains more central positions. In this way the community renovates itself. New apprentices arrive and those who previously were in the periphery are now promoted to teaching positions. A teaching position should not be understood as a traditional transmission of information, but as the introduction of the learner in a practice.

The common element between the ecological approach and situativity, as Hanks (2009) points out, is “the premise that meaning, understanding, and learning are all defined relative to actional contexts, not self-contained structures”. It is certainly not fair to mention situativity theories in such a brief text, but suffices to say for the purposes of this thesis that being situated involves much more than being located in a particular place and time. Learning is situated because the learner is situated in a community that grants him a role and status in a practice, and through this practice he can also perceive himself as situated in a larger social context.

4.4.4 Intelligence as interaction with the environment

This Chapter started with an epigraph of the professor of robotics Rodney Brooks, who defies the limit between what is intelligence and what is environmental interaction. The key idea from intelligence, Brooks says, is that “intelligence is determined by the dynamics of interaction with the world” (Brooks 1991a).

In coincidence with Brooks' statement, the ecological stance does not see the epistemic relation between the agent and its environment as information processing in its head. The agent performs instead a detection of information in the environment. The ecological approach posits that human agents do the same. We do not process information from the environment, we simply detect it and use the opportunities embedded in this information.

Although this idea is not shared by all cognitive researchers, it is not as strange in other areas. This could be further explained by means of analogy with highly autonomous organisms developed in Artificial Intelligence. In this area, the relationship between agent and environment has also become essential to define intelligence. Intelligence is associated with autonomy, and autonomy in turn is associated with environmental attunement. The more attuned with its environment an agent is, the more autonomous such agent is. The environmental attunement is essentially an ability to perceive (know) the environment and act according to that perception (perception-action cycle). However, to be fully autonomous the agent needs to learn. If we assume a traditional point of view, this means that the agent needs to be able to perform in new settings in concordance with past experiences. From an information processing perspective, the retrieving of memorized information becomes an essential pillar. Reality though proves too dynamic for agents, and unforeseen events too numerous to be processed. In view of this fact, researchers and some critics of the first approaches to Artificial Intelligence have long ago suspected that information processing is not the best way of creating genuine intelligence and autonomous agents (HL Dreyfus & SE Dreyfus 2000). For this reason, some of them began to shift their attention to the detection of information. Brooks (1991b) for example, has pioneered the production of intelligence without representation, hence without processing, an idea that has a clear affinity with the one of detection without processing of Gibson.

What is remarkable about Brooks' experience is the following. He has declared that the best model for his autonomous agents is the human being, and some animals. Though this is what we all expect, there is a particular trait of human beings and animals in which Brooks seems to be particularly interested. Humans as well as animals carry on their existences in “direct contact with the world”. It is paradoxical then that robots have humans as models in the process of knowing, and humans are still taught like robots. What does it mean to be taught like robots? (old robots to be more precise). It means that the pillar of learning is still the ability to memorize information.

In a similar manner as in Artificial Intelligence, the model of detection and attunement proposed by Gibson has implications on our understanding of human learning. The most important one is that the learner can dispense with the mechanism of storage and later retrieving of information, which is the basis of the educational system of transmission. Consequently, the task of cognition in the ecological cast shifts from improving the mechanisms of collection, memorization, and retrieval -confined in the head of the learner- to improving our detection of affordances, which explicitly drives the process off the head and leads it to the environment.

Driving the cognitive process toward the environment implies a necessarily active agent who must discipline its perceptual systems in order to detect information in a better way in every new experience, and abilities to act upon the environment according to that information. The detection of information is meaningful only in relation to that action. This circumstance puts the agent's body in a privileged position. The agent is active, not metaphorically, but because he has a body that is equipped with 5 perceptual systems -the basic orienting system, the auditory system, the haptic system, the taste smell system, and the visual system- including their exploratory activities, supported by a set of effectivities (Gibson 1966)

4.5 Conclusions Chapter 4

A large number of concepts has been discussed in this Chapter that may be unfamiliar to educators in architecture. While the underpinning concepts are sometimes difficult to grasp, the central idea is simple. Learning, in the ecological cast, occurs in the contact between learners and their environments. Something that may be confusing though is that the word *environment* does not refer here to the whole terrestrial environment that we usually talk about in environmental design, but to the physical, social and cultural context that can be felt by and surrounds the learner.

This coupling learner-environment is quite evident in the relationship between an animal and its environment, and this is the analogy that the ecological approach to learning proposes. Between the animal and its niche (particular environment) there exists an information link, a bidirectional flux of information. In the absence of this flux the animal would be rendered inert. However this is not what we often observe in nature, but the opposite. Agents are always in need of information in order to act, and the environment provides it copiously. What educators inspired by Gibson, like Barab, Young, and others sustain is that genuine knowing and learning can not occur when the learning agent is separated from its environment, in particular from its environment of practice.

If learning is dependent from the environment in which it happens, then the school, the studio, the lecture theatre and any other learning environment, are far from being mere places better or worse staged to afford instruction. And if designing is the characteristic learning activity for a student of architecture, then such learning environment should afford that activity in the best possible way. In the following chapter the notion of design as a conversation will be discussed.

This notion is widely accepted among researchers of design, however this is not always the case in schools of architecture. The definition of what we understand by design is relevant since from this definition follows what affordances are to be orchestrated in the learning environment.

Chapter 5. Design: an exploratory conversation

The problem of implementation of technical subjects in the studio has been addressed before, usually building on the difference between the paradigms of Art and Science. In Particular, the prominence of Art inherited from the French Academies, is often blamed for the permanent difficulty at implementing technical subjects in the studio. Accordingly, in order to solve this problem some authors have called for a radical departure from it (N. John Habraken 2005; Rapoport 1997; Rapoport 1983). These propositions draw on a dichotomous view of culture that has monopolised all the spectrum of the discussion. Its seems that we have just two options: being artists or being scientists. Or at the best, being in an uncomfortable tension between both (Groat 2000).

Recently, however, a third option has been suggested: Designing. We do not usually see it as valid paradigm of inquiry, perhaps because we are immersed in its practice, or because our educational system does not consider it as such (N. Cross 2007). But the fact is that an already significant body of research and thought, part of which will be alluded in this Chapter, substantiates such a thesis. Designing, in this light, is a discipline in its own right, that has its own ways of inquiry (N. Cross 2004).

In spite of the fact that some architects perceive themselves like artists rather than scientists, literature on design does not regard them as any of those archetypes. Architects, for design researchers are regarded clearly as designers. Indeed the literature about design identifies architecture as the cradle of design as an independent discipline, the roots of which can be found in Italian Renaissance.

Seeing architects neither as artists nor as scientists, but as designers, narrows down the perspective of our own inquiry, since being in the uncomfortable position between two major paradigms -Art and Sciences- makes the definition of the practice virtually impossible. Assuming design as a fully idiosyncratic discipline makes its characterization easier.

Regrettably the concept of design has become increasingly blurry in the last decades. It may refer either to the conception of a national policy, or to the conception of a new line of clothes. Herbert Simon's sentence that "everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (Simon 1996, p.111) opened the door to a virtual endless list of labours, and at the same time made the idea of design as a discipline very difficult to delineate. Donald Schon has pointed out that in pursuing this line of thought "we risk to ignore or underestimate significant differences in media, contexts, goals, and bodies of knowledge specific to the professions" (Schon 1991, p.77)

In coincidence with Schon's critique, researchers have started to unearth some patterns of design as an identifiable discipline, drawing on interviews with designers, study of protocols, case studies, and theorising and reflection. Slowly but steadily an image has started to take shape. While this process is still in progress, an initial consensus exists. Design is not the mechanistic sequence of activities that the first generation of methodologists –the Design Methods Group- thought it was in the 1960s. Neither it is a purely emotional artistic individual task.

Among the patterns identified there is one that is inescapable in the literature and appears to be in the core of the activity. Designing is a transactional task (Lawson 2006), or as Schon puts it, “design is a conversation with the materials of a situation” (Schon 1991). Likewise in a conversation, the designer neither imposes a personal topic on his counterpart, nor he is a passive listener. He establishes this conversation as a way of understanding and solving a problem. Schon's key concept will be used throughout this Chapter as a common thread.

The purpose of this Chapter is to match elements of the conversation that are present in the pedagogical experience presented in Chapter 6 (p. 153), which could be replicated in other cases. The Chapter is divided in 3 sections attempting to order the ideas from general concepts to more particular ones applied to the studio. The first section sets out to situate Schon's idea of conversation within a larger context of design models evolution. To this end three milestone models of the design process are discussed. These models were derived from observations and theorizations made 'outside' the schools, yet this transition arguably runs in parallel to them.

The second section discusses Donald Schon's concept of design as a conversation with the materials of a situation in view of extracting operative elements of the conversation, that can be linked to a pedagogical strategy.

The third section discusses three important features of the designer's peculiar way of participating in this conversation. If we adhere to the analogy of conversation, they may appear as 'bad manners'. On a closer look however, these attitudes seems to keep the conversation alive, or in terms of Schon, “they keep the inquiry moving”.

5.1 Three Models of Design (and conversation)

Various attempts at understanding the nature of design have been made in the past decades. These attempts have taken the form of models or maps. For reasons not entirely clear, science has played a role in this task. In the beginning, design was seen as an activity very close to it, yet later this supposed similarity became less apparent. In any case, science served to speculate the nature of design by means of analogy first and distinction later.

Many maps were elaborated for design in general, and for architectural design in particular (Lawson 2006). Here, three of them will be discussed. The analysis/synthesis model, the conjecture/analysis model, and the generator/conjecture/analysis model. These models are relevant because they represent three stances regarding a conversational process of design.

5.1.1 Analysis/synthesis: a non conversational model

The emergence of the analysis/synthesis model coincides with the second attempt to 'scientise' design by means of Design Methodology[45] (N. Cross 2007).

45 Cross(2000b) has detected a temporal cycle of 40 years in which attempts to 'scientise' design take place. During the first one, in the 1920's, architects embraced rationality and functionality as a paradigm of design. Le Corbusier (1929) who saw the house as a 'machine à habiter' declared, 'The use of the house consists of a regular sequence of definite functions. The regular sequence of these functions is a traffic phenomenon. To render that traffic exact, economical and rapid is the key effort of modern architectural science'. Though now this view may look narrow to us, Le Corbusier was by no means alone. Some years before Theo van Doesburg (1923) expressed this perception of a new spirit in art and design: “Our epoch is hostile to every subjective speculation in art, science, technology, etc. The new spirit, which already governs almost all modern life, is opposed to animal spontaneity, to nature’s domination, to artistic flummery. In order to construct a new object we need a method, that is to say, an objective system”

The intention was , "to base design process (as well as the products of design) on objectivity and rationality" (N. Cross 2007, p.119). Buckminster Fuller, one of the heralds of this movement, called for a "design science revolution", based on science, technology and rationalism, to overcome the human and environmental problems that he believed could not be solved by politics and economics.

In this spirit, a first generation of design methodologists, in an attempt to capture the elusive nature of design, engaged in the task of devising maps of the design process. In its most basic form, to elaborate a model of designing means to map a route through the process from beginning to end, aiming at identifying the actions that the designer performs in order to achieve a desired solution. Knowing this sequence would have lead to unravel the secrets of the design process, with ample consequences on production of artifacts in general, but also with obvious advantages in education. With a map, designing could have been easily taught.

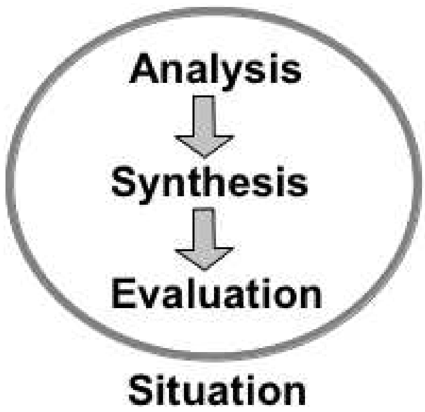

Figure 9: Analysis/Synthesis. A non conversational model

These maps are grounded on the notion that the design process consists of a sequence of identifiable activities that occur in some predictable logical order.

(Lawson 2006). A generalized map of the design process that emerged from these methodologists suggests that activities such as analysis, synthesis and evaluation occur in sequence, and independently of the design situation (See fig. 9)

Accordingly, this model was labelled analysis/synthesis. Analysis involves breaking down the problem into fragments to solve each fragment separately; synthesis is the attempt to create a response to the problem by piecing together the parts previously fragmented; and evaluation involves the critical appraisal of suggested solutions against the objectives identified in the analysis phase.

Critiques against the analysis/synthesis paradigm arose first in terms of the classical problem of the 'parts and the whole' in architectural design. Parts, in this model, were given a disproportionate relevance, in detriment of the whole. Solutions were expected to be assembled from fragments. However, the reality of architectural design seemed to differ from this presumption. Further, it violated a classical principle of harmony that states: "in design, the whole or aspects of the whole govern the parts" (Bamford 2002, p.254)

Yet the pressing question was other. Apart from the issues of integration of fragments, which addressed shape composition rather than the process itself, the analysis/synthesis model was later criticized, even by some proponents of these kind of maps, because it was extremely rigid and naively linear[46]. Along with its inflexible linearity this model appears as highly detached from reality (Lawson 2006; Ingold 2000b). Consider the following description of a design session in the light of the analysis/synthesis model: "A designer begins a conceptual design

46 Christopher Alexander (1964), one of the original advocates of a rational method for architecture and planning, said later: 'I've disassociated myself from the field... There is so little in what is called 'design methods' that has anything useful to say about how to design buildings that I never even read the literature any more ... I would say forget it, forget the whole thing' (Alexander 1971).

session by analysing the functional aspects of the problem. As the session progresses, the designer focuses on the three aspects of function, behaviour and structure, and engages in a cycle of analysis, synthesis and evaluation. Towards the end of the design session, the designer's activity is focused on synthesising structure and evaluating the structure's behaviour". (McNeill et al. (1998) quoted in Cross). Such a description seems very distant from the events as they can be observed in a design studio, or in a professional practice. In reality the designer moves in an unpredictable manner even for himself. He needs to go back and forth a number of times to discover another problem, or establish another provisional connection. Sub-problems grow or decrease, even disappear and the most of the times they overlap, or are interlocked. (Lawson 2006).

These analytical maps were also problematic because they were adamantly hierarchical. They proceeded typically from general to specific, from 'outline proposal' to 'detail design'. Reality, again, showed a different picture. Architects change the scale in which they address the problems of design many times during the process, not necessarily in a decreasing order. Some architects proceed, against the prescription, from details to a general proposal. Reality demonstrated that, while a number of things must occur for design to take place, these things do not occur in strict linear order, or from big to small.(Lawson 2006)

In addition to the problem of linearity, the Analysis/Synthesis model assumes a discreteness of the parts or sub-activities as if they were undertaken by a robotic performer. In this model, it was taken for granted that the parts were not overlapping or connected. An activity could start only when the previous one was finished. And once an activity was finished there was no need to go back to it. Whereas in later maps a series of loops connecting activities to preceding ones were introduced, these seemed still arbitrary. The description of the design process was still far from the real practice.

The origins of the emergence of new prescriptive design methods, it has been suggested, lays in the application of novel, scientific and computational methods arising during and after 2nd World War (Ingold 2000b). Bamford (2002) suggests a direct connection of the analysis/synthesis model to philosophers of the scientific method, such as Descartes or Bacon, involving therefore the classic dichotomy of the knower and the known. In either case the inspiration comes from a scientific paradigm of inquiry in which the researcher must conform to values of objectivity and distance from the phenomena in study.

This is problematic for a designer because in this logic he is prevented from getting involved in the process of inquiry. This is not to say that he is prevented from inquiring, but the manner suggested by the model is alien to the designer. To use Schon's analogy, no conversation is really possible. The dialogue, if any, is dictated in advance. Moreover, by following the rules of the model, there is no need for a designer. While a model is a description of a process or a representation of something, rather than a prescription, the analysis/synthesis model failed to describe what designers do.

5.1.2 Conjecture/Analysis: a semi-conversational model

After this first failed attempt to capture and understand the nature of the design process by means of analysis and mapping, Hillier et al. (1972), elaborated a new method which included a series of conjectures as a departure point of the process. This proposal is arguably inspired in another scientific paradigm: Popper’s account of the scientific method (Bamford 2002). A conjecture is a configuration of a whole entity, not an accumulation of parts: 'design is by nature a holistic, intuitive process, and this conclusion follows from a reasoned analysis of the process of design' (Hillier 1996, p421).

Hillier and his colleagues believed that the rationalization of the design process proposed by the Analysis/Synthesis paradigm was impracticable because it suggested that design should be deduced from an analysis of requirements specified in the brief, rather than from the designer's preconceptions. Accordingly they proposed the figure of conjectures to be tested, as an alternative to approximate a synthesis by logical procedures.

'The Conjecture/analysis model emphasizes the importance of the designer’s pre-structuring of the problem, rather than denigrating it' (Bill Hillier et al. 1972, p.258).

The Popperian view applied to design started to gain credence among designers in the late 1970’s. The possibility of 'hypothesizing' approximate solutions much earlier in the process than the method of Analysis/Synthesis allowed them to structure and understand the problem. Further, designers saw, in the conjecture-analysis model, a resemblance to what they were doing in practice. Brawne(2003) judges that the inclusion of this starting point in the sequence, as a recognition of the problem in the form of a hypothesis, is a most accurate description of the origination of the process. “The recognition of a problem then put forward a hypothesis, a kind of tentative theory which needs to be tested in order to eliminate errors and end in with a corroborated theory which is, however, the start of a new sequence in which it becomes the initial problem” (Brawne 2003, p.33)

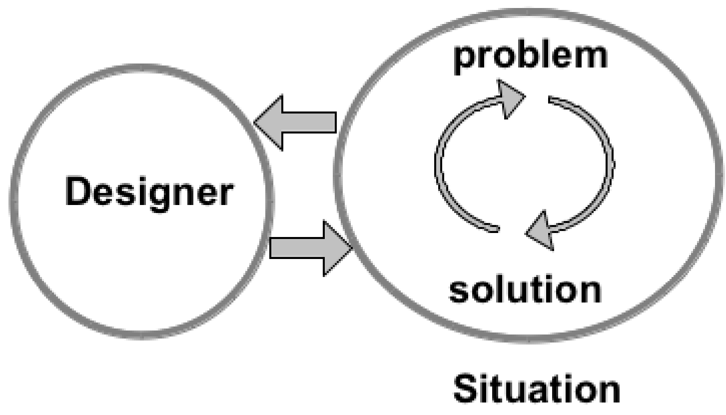

Figure 10: Semi-conversational model. Designer observing situation from a distance

It has been observed that whereas this description is certainly closer to the design process, the underlying logic of inquiry -Popper's account of the scientific method- is different of the designer's way of inquiry. In the he Popperian logic of hypothesis testing, the scientist compares hypotheses and the one that best resists refutation is confirmed, the rest is eliminated. It is true that a form of conversation is proposed -trial and error- however the emphasis is still placed in rational elimination .

> “There is no more rational procedure than the method of trial and error – of conjectures and refutations; of boldly proposing theories; of trying our best to show that these are erroneous; and of accepting them tentatively if our critical efforts are unsuccessful” (Popper 1953)

Transferring this logic to our discipline, design would consist of comparing solution types, and the one that best resists refutation is confirmed. In principle this is perfectly faithful to what designers do. A designer may produce a number of hypothetical solutions from which he can choose the best fitted, but as Schon has observed, designers do not use the cold logic of scientific discrimination. The scientist is committed to eliminate weaker hypotheses and he does it from an objective and rational position. The designer on the other hand, performs a kind of hypothesis testing in which he is involved. Further, he does not want "to show that his hypothesis is erroneous", all the opposite, he wants it to be confirmed, and he intervenes for this to happen (Schon 1991).This systematic intervention to modify the conditions of the experiment is the basis of a conversational model.

Hillier et al.(1972) claim that the incorporation of a conjecture makes the process more 'life-like', and their proposal arguably describes the design process in a much better way. Beyond the problem of neutrality vs. involvement, the value of the model, as Hillier remarks, is the inclusion of the "problem pre-structuring". Schon calls it "problem setting" or "problem framing", and Lawson interprets it as an actual window to a portion of the problem, which is consistent with Hillier's assertion that "it is only by means of this window that the problem can be contained within manageable bounds".

While the model promotes communication between the designer and the situation, by means of problem pre-structuring and hypothesis testing, this communication is not yet a genuine conversation. A conversation is not ruled by neutrality and distance.

5.1.3 Generator/Conjecture/analysis: a conversational model

While conducting a socio-constructivist research, Jean Darke (1978) detected that outstanding architects very early in the design process used "strong guiding themes for setting problem boundaries and solution goals" (Darke quoted in Ingold 2000b). She agreed with the previous model in that "the greatest variety reduction or narrowing down of the range of solutions occurs early on in the design process, with a conjecture or conceptualization of a possible solution". In addition, "further understanding of the problem is gained by testing this conjectured solution". Yet she observed something else. The conjecture was not always a logic consequence of rational scrutiny of the problem. On the contrary, the most of the times the designer formulated a personal objective that Darke (1978) describes as "a broad initial objective or small set of objectives, self-imposed by himself, a value judgement rather than the product of rationality".

From her observations she suggested a re-elaboration of the model of conjecture/analysis. Her proposal included a new third term that she called "primary generator", raising a tripartite model: generator / conjecture / analysis.

Cross (2000b) sustains that the advantage of the primary generator is that "both defines the limits of the problem and suggests the nature of its possible solution". For Lawson, the primary generator is a **window to the solution**, as it is the Schonian frame[47] a **window to the problem**. Does it mean that in the conjecture/analysis model the designer is not able to see the problem? Yes and No. The designer sees a problem, but he is assumed neutral in regard to it, in virtue of the scientific nature of the underlying Popperian stance. His stance

47 Framing is an important component of Schon's concept of design as a conversation with the materials of a situation, its counterpart is experimenting.

towards inquiry is, in Schon's terms, “that of spectator/manipulator”(Schon 1991, p.163).

In the third model, the designer has gained a personal position from which he both frames the problem, and foresee part of a possible solution. This model conjugates a window to the solution (generator) and a window to the problem (frame), which are the basis for a conversational model. Notice that the designer is not seeing neither the whole problem nor the whole solution, but a partial view of them through windows he chooses to use. Thus the solution is **not independent** from him as it was in the first model, nor it is **neutral**, as it was in the second. When the designer hypothesises a solution, he is involved in it. He works in order to affirm it. In the words of Schon, the designer “makes his hypothesis come true” (Schon 1991, p.149) The primary generator is a hypothesis of this type, not a scientific one. The designer wants it to fit, and modifies -designs- the conditions of the experiment for this to happen.

5.1.4 Seeing the models through a conversational lens

This account of three models of the design process may be read in various ways. The first one, and most obvious, is the transition from a hypothetical and mistaken description of the design process to a more life-like one (Hillier 1972). A second reading following from this, is that this evolution is one of participation and involvement of the designer with the **situation**. He transits from being virtually absent in the first model, to an intermediate state of neutrality in the second, to a final personal involvement in the third.

A further interpretation, concerning the idea of design as a conversation, underlying the three models can be observed. In the first one

(Analysis/Synthesis), designing may proceed without a designer, a machine may eventually perform it. The designer's preconceptions must be left aside, and if any communication occurred between the designer and the situation, this has to follow an algorithmic order. As stated before, in this circumstances no genuine conversation can proceed.

By advancing a 'problem pre-structuring' in the second model (Conjecture/Analysis), the mechanistic nature of the Analysis/Synthesis description is overcome to a certain extent, however its spirit remains of objectivity. The communication between the counterparts in this second case is a respectful one, but its not yet a conversation. Here, the designer function as a spectator/manipulator. He structures the problem, defines the competing hypotheses and discriminates among them, but he is always taking distance from the phenomena.

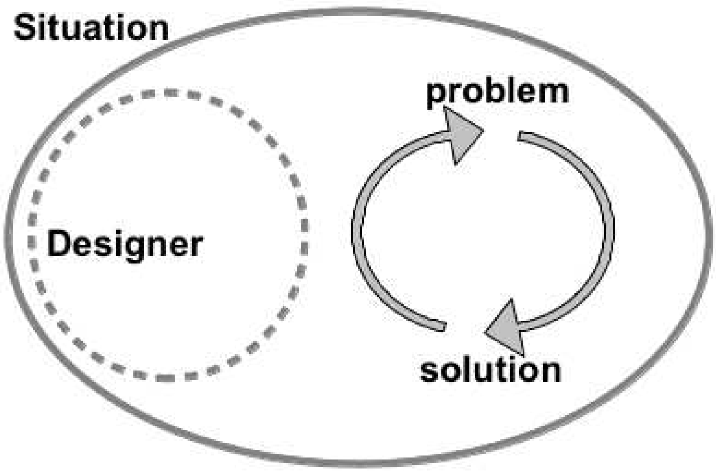

Figure 11: Designer in situation

The third model (Generator/Conjecture/Analysis) posits a further alternative. The designer becomes part of the problem, since he violates the canon of objectivity of the scientific method. The primary generator is not a neutral viewpoint, but a window he has chosen to see the problem through. His choice makes him part of it, and because of this he is able to have a conversational relationship with the situation.

While the first two views may appear as more appropriate from a rational standpoint, the third one, with its peculiar stance of involvement with the situation, seems closer to what design is, as a vast body of research has substantiated. Figure 10 summarises the end of this transition, for the moment. The designer is **in** the situation, and from there he can observe and also manipulate the dialectics of problem and solution.

5.2 Design as a conversation

The concept of conversation implies the development of arguments that are not defined in advance, but co-evolve. A conversation, Suchman (2006) suggests, "is not so much an alternating series of actions and reactions between individuals as it is a joint action accomplished through the participants" continuous engagement in speaking and listening' (p.87)... Viewed as highly skilled performance, the organization of conversation appears to be closer to what in playing music is called "ensemble" work, than it is to the common notion of speaker stimulus and listener response' (p.89).

Schon's proposal of conversation contradicted an old idea of design more akin to a soliloquy, the roots of which can be found in the written work of Leon Battista Alberti (1404-1472). The distinguishing trait of the designer for Alberti, discernible in his own architectural production, and later in the theories and built work of Serlio (1475 – 1554), or Palladio (1508 –1580), was his capacity to 'see' in advance the geometry of the building to be erected.

> “It is quite possible”, sustained Alberti, “to project whole forms in the mind without any recourse to the material, by designating and determining a fixed orientation and conjunction for the various lines and angles. Since that is the case, let lineaments[48] be the precise and correct outline, conceived in the mind, made up of lines and angles, and perfected in the learned intellect and imagination” (Alberti quoted in Lang 1965).

Alberti's conception consolidates the split between the intellectual conception of the edifice on the one hand, and its actual making on the other. For this reason, he is considered the initiator of design as a discipline. Design -disegno- means in its original sense, drawing ideas on paper and, as Alberti suggested, these ideas can be wholly preconceived in the mind of the designer without recourse to nothing more than his imagination[49].

Alberti's and Schon's ideas of architectural design are clearly incompatible. The contrast is apparent in three respects. While Alberti's designer is engaged in solipsistic monologue 'in his mind', Schon's designer is engaged in a conversation. There is something else outside his mind, participating in the process, talking and listening. While Alberti's designer can perform the whole process of geometric conception in his mind, Schon's designer is physically situated and dependant on that situation. And finally, while Alberti's designer can neglect the materials of the situation, at least during this process, for Schon's

48 He defines the term lineamenta by opposition: Lineamenta in architecture derives from the mind, as opposed to materia, which derives from nature.

49 In Italian, *disegno* is indeed the act of drawing, whilst what in English is design, is termed as *progetto* or *progettare*, something that refers to the projection of something from the mind of the designer to the matter of the building.

designer, materials' backtalk makes this conversation possible.

Schon recognizes design as a process of anticipation and subsequent construction, yet he adds the concept of design as a frame experiment. To explain this, he contrasts the attitudes towards design of two people. The first thinks of design in terms of imposing forms upon materials, while attending to technical considerations such as acoustics and energy conservation. This designer thinks that he can select an idea "in his head" and impose it on the materials of the situation and make it work. For the second designer, design is a matter of trying out 'meaning-establishing moves'.

While the first person looks at the experience of design as a conceptual exercise of control over the situation, for the second, design is an uncertain matter of experimentation which aims at discovering an over-all coherence in it. On this conception of design an original idea, a 'frame' of meaning, is put into play in the design process. In that moment the designer enters in a 'frame experiment', a 'dialogue' with the materials of the situation. In this process the designer attempts to perform operations, and materials 'talk back' to him, constraining and shaping the next steps. During this dialogue even the original frame can be questioned. Finally a new order of consistency, a new world emerges through the co-creation by designer and materials in the frame experiment.

For Schon, design is to find a framework of meaning in an uncertain situation through practical operations on the situation. This has three Implications.

1.Designing is learnable but not didactic or discursively teachable. It can be learned only through practical operations of frame experimentation or dialogue with the materials of the situation.

2.Designing is inclusive or holistic: its parts can not be learned in isolation.

3.Designing depends upon the ability to recognize desirable and undesirable qualities of the discovered world.

In order to understand how this conversation proceeds the main elements are discussed in the following sections.

5.2.1 Problem Framing[50]

In order to initiate this conversation the designer needs first to make sense of the situation in which he is going to take part. As a reflective designer, in contrast with a technical rational stance toward inquiry[51], he confronts every problem as a unique situation, the most of the times uncertain and troubling. He is impelled to make sense of the problem because of this uncertainty and uniqueness. To this end, he sets the problem from his personal position, in "a process in which, interactively, he names the things to which he will attend and frames the context in which he will attend to them"(Schon 1991).

"Because problems are not given, but unique and uncertain, they 'must be constructed from the materials of problematic situations. In order to convert a problematic situation to a problem, a designer must make sense of an uncertain situation that initially makes no sense...When we set the problem, we select what we will treat as the 'things' of the situation, we set the boundaries of our

50 Schon uses the expression 'problem setting' when the designer frames the problem for the first time. For successive 'problems settings' within the same design process he uses the expression 'framing'.

51 From the perspective of Technical Rationality (cf. Chapter 2), the problem is contained in the brief. From this follows that a professional response of the designer should follow the rules of technical problem solving. In such a view, problem solving consists of a 'selection from available means, of the ones best suited to establish the ends' p.40. These available means have been pre established by others who produce the knowledge. In this view, the task of the designer should be **the application** of the best available solution from an available set of them. This attempt to standardize every problem, assimilating it to one 'in the book', is for Schon an irreflexive attitude.

attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situations need to be changed" (p.40).

Lawson (2006) has suggested a literal interpretation of the expression 'framing', in the sense that the designer selects a portion of the problem to be seen through a window. In the same sense Hillier sustains that it is only by means of this window that 'the problem can be contained within manageable bounds'.

There is another important reason why the designer needs to frame the problem. He tries to frame one he can solve, otherwise he would be stuck. He steps in the situation with a view of a possible solution. This is not to say that, at the moment of framing, he knows what the solution to the problem will be, nor can be sure that the new problem will be soluble at all. Still he is now in a position in which he can see a manageable problem with himself in the picture, including his previous accumulated experience, his strengths and weaknesses, and above all, "with a framing of the problem for which he feels he can find a solution" (p.134). Once the problem has been framed the process of reflective conversation is set in motion.

Problem framing does not occur 'in one burst' just at the beginning of the process but it is recurrent at different moments of it, as it has been documented in research. Goel and Pirolli (1992) while conducting comparative protocol studies of architects, engineers and instructional designers, found that *problem structuring* not only dominated at the beginning of the design task, but also re-occurred periodically throughout the task. On the other hand, other studies have shown that having only one frame -that is a form of fixation to an early concept that never evolves- hinders the quality of solutions. Problem framing may be considered a skill in a conversational design process, an ability that is tied to previous experience of design. In a comparative study of experienced designers Cross (2001b) found that in all cases, designers adopted a particular point of view, or frame, in the first stages of the process. Conversely, other studies of novice designers show that they adopt a strategy of gathering information to define the problem, delaying the adoption of a particular perspective until it is inevitable (Lloyd and Scott (1995).

5.2.2 A conversation by experimenting

This conversation proceeds by virtue of iterative framing and testing. After the first framing of the problem, the designer proceeds to evaluate its suitability. He then tries to adapt the situation to this frame. In order to do this he conducts a series of experiments. He needs to "discover what consequences and implications can be made to follow from the framing" (p.131). A successful framing of the problematic situation leads to a continuation of the reflective conversation, while an unsatisfactory framing leads to a reframing and subsequent testing by an on-the -spot experiment. Schon distinguishes three kinds of experiments. Exploratory experiments, move testing experiments, and hypothesis testing experiments.

5.2.3 Exploratory experiments

In its most basic sense, Schon suggests, to experiment is to act in order to see what the action leads to. "The most fundamental question is, What if?" (p. 145) This kind of experiment is very common in early stages of the design process. The designer does not pursue any preconceived outcome. He is just trying configurations only to see what follows, without accompanying prediction or expectations. He is, in one word, playing, very much as a child plays with assorted Lego pieces without instructions. “Exploratory experiment is the probing, playful activity by which we get a feel for things” (p. 145). Turning a model up side down, for example, may accidentally lead to discover a better response to the site. The function of exploratory experiments is to induce the situation's backtalk, which causes the designer to appreciate things in the situation that he was not able to see in the initial stage of the problem. The experiment is considered successful when it leads to a discovery.

5.2.4 Move-Testing experiments

In this kind of experiment the designer is trying to produce an intended change. This happens, for example, when a designer changes the size and position of windows, and opacity of glass, in order to calibrate natural lighting in a reading space; or when the designer modifies the materials and geometry of a lecture theatre in order to improve speech intelligibility. In short, any deliberate act with an end in mind. The logic of move testing experiments depends on the “appreciative system” of the designer. (p. 146). If he likes what he gets from the action, taking its consequences as a whole, the move is affirmed, if he does not, the move is negated.

5.2.5 Hypothesis-testing experiments

In this kind of experiment the designer tries to corroborate a theory (hypothesis), and normally this is implicit in the designer's move.

The function of hypothesis testing is to cause an intended discrimination among competing theories, and its logic is as follows: theories that best resist refutation, succeed. If a designer asks himself, for example, what makes glare to be reduced in this room? And start to experiment to find out -trying for example different filters or degrees of opacity - he is in the same kind of endeavour as the scientist is when comparing competing hypothesis. He is trying to discriminate among them. The theory, implicit in the move, is confirmed when it succeeds in predicting its consequences. On the other hand, the theory is disconfirmed (*refuted*, in Popper's account) when the move fails to get the outcomes predicted.

5.2.6 The logic of experiments in design

Whereas the designer makes use of the same logic in hypothesis testing as the scientist does, an important difference exists, and it has to do with the different kind of commitments both have. The scientist does not want to interfere in a naturally occurring phenomenon he is observing, because he is trying to discover extant patterns in it. He must refrain from imposing his biased views. The designer, on the other hand, “has an interest in transforming the situation from what it is into something he likes better”. Likewise the scientist he wants to understand the situation, “but it is in the service of his interest in change”. The designer's experimenting, then consists of moves that change the situation to make the hypothesis fit (Schon 1991, p.147).

Nevertheless, the situations are almost never completely ductile. Whether being because of functional requirements, or site topographical features, or other peculiarity, a degree of resistance always exists. Cross points out that there is always an element of reconciliation between “the (designer’s) high-level problem goals and the (client’s) criteria for an acceptable solution”.

Thus, the reflective designer's hypothesis testing is not a capricious affair, or a 'self-fulfilling prophecy' which he forces to work against disconfirming data. The relationship between the designer and the situation, when it is genuinely reflective, is better described as transactional[52]. This is the core of the reflective conversation. While the designer shapes the situation, he does it in a conversation with it, so his own discernments are also shaped by the situation's backtalk.

5.2.7 The language of the conversation

The expression 'Reflecting-in-action' does not only mean 'thinking while doing', but keeping engaged in the ways of inquiry of the practice, i.e. in its peculiar language, tools and traditions. Even when addressing scientific topics the designer does not abandon this language (Waks 2001).

Modeling

At the core of design is the language of modeling; Cross sustains that it is possible to develop students' aptitudes in this language, equivalent to aptitudes in the language of the sciences (numeracy) and the language of humanities (literacy). Modeling allows testing and modifying, that is the central, iterative activity of the design process (N. Cross 1982). Its worth noting that for Cross, modeling includes sketching.

Modeling is part of the virtual world in which the designer operates. "The ability to construct and manipulate this virtual world is a crucial component of the designer's dexterity not only to perform artistically but to experiment rigorously" (Schon 1991). The modeling dexterity of the designer ensures an authentic conversation, with authentic topics. This means that the rigour of the experiments rely on the ability of the designer to represent the situation of the

52 Schon borrows from Dewey this term. Dewey refers to the relation between the learner and the learning environment as a transaction.

real world.

This kind of models should not to be confused with 'presentation models' in which the reality is intended to be replicated in detail. The kind of modeling that is useful for experimenting, while trying to be faithful, discriminates some portions of reality. Modeling works as a context for experimenting “precisely because it enables the designer to eliminate features of the real world situation which might confound or disrupt his experiments”(Schon 1991, p.159), however the designer must be aware of the factors that have been removed at the moment when he comes to interpret the results.

The manipulation of reality enabled by modeling occurs also in a temporal scale. Some phenomena can speed up in time, as when a year of sun exposure can be compressed in 5 minutes. Or they can be frozen, or reversed, to be examined at designer's leisure.

Models belong to a “virtual world” that is an advantaged context for experiments within which some of the everyday hindrances to reflection-in-action can be suspended or controlled. A classic example of this kind of modeling, in which a particular phenomenon is isolated, is the famous funicular model made by Antoni Gaudi's atelier for the church in the Park Guell. This model was carefully crafted to study complex problems of statics, masses and gravity, within the constrains of stone masonry. Gaudi devised an ingenious upside down model made of strings and bags of sand. Of course, the purpose of the model was not to portray the visual aspect of the church. Gaudi's intention was clearly other. He needed to discriminate a combination of phenomena -masses, gravity and geometry- in order to have a conversation with them. The model was not simply pre-conceived in Gaudi's mind, but resulted from a negotiation with the materials of a situation. From the model's backtalk, Gaudi could predict an harmonious geometry, and approximate values of compression in critical elements of the structure. Gaudi's example of experiment as reflection-in-action is consistent with Schon's view that designers do not abandon the way of inquiry of the practice, even when exploring unknown territories.

Sketching

Sketching is arguably the modeling mode that more readily lends itself to a conversational design process. It is through sketching that the designer 'shapes the situation, in accordance with his initial appreciation of it; the situation "talks back", and he responds to it (Schon 1991). By sketching, ideas in progress are expressed and reflected upon: they are considered, revised, developed, rejected and returned to.

Sketching, it has been sustained, involves important cognitive aspects. They serve "as an external memory device in which to leave ideas as visual tokens, as a source of visuospatial cues for the association of functional issues, and as a physical setting in which design thoughts are constructed in a type of situated action" (Suwa et al. 1998)

Particularly when occurs at the earliest stages of the process, sketching constitutes what Cross (2001a) calls "the designer's thinking with a pencil"[53]. Cross sees sketching as an intelligence amplifier, or cognitive system, very much in the spirit of Clark and Chalmers' proposition of extended mind (Clark & Chalmers 1998). Design sketches enable designers to handle different levels of abstraction simultaneously; identification and recall of relevant information;

53 This topic has been extensively discussed by Juhani Pallasmaa in his recent book The Thinking Hand.

structuring through solution attempts; recognition of emergent features and properties of the solution (N. Cross 1999). Sketching is also a particular occasion in which knowing and acting intertwines. This is evident in the drawings of Leonardo da Vinci in which annotations, calculations, and (for us) incomprehensible marks alternate with the drawing itself. If we subscribe Clark and Chalmers thesis, we can say that designer and sketch constitute a cognitive system. By removing the sketch from the system, we will have the same deleterious impact as removing part of the designer's brain.

Through sketching the designer can have an intimate conversation that "goes on between internal and external representations" of the situation(Cross). In the same sense Pallasmaa sustains that "drawing looks simultaneously outwards and inwards, to the observed or imagined world, and into the designer's own persona and mental world" (Pallasmaa 2009, p.91).This conversation is not just metaphorical. A good example is the case observed in detail by Cross & Cross (1996) of F1 car designer Gordon Murray, who does "lots of thumbnail sketches, in which he 'talks' to himself by annotating them with criticisms such as 'too heavy', and 'stupid' or 'rubbish'".

Whereas sketches may look pleasant, their practical nature must be emphasised. Sketches are in the first place, tools. Their function in design is not so much to be admired by its beauty as it is to serve a purpose. Sketching is an instrument of exploration, "the concepts that are drafted in design sketches are there to be criticised, not admired; and they are part of the activity of discovery that is the activity of designing" (Ingold 2000b, p.57).

5.3 Designerly Conversation

This section borrows from Nigel Cross (2001a) his idea that design has particular ways of knowing, different from those of art or science. These ways of knowing are manifested in attitudes and strategies to confront problems. From a conventional viewpoint these attitudes appear less mysterious than the artistic ones, but some of them, as Schon(1991) suggests, may still look anomalous to a rational eye. What is more, these ways of knowing appear at first glance as contradicting the conversational quality of designing, previously described; however on a closer look they make an active conversation possible, or in the expression of Schon, they keep the inquiry moving.

5.3.1 Solution Focused

The 'solution-focused' strategy of designers has been often criticised, arguing that this cognitive style hinders the development of critical thinking. These critiques, it seems, assume that being solution focused is an unjustified reluctance at formulating thorough problems to be satisfied by untroubled responses. However, others have pointed out that this ill-behaved attitude is intrinsic to the the kind of problems designers have to confront (Lawson 2006; Ingold 2000b).

Design problems have been described as 'ill-structured', meaning that some necessary information is not available to problem-solvers. A complete definition and clarity of formulation in some respect is missing (Simon 1973).

It has been observed that even when the problem can be thoroughly described, designers prefer the ill-defined problem, as part of their 'designerly' nature. Moreover, they tend to structure all problems, either well or ill-defined, as ill-defined ones (Cross 1991). Because of this missing part of the structure, either real or self-imposed, these problems “are not susceptible to thorough analysis, and there can never be an assurance that 'correct' solutions can be found for them” (Lawson).

Lawson(2004) and Cross(2000b) coincide with the idea that the information the designer needs to understand the problem depends very much on his own ideas about solving them. The failing in acknowledging this was perhaps the main weakness of the Analysis/Synthesis model shown in the first section. The designer, in that model, before attempting any solution, required to perform an exhaustive determination of the problem, based on the “illusion of universal data collection and processing, uncontaminated by the designers view” (Bamford 2002, p.254). While a thorough study of the problem may eventually result in a good design, it is not clear that a correlation between analysis and better solutions exist, as research has shown (Ingold 2000b).

Evidence of a relation between a solution-focused strategy and experience has been also found. After a protocol analysis of experienced engineer designers Lloyd & Scott (1994) found that the more experienced the professionals, the more generative reasoning they used. Less-experienced designers, by contrast, tended to stick to a deductive reasoning procedure. They concluded that : “It is the variable of specific experience of the problem type that enables designers to adopt a conjectural approach to designing, that of framing or perceiving design problems in terms of relevant solutions” (quoted in Cross 2001).

While a solution-focused strategy seems to be an adequate response to an ill-defined problem, some researchers have warned about inherent risks (N. Cross 2007). One of these risks is the fixation of the designer to early concepts. This is not necessarily a bad thing in design, for the commitment to guiding principles is a form of fixation, but it becomes unfavourable when the fixation is to early concepts that do not work. Though the concepts may be forced to work, this implies a considerable effort from the designer, being the quality of the outcome uncertain, or plainly unsatisfactory.

In sum, the solution-focused strategy of designers in a context of ill-defined problems does not appears as illogic, or inappropriate. On the contrary, it seems rather more advantageous than a problem-focused one. As Hillier and Leaman (1974), remark "it is only in terms of a conjectured solution that the problem can be contained within manageable bounds".

The solution focused strategy should not be confused with a lack of reflection. It is also wrong to assume that the designer knows the solution in his mind before setting the problem, and that he makes his way to it, blind to other possibilities. Even after setting the problem, the solution is still in a long process of formation. This has been interpreted also as a co-evolution of problem and solution.

5.3.2 Co-Evolution of Problem and Solution

The idea of co-evolution of problem and solution was set forth by (Poon & Maher 1997) . They criticise "the assumption that a problem is defined once-and-for-all". They posit that "this is definitely not true for design" (Ibidem p.2). Instead, design "should be considered as an iterative process where there is interplay between problem reformulation and solution generation" (Ibidem p.2)

As it was shown in the first section, designers tend to use solution conjectures as the means of developing their understanding of the problem. Since 'the problem' cannot be fully understood in isolation from consideration of 'the solution', it is natural that solution conjectures should be used as a means of helping to explore and understand the problem formulation. The solution, sustains Cross, is not just hidden but "it has to be actively constructed by the designer's own efforts". This is consistent with Schon's suggestion of *hypothesis confirmation* as the permanent attitude of the designer.

Dorst and Cross (2001) proposed to understand designing as a process of fitting 'problem space' and 'solution space'. After conducting protocol analyses of experienced industrial designers they reported that: "The designers start by exploring the [problem space], and find, discover, or recognise a partial structure. That partial structure is then used to provide them also with a partial structuring of the [solution space]. They consider the implications of the partial structure within the [solution space], use it to generate some initial ideas for the form of a design concept, and so extend and develop the partial structuring. They transfer the developed partial structure back into the [problem space], and again consider implications and extend the structuring of the [problem space]. Their goal ... is to create a matching problem-solution pair".

In sum, "problems and solutions are seen as emerging together, rather than one following logically upon the other" (Lawson 2006, p.125).Designers are able to define, and redefine the problem in "the light of the solution that emerges from their minds and hands" (N. Cross 2007, p.56). A co-evolution of problem and solution seems to be a more appropriate description of how the designer approaches a desired outcome.

5.3.3 Opportunism

The model of analysis/synthesis shown in the first section of this Chapter implies a highly mechanised process of design in which the participation of the designer is reduced to the application of procedures specified in advance. Some of these methods have been applied in design education, yet "it is not clear whether learning a systematic process actually helps student designers" (N. Cross 2001a).

Studies on mechanical engineers, (Radcliffe and Lee (1989) quoted in (N. Cross 2001a), show that "there was a positive correlation between the quality or effectiveness of a design and the degree to which the student follows a logical sequence of design processes". Yet others studies, also on mechanical engineers, have shown contrasting results. Fricke (1999) found that designers following a "flexible-methodical procedure" tended to produce good solutions. In comparison, designers either behaving "unreasonably methodical", or with very "unsystematic approaches", produced inferior design solutions. This suggests that a structured approach to designing might result in effective outcomes, though this is not assured in all the cases.

In stark contrast to a structured process, a number of researchers describe what they call an opportunistic behaviour of designers during the design process. This is manifested as a persistent tendency to deviate from a structured plan of action in an 'opportunistic' pursuit of issues or partial solutions that catch the designer's attention. (N. Cross 2007). Schon (1991) points out the relevance of this trait in relation to the opportunities that unintended moves produce during the design process. The perception of these opportunities are in the core of what he calls the reflective conversation.

While this disposition may be attributed mainly to architects, evidence shows that this is not always the case. Cross cites the studies of (Visser 1990) and

(Guindon 1990), which documented examples of this behaviour in other professions. Visser reported the case of an experienced mechanical engineer, who perceives himself as following a pre-structured process, while in reality a number of frequent deviations from this plan were observed. Visser attributed these deviations to reducing the cognitive load of maintaining a principled, structured approach throughout the whole process. (Guindon 1990) observed a similar pattern in experienced software system designers. These practitioners used to shift from problem specification to solution development, and vice-versa, jumping into 'exploring suddenly-recognised partial solutions'. Likewise Visser, she attributed this opportunistic behaviour to reducing the cognitive cost of maintaining one structure throughout the process.

Opportunism has been criticised as an unprincipled and heterarchical (in opposition to hierarchical) view of the design process (Ball & Ormerod 1995), however, other researchers have suggested that “rather than regarding opportunism as unprincipled design behaviour, it should be considered as an inescapable consequence of the ill-definedness of design problems”. Guindon also observed that opportunism is more frequently found in expert designers. Her observations, in the sense that opportunism increases with experience, suggest that it can be learnt .

In sum, an inflexible adherence to a structured plan does not assure satisfactory outcomes in design, furthermore it does not seem to correlate with what designers do in reality. On the other hand an opportunistic behaviour, though criticised as heterarchical, seems to be an intrinsic attribute of designers. Some have seen opportunism as a natural response to ill-defined problems. The literature also suggests that experienced designers develop a deep sense of opportunism, along with a solution focused strategy.

5.3.4 Responsive-in-action

This pattern of behaviour is not explicitly mentioned in the literature but it can be deduced from the concept of reflection-in-action, or thinking-in-action, which is a central idea of Schon's contribution to the theory of design. The expression reflecting-in-action has two meanings. The first one, as it is usually understood, is that designers reflects while he is performing: reflection and action are simultaneous. The second meaning, is somehow subsumed in the first one, and for this reason is often overlooked in spite of its relevance.

Action is not simply a state of being active. In Schon's view, action is equivalent to practice, in its dual sense as a customary way of operation or behaviour of a community, or as a systematic training by multiple repetitions. From this follows that reflection-in-action also means reflection-in-practice.

A brief comparison between Schon's proposal and Dewey's method of inquiry is necessary here. Dewey's method of inquiry seems to have influenced Schon's proposal, but an important difference exists among both visions. Dewey (1938b) postulates that "scientific inquiry is a stage in a process which begins when practice becomes unsettled or problematic. This leads to a 'time-out' from practice for reflection, during which inquiry guided by the methods and spirit of the sciences yields causal connections to apply in practice" (Waks 2001). For Dewey, then, the arena for reflection is science. For Schon, on the other hand, the arena for reflection is not separated from practice, reflection and practice are instead inextricably intertwined.

Coming back to design, this means that when designers, acting as reflective practitioners, confront their messy problems, 'they do not take 'time out' to reflect', but most importantly, 'they do not disengage from the language of practice in order to use any more general methods of scientific inquiry' (Schon 1992b, p.125). Instead they 'reflect-in-action', and in the languages specific to their practice. Even when they do stop to think retrospectively on-action, they think in the language of practice, not the language of science (Waks 2001).

So the expression 'reflecting-in-action', does not only stand for 'thinking while doing' that is its primary meaning, but also thinking using the peculiar language of a practice, its tools and traditions. Thus the engineer, when confronting a problem, reflects using his own methods of inquiry, and the same happens to the lawyer, or the architect. Reflective practitioners do not adopt an alien language, but remain faithful to the one of their own practice.

5.3.5 Intrinsic attributes

This section has described 3 patterns of behaviour of the designer. The first two may appear as imperfections from a conventional point of view. Being solution focused may seem to hinder reflection, or critical thinking. Being opportunistic in the sense described here, subvert the common sense of a well structured plan of action.

Seen through the eyes of design researchers, these 'anomalies' do not seem wrong. On the contrary, given the nature of the problems that designers use to confront, they make good sense as appropriate attitudes, or strategies. Further, as Schon, Cross, Lawson, and others suggest, based on a significant body of research, these strategies are legitimate and very effective ways of inquiry given the context in which the designer operates.

For situated theories of learning, the acquisition of knowledge is inextricably tied to practice. Considering the fact that our concern is how to situate environmental design in the practice of design, the characteristics of the practice of design turn important in order to devise a strategy for implementation.

5.4 Conclusions Chapter 5

From an ecological learning perspective, all knowledge is inescapably tied to a practice. This Chapter explored design as the practice in which environmental design is intended to be situated: design.

Various attempts to define the identity of design have been couched in terms of how far or close design is from Science, which at the same time implies how far or close design is from Art. This pendulous appreciation of the problem has complicated the definition of design as an independent activity. Fortunately, in the last decades, thanks to the contribution of researchers and theoreticians, designing has emerged as an enterprise having its peculiar manners of inquiry. One of the theoreticians who has made a great contribution to this understanding is Donald Schon. His influential idea of design as a *conversation* with the materials of a situation was used in this Chapter as common thread.

The intention of this Chapter was threefold. First, to situate Schon's idea of 'conversation' within a larger context of design models evolution. Second, to extract practical aspects of the proposed model of conversation. And third, to examine several behaviours of the designer -sometimes considered as disrupting or anomalous- in order to see how they contribute to the development of the conversation.

From the discussion of the three models in the first section, it is concluded that the view of the design practice has evolved towards a conversational or transactional description, consistent with Schon's view. By acknowledging the conversational nature of design, a particular stance of the designer toward inquiry is implicitly accepted. The reflective designer is not neutral in front of the problem he tries to know and solve, nor he is trying to impose his view. For these reasons he can establish a 'familiar' conversation with it.

From Schon's description of the conversational practice of design in section 2, the following aspects can be deduced.

1. The conversation is reflective, and this reflection occurs in-action, which means that the designer does not take 'time out' for reflection, but reflects as part of the design process.

2. The activity of **experimenting** is at the core of the conversation, and also occurs in action. When experimenting, the designer does not abandon the **language** of the practice, neither its tools and traditions.

3. The logic of experimenting in design is of affirmation of the hypothesis that is set forth, in contrast with a logic of refutation in science. The designer modifies the conditions of the experiments to make the hypothesis fit.

4. The language of experimenting is **modeling**. While verbal language plays an important function in the design process, modeling is its distinctive language, including sketching and other representational media.

5. Faithful modeling, in terms of a correct depiction of the phenomena, is crucial in order to have a genuine conversation with the situation.

6. Fluidity of the conversation depends on the model's capacity of readily accepting modifications.

From the third discussion on 'designerly' patterns of behaviour, and how they contribute to the conversation, we may conclude that:

1. Being solution focused should not be confused with a fixation to a unique solution that the designer keeps obstinately unchanged in his mind from the outset. Neither it should be interpreted as an incapacity at formulating problems. Solution focused nature of the designer fuels the experimenting activity.

2. Being opportunistic means to be vigilant and open to discovery, and it is not necessarily conflicting with a well structured plan of action. Opportunism is essential to the exploratory nature of a conversational concept of design.

3. Being responsive-in-action means not only that the designer can respond to uncertain situations on the spot, but also that the designer is reluctant to abandon his way and environment of practice. He prefers to respond to them from within the language and traditions of his practice.

Implicit in most of the literature on designing is the concept of **exploration**, and this is particularly relevant in the context of education. When performing, the designer, or the student, is in a sort of exploratory mood that sometimes is expressed as an obsession. Exploration can be said is his modus operandi while aiming at knowing a phenomenon. Cross (2001) defines the exploratory nature of design thinking as one of its main features, along with its reflective and opportunistic character. The designer, he points out "is engaged in an exploration of an unknown territory from which one solution of many can be found". The designer does not simply receive the brief as a command, but he interprets it as a “kind of partial map” of this territory which he setts off to investigate. While exploring it, 'the directions that are taken are influenced by what is learned along the way, and by the partial glimpses of what might lie ahead' (Cross 52).

Exploration may take occasionally the form of a play in which no intended outcomes are consciously pursued (Schon). This is the same kind of activity in which children usually engage. In this play, however, the designer is completely vigilant at emerging opportunities. It is in this sense that design is said to be opportunistic. But the most of the times, exploration is conscious and take the form of a “hypothesis testing experiment” in which intended outcomes are explicitly pursued .

The combination of exploration and opportunism is perhaps the feature of designing that best distinguishes it, as a knowing enterprise. Knowledge is not acquired because it is accepted, but because the designer builds it by having a conversation with the situation.

Chapter 6. Situating Environmental Design in the Studio. The Experience of the Dynamic Modeling Lab (DML) at the University of Santiago

Actual cases of implementation of Environmental Design in the studio provide specific examples which are especially helpful in illustrating pedagogical strategies. For the present purposes, 4 examples of studio assignments are described retrospectively here. They are all nested in a revealing pedagogic endeavour – the Dynamic modeling Lab- developed at the School of Architecture of the University of Santiago de Chile over 5 years, from 2000 to 2004. This case has resulted in major improvements in the curriculum of the school in which it took place.

In the context of this thesis this pedagogical experience of implementation is important for various reasons. First, because there is a clear intention in connecting doing and knowing. Second, because it clearly adopts an approach that emphasizes learning, rather than the delivery of information. Third, because it is consistent with contemporary tendencies of learning as situated in a context of practice. And fourth, because Environmental Design was implemented in the studio without a peculiar environmental discourse, but as a standard component of architectural design.

Unfortunately, as often happens in architectural education, and in spite of significant learning outcomes, neither the underpinning principles, nor the use of specific strategies were made explicit and available to others. This is, however, not uncommon in schools of architecture, not because people are simply reluctant to share experiences, but because instructors, lecturers, and students are immersed in a hectic business of production and consumption of information, which makes the sharing impracticable (Crysler 1995). To use Schon's expression, all the reflection tend to occur 'in-action' and thus remains, regrettably in this case, as tacit knowledge only of the people who take part in the experience, making it not replicable by others.

It is important to say that the author of this thesis was invited to participate in the DML from 2001 to 2004. This is therefore a first person account of this pedagogic experience.

This Chapter describes the kind of studio exercises that led to the current more consolidated state of environmental design teaching in that school. Yet, the focus on the origins is deliberate, because it is there where the impetus of the project is better revealed. By describing four exercises, this Chapter sets out to illustrate the kind of activity the DML promoted in the studio. It also advances in a preliminary form the principles underlying these activities. The Chapter is organised as follows: section 1 explains the context of the School of Architecture of the University of Santiago and the Dynamic modeling Lab. Section 2 describes four specific exercises of integration undertaken by students at different moments of the course. Section 3 introduces the idea of memorable place as a guiding idea of environmental design.

6.1 Overview of the School of Architecture of the University of Santiago

The School of Architecture of the University of Santiago was founded in 1993 within the University of Santiago, formerly the State Technical University, formerly the School of Arts and Crafts (Escuela de Artes y Oficios). The School has remained small in spite of market pressures. Just 60 to 80 students per year are offered a place to study here. The total community including academic and administrative staff rarely exceeds 500 people.

Most students come from families of low to middle income. A significant number of them have studied at technical high schools in which they have acquired basic skills, such as car mechanics, welding, carpentry, etc. Some of them have helped their parents in workshops and small family businesses. Others have received a more general education of a scientific-humanist type. This variety contributes to form a multifaceted profile of students who have a varied contact with reality. This circumstance is important because, arguably, has perhaps shaped a type of experience in the environment different from students whose families have fewer economic limitations [54].

In 2003, after a period of 10 years with no distinguishing plan of action, the School defined a plan that made specific emphasis in environmental and sustainability issues. In accordance with an increasing national concern for such

54 Many of them have never traveled abroad, their families have no car, there is no central heating at home, for example.

aspects, a renovated attention was given to energy issues in relation to the conception (design), construction, and operation of buildings. Together with this concern, the new plan placed the notion of 'learning by doing' in a central position. As part of this new orientation some studios engaged in novel pedagogical experiences concerning environmental design from an experiential point of view. The experiential perspective of learning made emphasis in hands-on activities instead of the transmission of purely theoretical information.

A milestone in this development was the establishment in the year 2005 of a network of 4 schools of architecture with complementary objectives, and strategic geographical locations in the country[55]. As leader of this network, the school of Architecture of the University of Santiago earned a MECESUP[56] grant with the project entitled: 'Profiling the Sustainability of the Chilean Architect'. Currently this project, that considers cross internship for students, new laboratories, workshops, and new tools and equipment for the four schools, is in the stage of implementation.

In this line, the School recently implemented a Factory/Lab for those students who want to focus on actual building. There, they have the opportunity to get involved in the design, testing and construction of small buildings, detailing and prototyping. As one of the first successful outcomes of this Factory-Lab, in the recent National Biennial of Architecture (2010), a team of students won the first prize for the design and prototyping of a 'Post-Earthquake Shelter'. The proposal was acknowledged for its versatility and constructive rigour. Currently, a team of students of the school, in partnership with a team of students of engineering, is

55 The Schools of Architecture of this network belong to the following Universities: University of La Serena, FSM Technical University, University of Talca, and University of Santiago. Each of the schools is situated in a strategic point of the territory.

56 MECESUP Programa de Mejoramiento de la Calidad y Equidad de la Educación Superior (Program for the Improvement of Quality and Equity in Higher Education).

involved in the design and prototyping of a 'solar car', intended to cover a distance of 1000 Km. relying exclusively on solar energy.

In recent years the School has become increasingly visible in the country by winning other various prizes in national competitions of architecture[57]. The school has also gained a reputation for its environmental and sustainable approach to architectural design. In this line, a Masters in Integrated Architectural Design (MIDA) is set to start at the beginning of 2011. Such a hallmark has been acknowledged in the School's latest national accreditation process, in which the experts panel also singled out the experiential approach to design as providing the most valuable asset for students.

6.1.1 Studios organization

As it is usual in Chile the course is stratified in 6 levels, one level per year. At the centre is the design studio that is normally divided in 3 units of 20 students each, assisted by one unit tutor and occasionally a helper. Studios are surrounded by humanities and technical subjects. Each level is coordinated by the studio leader, who, in addition to coordinate the studio units, has to coordinate all the matters of the level, including humanities modules, and technology labs. To this end, lecturers, unit leaders and coordinator, hold periodic meetings, usually once a month.

Among the responsibilities of the coordinator is the writing of studio briefs, yet final versions are the result of an agreement between him and unit leaders. Technology and Humanities staff play a fundamental role in this structure, and are frequently invited to contribute with comments, depending on the relevance

57 1st Prize for Timber Design Competition CORMA , 2009; 1st Prize for Steel Design Competition CAP, 2008.

of their area on the assignment.

6.1.2 The Dynamic modeling Lab

While the school has at present a clearer profile in terms of an overall teaching project oriented to experiential learning, this current state of affairs did not happen overnight, nor was enacted by a single will. Several people contributed their views to shape the school academic profile . Among these, a great influence was exerted by a small and informal community of studio instructors and students over a period of 5 years, from 2000 to 2004. This community -called Dynamic modeling Lab (hereafter DML)- initially developed spontaneously around design topics and pedagogical strategies that later turned to be a deep interest in integrating environmental design in the studio, despite the fact that none of its original members had a technical or scientific expertise. The label 'environmental design', nevertheless, was never used as such. What the community was attempting to do was simply 'architectural design' [58].

A conjunction of coincidences made this community to exert great influence in the implementation of environmental design in the studio at different levels of the curriculum. The fact that three of its members were studio leaders at different moments was fundamental. This unplanned but fortunate circumstance made possible for the DML to implement novel and sometimes unusual pedagogic activities in the studio. It is not exaggerated to say that the school owes much of its current hallmark to the pioneering work of the community. In a very deep sense this group of people constituted a community of practice nested in an institution. It was therefore a privileged setting for learning. (Wenger

58 When asked for his expertise, David Cabrera, one of the original members, used to respond, "architecture".

1999)

The name of the community - Dynamic modeling Lab- was intentionally chosen to make emphasis in modeling of environmental phenomena[59] with an additional concern. Students are expected to manipulate shape and environmental phenomena from the beginning. Such a process is called dynamic modeling, since the definition of form and the manifestation of the phenomena are mutually co-determined, unlike what usually occurs in a typical design process, in which environmental attributes are added on to the form later.

Though modeling was in fact its distinguishing trait, the members were always aware of their belonging to a larger discipline context: architectural design. Nonetheless, the conception of Design that the DML advocated was not oriented to stylistic canons, neither was to purely technical solutions.

At the core of the community was the strong belief that environmental phenomena were missing subjects of architectural design. Of the utmost importance for the community as well, was the idea that design was not considered as a post-research activity, but research in itself, or as Nigel Cross (2007) puts it, "a way of knowing". Design, in the view of the community, had the power to situate knowledge, though the idea of situating knowledge was, at that moment, just an intuition.

6.1.3 Environmental Design Teaching

The area that was most notably and positively affected by the activity of the DML

59 This hallmark of the community, given the lack of economic resources, proved an extraordinary challenge to the creativity both of tutors and students. A number of ingenious pedagogic strategies, artefacts, and tools devised during the lifespan of the community is a testimony to this.

was the teaching of environmental design. Until 2004 environmental design was taught on the basis of a traditional model of lectured modules aimed at supporting studio activities. These modules covered an extensive variety of related topics according to a programme that the school had established since its foundation in 1993. The stated aim of those modules was to provide students with data, technical concepts, and the theories that students can use in their design projects. Nevertheless, in reality these modules used to run independently of the studio and their aim, judging by its contents[60], seemed to be oriented to supply students with general information for their *after graduation* career, rather than for them to apply it during their stay in the school. This emphasis on the provision of information is not uncommon in schools of architecture in Chile, and can be related to a widespread positivistic conception of knowledge the type discussed in Chapter 2 (p. 19)

What seemed more problematic was the fact that the responsibility of integration was left in the hands of students, for in the traditional split model of lectures/studio, students, not the school, were accountable for the integration of the data, technical concepts, and the theories provided by the support modules, in their design projects.

That same year (2004) the School decided to implement an important change in the modules of the curriculum, in particular those imparting technical information, as structures and environmental design. In concrete terms this meant the establishment of a system of Lecture/Lab in order to assist the studio assignments. The aim once again was to provide support for students in their

60 These modules, that were imparted over 4 semesters, covered aspects of comfort and climate, solar architecture, natural and artificial ventilation, energy balance, thermal concepts and calculations, humidity, concepts of natural and artificial lighting, concepts of acoustics, methods of evaluation, and relevant regulations. (summarised from Testa 2003)

design processes, yet this time the mechanism was different. On the one hand, lectures were conceived as directly related to studio assignments, and on the other, the laboratory incorporated hands-on exploration/experimentation of issues raised in the studio. For example, if the assignment required timber detailing, such exploration took place in the laboratory of construction. The same mechanism applied to the laboratory of environmental design should the project to explore, for example, natural lighting levels.

The implementation of this plan of action required additional space yet much of the laboratory explorations were performed in the same studio space, i.e., students did not need to migrate from it to develop their explorations, except when a highly precise verification was required. This option obeyed in part to the almost perennial budget limitations, that prevented at that time implementing a well equipped laboratory, but also to the aim of transforming the studio into a place of exploration of physical phenomena beyond purely visual aesthetics. The studio, in this way, assumed a central role in the project, as a physical setting where the integration found a locus.

The Lecture/Lab system resembled very much the Technology Discovery Laboratory suggested by Watson (1997) in that its aim was to "inspire students through 'technological imagination', by which structures, climate, sun and daylight, wind, sound, and environmental resources are introduced as sources of **design** insight", and following from this, to present the technological problems not as **ready made knowledge**, but as "**principles of jenquiry**"(p. 123). In the DML view, physical phenomena were equally potent triggers of design.

While not being as radical as Levy's "total studio" (Levy 1980), the Lecture/Lab system also shared some features with that pedagogical experience. As Levy points out of that experience, this one was based on the premise that "learning (is) structured around, and reinforced through, comprehensive design problems where creative opportunities are **revealed**, and design implications **tested.** The hard data required to solve the technical problems are provided either by directed research or in tightly organised support lectures given by the studio faculty" (Levy 1980, p.1).

The setting up of the Lecture-Lab on a par with the studio was the curricular outcome of the efforts of the DML initiated in 2000. The Lecture-Lab was first experimented within the controlled environment of the DML thus minimizing risks of failure and above all, minimizing resistance of staff.

6.2 Four Exercises in the Studio

> When I was still at the art and crafts school… we looked for a new solution to every problem. We felt it was important to be avant-garde. Not until later did I realize that there are basically only a very few architectural problems for which a valid solution has not already been found. (Zumthor 2010)

This section describes four exercises undertaken by students in 1st, 2nd, 4th and 6th year (diploma), respectively under the influence of the DML. The examples chosen here try to depict how environmental attributes of places intervened in the process, as well as the strengths and weaknesses of this approach.

The label 'exercise' is used in many schools in Chile as a synonym of assignment, and has the same sense as an exercise in musical training. Students acquire a skill and knowledge by practising. It is not possible to learn just by memorizing information. In fact, from an experiential learning perspective, the boundary between skill and knowledge is difficult, if not irrelevant, to discern (Ingold 2000h; Lave 1988; Bourdieu 1992).

In addition, some of the exercises undertaken in the schools are considered as 'exemplars' in the sense described by Kuhn (1996) in scientific education, that also coincides with the view of 'architectural problems' of Zumthor in the epigraph above. This is to say that, they are standard solutions to some problems that become well known to the practitioners of a field, and therefore are taught as basic knowledge [61]. For the DML a student of architecture should acquire knowledge through exemplars, and only then can undertake a major challenge. An exemplar in architecture would be, for instance, how to design a staircase, but also how to orient a building and orchestrate its elements to best take advantage of sunlight.

6.2.1 Exercise 1: Shade and Place

As part of the pedagogical strategy of integration in 2001 an introductory unit was devised for 1st year students at the very beginning of the course. This comprised preceding seminars, basic mapping of temperature gradients, and manipulation of an environmental phenomenon, namely shade.

Architecture, says one of the most quoted sentences of Le Corbusier, "is the

61 "(By exemplar) I mean, initially, the concrete problem-solutions that students encounter from the start of their scientific education, whether in laboratories, on examinations, or at the ends of chapters in science texts. ..." (Kuhn 1996, p.35). For Kuhn, " all physicists, for example, begin by learning the same exemplars: problems such as the inclined plane, the conical pendulum, and Keplerian orbits; instruments such as the vernier, the calorimeter, and the Wheatstone bridge" (Kuhn 1996, p.187). Students of physics, sustains Stinner, "learn their craft by studying specific applications and concrete examples ("exemplars") which involve working with instruments in the laboratory and practising problem solving" (Stinner 2003, p.343)

masterly, correct and magnificent play of volumes brought together in light". While this exercise can be regarded still as part of this tradition in architectural design, that deals with light, shade and shape within an 'ocularcentric' tradition (Pallasmaa 2005), shade-making is connected here to the the idea of 'rudimentary place' explained later.

Introductory phase

Before issuing the actual assignments, some introductory activities took place in the studio. In the first place, students were given a time for 'playing' with the modeling technique of this exercise in order to learn some of its inherent constraints, and freely exploring its possibilities. In parallel to this exploration, forums were held to introduce and discuss the notion of place and place-making. The students' voice was of the utmost importance in these activities. Instructors were particularly interested in listening to what is normally thought to be an 'unsophisticated' opinion of the newcomers (Yanar 2007).

Students were encouraged to participate in the conversation employing their own language to describe a memorable place to them. Perhaps because the discussion was usually framed in those terms, many students were able to summon and describe their own 'environmental memories' -not necessarily pleasant ones- alluding to sensory features of places. One of the students for example remembered his classroom in primary school as 'uncomfortably sunny' in summer, but a delightful place in winter thanks to the salamander he and his fellow students used to feed with small logs early in the morning. Another student remembered the backyard of her house as one of her favourite and most memorable places of her childhood. She was able to remember not just the image of the place, but the sensory experience of feeling the breeze while swinging in the shade of an old walnut tree.

After holding these forums, students were introduced to a different but related topic. What is commonly called space inside a room -and usually likened to a void- is in fact populated by a number of environmental physical phenomena that while not visible, can be felt. Taking advantage of the large studio space, students were asked to corroborate this in the very studio. They had to 'feel' and represent its temperature gradients. The instructors team was aware that due to poor ventilation, and inadequate roof insulation, a stratification effect was perceptible at that moment of the year. Organised in small groups, students were given a plan and a section on which to represent temperature gradients, by colouring. The purpose of this activity was not to produce accurate data, but to instigate what Schon calls a "feel for the phenomena" (Schon 1988), arguably linked to their visualization (Gilbert et al. 2008). The activities aforementioned served as a preparation for embarking in the following assignment.

Exercise 1 Brief

The brief for this 1st exercise was succinct and many of the doubts were answered during its development. Basically, students were asked to create a place located in an open field, and a transitional pathway towards it. As part of the requirements the place had to meet the following: to be in full shade from midday to sunset, and between two specifics dates: summer solstice and autumn equinox. The achievement of the shade, it was suggested, could make that portion of space qualify as a rudimentary place. Proposals were intended to be in the same latitude of Santiago de Chile (33° 26', South) where shade in summer is much appreciated.

Many of the design issues were deliberately simplified as a way of prompting attention and intentions of the students on the phenomenon being addressed. For this first exercise, students had to consider an approximate scale, and a simple function: a shelter for 3 to have a picnic. Scale was to be 'suggested' by incorporating 3 human figures in the model. Later throughout the year, a program, events[62], a defined scale, and context were gradually incorporated in the ensuing assignments.

Exercise 1 Process

At first glance the exercise may seem to require a rather mechanical response to a deterministic assignment, and this was in fact one of the concerns of the instructors. Shade-making does no seem to be a particularly difficult challenge. However, as it usually happens in all assignments, the student rarely deal with a single variable. What makes the design fairly complex is the conciliation of many variables. There are several elements that should be chained together so that the problem becomes an architectural problem. The shade should be gained in coordination with other achievements, in this case, geometry, structure, scale and function. Shade and shape are reciprocally dependant, but shape is also dependant on structure. The solution of the problem implies juggling with at least three elements, and thus a linear process is less plausible.

62 Events were understood as celebrations or festivals, as those that ancient peoples used to hold in specific days of the year. For example, the 'day of the snake' during the fall or spring equinox in Chichen Itza , or some rituals held in equinoxes and solstices in Stone Henge.

Modeling: Paperfold[63] under sunlight

From an ecological learning viewpoint (cf. Chapter 4, p.73) the manipulation of objects, tools, artifacts etc. is particularly relevant in the process of acquiring knowledge. Modeling for a student of architecture is not just a mechanism that he uses to make his ideas visible to others, but it is an essential tool in performing his own creative discerning (Dunn 2007). In the view of Nigel Cross (2007), modeling is "the" language of design. For these reasons, the choice of a modeling technique is not immaterial in a designing-learning process. While an appropriate technique may favour a fluent *conversation* between the designer and the situation, an inappropriate one may make that conversation difficult (Schon 1991). This suggests that designing by plaster modeling, for example, will render a different result than designing by drawing, but also will make the process unfold in a different manner, because the techniques provide a different back-talk.

For the first exercise described here, the modeling technique was chosen in order to enable a fluent conversation with the situation. The technique was paper folding exposed to an environmental variable: sunlight. In the view of Lobiano et al. (2000), the technique should not be seen as the modeling of a shape plus a phenomenon, but as the co-occurrence of both. The model is not defined completely in advance, and then taken to another setting to be tested. In this case, while a reluctance to change a conceived shape is typical of the student, he/she must remain open to modifications. Testing and modifications are not 'extras' of the design process but are constituents of it.

63 Paperfold means here the process and result of paper folding. While the modelling technique has been described as sharing some features with origami (Vyzoviti 2004) it is important to stress that for the purpose of the assignment, paperfold was not considered representational.

Paperfold imposes a highly abstract use of elements, - there are no walls, roofs, overhangs, or other elements of that type- instead there are surfaces, planes, angles. The absence of conventional architectural elements made the technique particularly suitable for an exercise in which an emphasis on light and shade was needed.

Paperfold, as Vyzoviti wrote some years later, is a "morphogenetic mechanism" that brings up three-dimensional space and structure "during a dynamic volume generation process" (Vyzoviti 2004, p.10). Paperfold was used in the previous two years (1999-2000) in similar exercises (without an emphasis on environmental phenomena though), and during that time several learning gains were detected. In the same folding process, almost as a natural outcome, students became aware of two aspects that are usually difficult to teach. First, a three-dimensional spatial awareness, and second, a structural awareness, both essential to a student of architecture. Volume and structure are what the paper can literally support by its thickness and structural capacity. In this technique, therefore, models are not only small-scale representations of another larger structure, but are in themselves a new reality. In this sense, paperfold requires from the student a degree of 'material awareness'. Paper as an actual material presents limitations to modeling that can be likened to the limitations of materials in the real world of construction. Some materials allow some shapes to be made and not others. Thus, genuine creativity is seen as directly related to the mastery of limitations imposed by the materials.

Building on that experience of two years, in 2001 Jorge Lobiano, 1st year coordinator, proposed to introduce a number of environmental variables as part of the exploration. For reasons of ease of handling and testing, the first variable introduced was shade.

Making

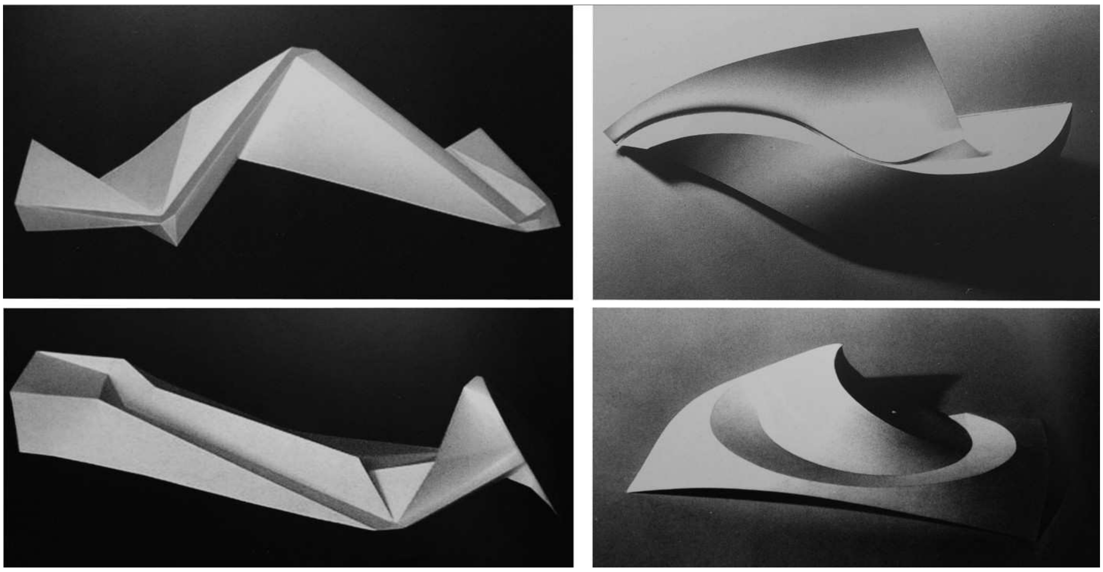

Image 1: 4 examples of paper folding

The first activity consisted of building the sundial suited to the latitude of Santiago, and to understand its function in the modeling process. After that, students were asked to make rudimentary models by paper folding. Contrary to the fear of some instructors, a variety of proposals were produced, yet only few of them roughly approached the requirements. Students were encouraged to test their models as soon as possible in the sunlight (or in artificial light when it was not possible[64]) even if their proposals were in a very preliminary stage. For this particular procedure the sundial suggested by Brown and DeKay (2000) proved particularly helpful. Though less precise than the heliodon, it does not require moving the model to another location to be tested, and may be occupied by each student when required, while designing in real time.Because graphic representation was not a requisite at this stage, except for quick sketching,

64 While artificial light distorts the reading on the sundial, and parallel sun rays are preferred, artificial light from a lamp was considered accurate enough for the purposes of the exercise.

physical modeling became the main focus of the design process. Initial rudimentary models were conceived as hypotheses which needed to be confirmed through experimenting. Very soon, students realised that valid hypotheses had to lend themselves to testing. Hypotheses that were not translatable to a manipulable testable form were rapidly discarded.

Tutoring as learning

An important part of the design process in a school of architecture is determined, either for good or evil, by tutoring. This exercise is no exception, although some aspects are different. Tutoring has been regarded often as a highly asymmetric learning situation. This means that it is a sort of confrontation between two persons that have significantly different levels of knowledge. One of the usual ways of transferring such knowledge is through actual performance of the tutor as a designer in front of the student who learns by watching this performance. Instructor's previous experience is therefore essential. The more times he has confronted a similar situation (though it is never the same), the better able he is to respond to a new challenge, and more confident he becomes in his role as an educator (Schon 1991) .

The difference here was that several aspects of the experience were new not only to the student, but also to the instructor. This condition caused a climate of discovery for both. It was pointless to judge the appropriateness of a model while at the same time dispensing with the phenomenon that gave the proposal its raison d'etre. While aspects of scale and proportion had to be taught in the traditional way, i.e. as transmission by means of propositions, the structural and environmental aspects were learned in the making.

For this reason, tutorials proceeded as a sort of conversation between instructor, student, and "the materials of a situation" in a similar way as suggested by Schon (1991). Nevertheless, an important distinction has to be made. While Schon's conversation occurs in a 'virtual world' of sketches and models that **represent** the materials of the situation, the intention of dynamic modeling was to make use of the actual materials as much as possible[65]. In this exercise, shade and structure were not virtual, but real.

Finally, but not less important, during this short design process, information concerning sun path, equinox and solstice, sun penetration, etc. was needed. This information was somehow naturally incorporated in the very exercise.

6.2.2 Exercise 2. A memorable place for Neruda

This second exercise was originally devised for students at the beginning of their second year, though currently it is being issued to 1st year students in a modified form.

Exercise 2 Brief

The aim of this exercise was to persist in some of the themes of the first year, in particular the idea of place, yet two related notions were added: First, places can be memorable because of their exceptional environmental attributes (Bloomer et al. 1977), and second, small places are nested in larger ones. This was part of the strategy aimed at, on the one hand, intensifying the presence of environmental phenomena in the design process, and on the other, acknowledging the importance of the physical context. Students' proposals had

65 Other exercises developed in first and second year included the use of water (tides), steam, weights and gravity, etc.

to produce a memorable experience for the occupant, in the way suggested by Tuan (1989) i.e. an experience of the environmental attributes of the place through the senses.

The brief required a Memorial for poet Pablo Neruda[66]. A building with minimal practical functions, closer to the idea of infrastructure rather than to architecture, including a space to read poetry to an audience of 20 people, and basic services.

Figure 12: Students during one of the visits to the site

In order to make environmental phenomena being the centre of the problem, the location was carefully chosen. Proposals were intended to be located in a rural environment, some kilometres north of Neruda's house in the seashore of central Chile. The site had striking environmental and topographical features located on a 70 meters high cliff, exposed to the strong wind of the Chilean seashore, and to the sound and humidity of the waves. The site enjoyed unobstructed views to the horizon, and to frequent dramatic sunsets. The strategy behind the choice of this site was clearly aimed at confronting poetry and environmental physical phenomena, taking advantage of the

66 Pablo Neruda is a Chilean poet, awarded Nobel Prize of Literature in 1971

superabundance of the latter in the site.

Exercise 2 Process

The first phase was aimed at finding references to environmental phenomena within the literature of Neruda (instructors were aware of many of them). In parallel, students and instructors made two visits to the site and stayed there from morning to evening. In small groups, students collected and documented environmental data they found relevant, and possibly connected to Neruda's poetry. Some students noticed, for example, the strength and sound of the wind as a relevant feature. Others noticed the palpable moisture of the atmosphere. Others concentrated their attention on the fluctuation of light levels during the day, etc.

In the second phase, students in possession of a chosen environmental phenomenon, had to declare what they intended to do with it, and begin the design process itself. While this declaration of intentions was a very personal choice, students were encouraged to focus on concepts that could be corroborated by modeling. The design process consisted in experimental work of trial and error in the studio, starting with a 'geometric hypothesis' consisting in a very rudimentary cardboard model to be tested in the lab.

The idea of memorable places was of great importance in this phase. Places needed not to be necessarily comfortable, or at least not all the time, so students were motivated to create a number of non-conventional proposals. One of the students, for example, wanted to build a place where wind could eventually produce sound, "whistle and sing" in the words of Neruda. As soon as he could produce a rudimentary shape, he had to test it in the wind tunnel [67], improving successively the configuration and attuning dimensions until his goal was partially accomplished. Based on precedents of 'aeolian harps', the student devised an architectural shape able to canalize the wind to those mechanisms. While the channelling effect on wind could be corroborated by testing, the sound hypothesis remained finally unproven due to lack of equipment. The manipulation of shape, however, clearly responded to his declared intention.

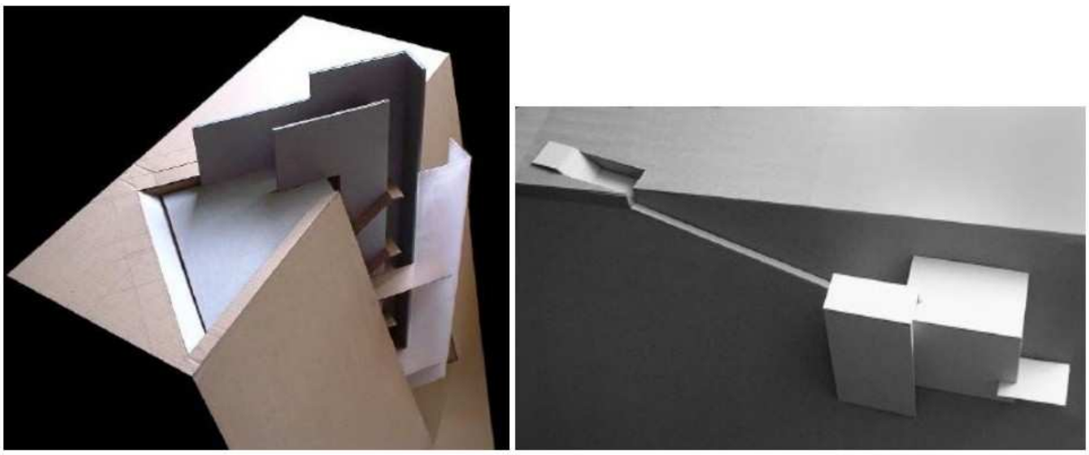

Figure 13: Two examples of the Memorial for Neruda. Students Rodrigo Alvarez y Paula Vallejo

In another interesting example, a student tried to capture and 'lengthen' as much as possible the dusk light, one of Neruda's usual themes. This problem not only implied a thorough understanding of orientation, but an artful manipulation of reflective surfaces and translucent screens, in order to bring the light under control and create the atmosphere announced at the beginning of the exercise. The reading of poetry was intended to happen during those extended twilight moments.Likewise in the aforementioned exercise of the 1st year, the response to this exercise did not consist of a mere manipulation of a single phenomenon in a

67 In the previous year, students built a rudimentary wind tunnel using spare parts of old appliances. In this particular case the increase of wind speed was corroborated. The testing of sound, however, remained largely speculative.

mechanical or linear fashion. On the contrary, the phenomenon manipulated necessarily interacts with other requirements of the project. The most important of these requirements was to accommodate the visitors of the memorial, and in particular the reading of poetry. The project in which the wind 'whistles and sings', for example, can certainly be memorable, but that's only part of the problem. It is equally necessary to create a pause of silence in which speech is made audible and intelligible, and this is an environmental design problem as important as the first one. This particular problem -the alternation between moments of silence and the augmented 'singing' of the wind- made appear in the project a series of movable mechanisms of control that gave the project a distinctive image. The image of the building, that usually is a preconception of the designer, was in this case partially shaped in the pursue of an environmental target.

6.2.3 Exercise 3. Heat and place

> For women of southern Italy the baker's shop is the place to gather for gossip in the winter, for the ovens make it the warmest place in town...(Heschong 1979, p.44)

This exercise was devised for 4th year students, and involved a subject that is rarely treated as a design problem either in schools or in professional practice: natural convection and heating[68]. This exercise intended to involve students in

68 While the historical origin of architecture can be firmly linked to the production of favourable thermal environments, for most of the twentieth century that task has become the responsibility of the H.V.A.C. designer. The architect is left the task of "struggling only to integrate the physical, and static, shell of the conditioning system"(Addington 2007).

the production of a thermal environment by orchestrating and calibrating passive architectural elements. While the source of heat was active -an electric oven- its function was not to heat space, but to bake bread.

Exercise 3 Brief

In this exercise, students had to address a number of problems typical of a more complex project. In addition to the environmental phenomenon, they had to deal with functional problems (production process of bread, provision of raw materials, distribution), construction techniques, regulations. The type of assignment, its scale and complexity, therefore, were crucial to promote testing out of environmental phenomena, in terms of keeping the 'non-environmental' issues within manageable limits.

The team of instructors agreed on a relatively simple brief that asked for a small bakery/café, the type of architecture Habraken (2000) would call 'ordinary', located in an urban plot of 8 x16 meters, in a terraced street of Santiago. As part of the pedagogic strategy, students had to consider the utilization of an electronically controlled bakery oven, for a small-scale production of bread and pastries.

The environmental problem proposed to students was the following. Using the surplus of heat from the oven in the cold season, distributing it to the cafeteria space, and thereby avoiding the use of an additional heating system. In the hot season, it was required the reverse effect, this is, the same excess of heat was to be dissipated into the atmosphere, also naturally. Complicated aspects of fluid viscosity or turbulence were not addressed, just buoyancy.

Exercise 3 Process

Modeling Technique: emulating Gaudi

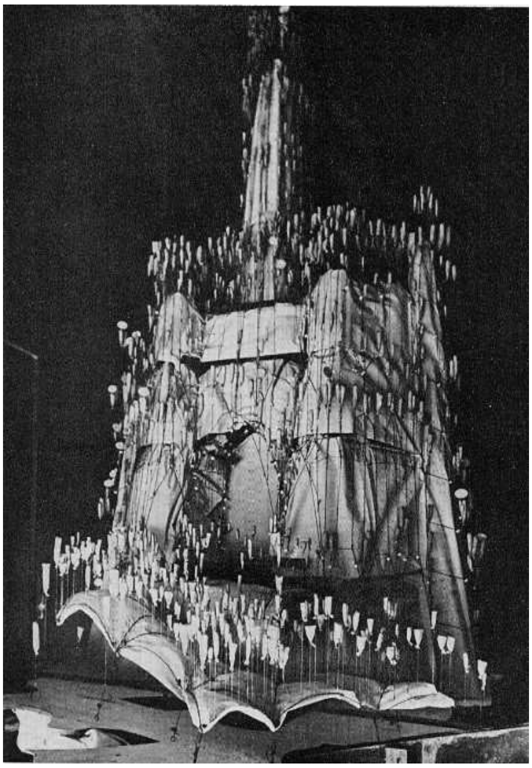

Figure 14: Gaudi's funicular model

As in the first exercise developed by first year students, the modeling technique in this one was crucial for the design process. The main environmental phenomenon this time was, however, considerably more difficult to model [69]. While at that moment a Computational Fluid Dynamics (CFD) package was available from the Faculty of Engineering, the pedagogical usefulness of a

69 The emphasis on a particular phenomenon does not mean that other phenomena should be disregarded. Natural lighting, for example, must be solved in parallel.

sophisticated tool did not seem so clear, as the aim was to enable all students to gain direct contact with the phenomenon by modeling it, in a relatively short time. A solution to this issue was suggested by 4th year coordinator David Cabrera, who devised an ingenious method of modeling heat convection inspired in combination of traditional salt bath modeling, and the funicular model (Fig.14) that Catalan architect Antoni Gaudi, used to study the geometry and structure of the the church in Park Guell, today only partially built. By using this procedure, Gaudi demonstrated a highly creative approach to a particularly difficult problem. In that specific case, Gaudi did not delegate the task to another professional. Instead he developed his own method, considering the problem of structures within the boundaries of design.

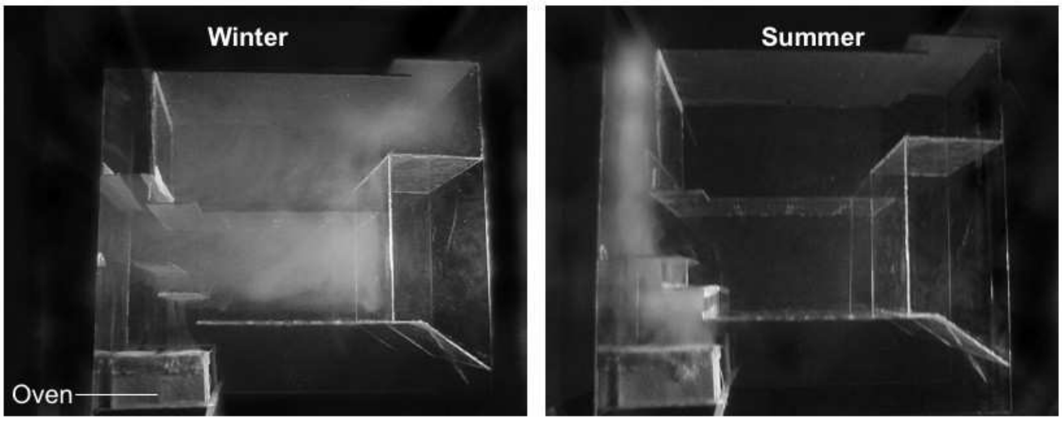

Figure 15: Heat modeling. Winter and Summer. Student: Pablo Fernández

Analogous to Gaudi's method, in this exercise students had to model the natural hot airflow within the space of the bakery/café by using a model turned upside down. The electric oven -that was an active element of the modeling rig- was simulated by employing a piece of solid carbon dioxide (dry ice). In order to sublimate gaseous carbon dioxide as a reaction, drops of water at room temperature were added when necessary. The concentrated carbon dioxide, that is clearly visible and heavier than air, tends to descend attracted by gravity and behaves very similarly to air moved by convective heating, in the opposite direction. For purposes of simplifying the modeling process, other heat sources were not considered. To start experimenting, students had to make a rudimentary model, or "hypothesis" (Cabrera 2003) previously considering basic distribution of functions, production processes, and circulations. Above all, it had to have two essential characteristics: first it had to allow easy viewing of the phenomenon, and secondly it had to allow easy modification of elements according to observations. To the end of making the phenomenon visible, models were manufactured partially or wholly in transparent acrylic (Figure 15). This allowed viewing, and mapping the phenomenon's behaviour through visual notes, and recording through photography and video.

For a conception of design like this, in which the process is as important as the outcome, the recording and documentation system is essential. This aspect is even more important in this type of exercises in which phenomena may appear or disappear, or are difficult to reproduce at will. For this reason, the recording process became for students of greater relevance than usual. This was particularly applicable for tutorials, since without such records the conversation could turn quite speculative.

Systematic recording, on the other hand, introduced a proper research discipline in the studio. Evidence of the achievements were needed in order to enable conversations with peers, and tutors. Recording included traditional methods such as the mentioned annotated sketches or photographic sequences, but also short videos that, at that time in the school, were an unusual recording method.

Seen in retrospective, videos proved particularly useful in order to understand the temporal and dynamic complexity of the phenomenon being manipulated. Videos could be slowed down, reversed, played again at will, making visible some aspects not clear before.

The increasing refinement of the recording system also meant learning additional skills that are usually considered marginal in the design process. How to improve aspects of visualization, for example, by gauging the density of carbon dioxide released from dry ice, or how to properly lighting the model, or choosing neutral background for photographing, are certainly instances of learning and in the long run may impact on the architectural final outcome.

6.2.4 Exercise 4. A silent place in a noisy city

The forth example chosen to represent this process of integration is a diploma project, that is the final year. This example was considered successful, yet the testing could not be carried out, and claims remained highly speculative. Thus, this example also serves to show the limitations of this approach.

During the 6th year students develop a design project divided in two semesters. During the first, students have to generate a solid argumentation and a basic exploration of form. During the second, they have to develop the project in depth, demonstrating proficiency in many aspects of the discipline. They have to address issues of structure, regulations, construction costs, land value, etc. This circumstance, not to mention the big scale of projects, tend to relegate environmental issues to a inferior place. In this circumstance the concept of the diploma project, that is explored during the first semester, plays a fundamental role in making environmental design a core issue from the start.

Exercise 4 Brief

The diploma project is in many aspects a solo performance. Students are not working with their peers in the same assignment, but one of their choice. In this particular case, the student was a karate black belt, and chose to develop a School of Martial Arts. Later, due to its location in a very busy area of the centre of Santiago, the project turned to be a mixed-use building including offices and shops. Nevertheless, the School of Martial Arts remained the part of the project that was developed in more detail.

Exercise 4 Process

A Mixed-use building, it was apparent during the development of the project, offers a great opportunity to work with environmental issues. Sometimes the uses are commercially compatible but not environmentally compatible. Among the many environmental problems that emerged during the development of the project, acoustics became an issue that required a particular attention. One of these problems was the noise from the school to offices and shops and vice-versa, though a more subtle problem arose during the tutorials. The School of Martial Arts necessitated silent places, being a necessary background for meditation, and for the practice of some particular defence skills (like hearing but not seeing an approaching attacker). The problem arose when noise data in adjacent streets showed very high levels[70]. For this reason, noise from close sources, became a relevant problem, and whereas mitigation or silence could be achieved by soundproofing a room, the problem did not seem to be limited to

70 While the optimal noise level recommended by the World Health Organization for functions like this is 35 dB in interior spaces and 50 dB out of them, in this area of the city, measured levels in interior spaces with the windows open were up to 66.9 dB average, some even reaching 80 dB. (source SESMA)

that.

Again it was evident that students have rarely to confront one single problem and even less in 6^{th} year. Most of the time the various aspects of the project are locked together and this was no exception. Due to a particular approach followed by this student, the problem was framed as follows. Silence was to be achieved without losing contact with the natural elements, namely, the vision of the sky, natural light, air, and rain. The challenge, then, was to have 'sky and silence'.

This approach triggered a process of searching places, in the city, where such a combination existed. Assisted by the lab instructor, the student made a series of sound measurements in different places of the city. The investigation revealed that several courtyards had this quality, particularly some 'patios' of religious congregations. These places provided the pleasant experience of being in an environment where silence was the background of subtle sounds, however perceptible in the midst of a noisy city.

But, what made these patios have this quality? With the help of the laboratory instructor, the student focused her research on sound absorptive materials, effects of geometry and surface roughness, dimensions and proportion of patios, etc. Based on this information she finally got an hypothesis to be tested out. Two patios were proposed for the design project, having particular materials, sizes and proportions.

The project was favourably evaluated by the reviewers panel, who acknowledged the proposal as developed according to rigorous prior analysis. However, the environmental hypothesis of the project's main feature -the silent patios- was left unverified. The reason for this was twofold. First, this environmental problem was just one among many others the student had to deal with in a complex project. Second, despite the intention of the DML to cover a wide range of environmental problems, energy consumption issues tended to monopolize the attention of instructors and students, outstripping other aspects of environmental design.

This last example shows one of the problems that have been difficult to overcome in the implementation of environmental design. As projects become more complex and professional demands increase, the integration becomes more difficult. Students, at this stage, are not only committed with environmental issues, but with a number of other demanding aspects, like structures, detailing, urban context, etc. Paradoxically, in professional practice these aspects are rarely the responsibility of one person. Additionally, students are preparing themselves for the job market, so they prefer to acquire the kind of skills the market finds valuable, which usually relate to the proficient operation of a computer.

6.3 Memorable Place as guiding idea of Environmental Design

The proposed scheme of Lab/Lecture in the school solved in part the problem of disconnection between practice and theory, yet this was a one-sided view of theory. The conviction of the DML was that the implementation of any practice in the context of education was not something that could be regimented, but should earn its position in the realm it wants to belong to[71]. In this line of

71 This concern has been raised many times in the past. An early example is that of Marguerite Villecco 30 years ago, who vigorously promoted the integration of energy conscious design in the architectural curriculum. Her concern was, how to present the practice of energy conscious design

thought, for the DML the pedagogic project could not be considered completely achievable without the contribution of Humanities. In the case of the DML, Humanities played a fundamental role in promoting the concept of Place as a destination for environmental design.

6.3.1 Rudimentary Places

Figure 16: Two examples of rudimentary places

Although the idea of *place* elaborated by philosopher Martin Heidegger was on offer at that time, the notion of place that inspired the briefs of the DML was a much less sophisticated construct. The DML chose an approach similar to Unwin's (1997) concept of places. The primordial impulse of architecture for Unwin is the "identification of places", and such places are portions of space distinct, and sometimes memorable because of their favourable environmental conditions. This idea was in clear contrast to the one of comfort, that in the view of the DML tended to **equalise** or neutralise environmental extremes.

Examples of these kind of primary places are, among others: a shaded area under a tree in summer; the warm space surrounding a camp-fire; an area of

"in an intellectual manner compatible with those of existing design philosophies and personages". In the University, Villecco argued, "the imposition of a new paradigm will always clash with the sense of autonomy and academic diversity", and suggested that this problem could be overcome by adopting an existing and accepted view.(Villecco 1977, p.8).

the beach protected from the excessive wind, etc. In all these cases, the 'place' is made to emerge by the modification –either natural or artificial- of existing environmental attributes to preferred ones. The persistence of these places is not much determined by conventional solid limits -walls, floors, roofs- as they are by environmental attributes that make places persist as long as they do. Thus, they may appear, grow, wane, and disappear as the environmental condition appear, grow, wane and disappear. The message to students was that while the visible features of space -position, form, extension and proportion- were important, the description of the place was incomplete if the invisible environmental dynamics was not included.

While it was clear that the identification of a place depends largely on the emotional attachment of the person to it -and this was beyond the control of the designer- it was clear as well, that the designer can perform an essential role in setting the scene for this to happen. As Rasmussen suggests, the architect is "a sort of theatrical producer, the man who plans the settings for our life"(Rasmussen 1962). Those settings are, in a more contemporary guise, potential 'places', and while they are not wholly *designable*, the designer can promote the generation of places by setting a favourable scene, in which environmental phenomena are fundamental constituents.

Thus, the rudimentary notion of place appeared as a unifying concept, and offered an alternative way of incorporating environmental phenomena in the design process. If place is largely determined by environmental attributes, the design process aiming at the creation of places, can be said to be triggered by the yearning of those attributes.

6.3.2 Buildings as containers of places

The idea of place is commonly associated to urban design, or public spaces. More unusual is the idea that places can be also inside buildings. The concise but significant thinking of architect Peter Zumthor helped to shape the idea that buildings could be conceived as containers of places, and that these places were largely determined by their environmental attributes. Owed in part to the leadership of Professor David Cabrera, 4th year coordinator and also lecturer of theory and history, the group started to adopt, and finally embrace, the idea of *buildings as containers of places*, a sort of destination of environmental design, beyond a strictly utilitarian view. Needless to say that Cabrera's double capacity -as studio leader and theory lecturer- further facilitated the links between Humanities and Studio.

The notion of 'place inside buildings' became a departure from the neutralising control of environmental variables, and at the same time, a departure from the pervading and ubiquitous concept of space, also neutral and neutralising (Casey 1997). Place refers instead to the environmental specialness of certain portions of space.

At that moment the thinking of Peter Zumthor was circulating through magazine and internet articles that later became books. In his book 'Atmospheres', Zumthor(2006)does not talk of places as such, neither he talks about environmental design, however his idea of architectural *atmospheres* marries both concepts and in many ways is similar to the idea of *memorable places* that was a key concept of the DML.

A proper handling of environmental attributes, Zumthor suggests, can "seduce, not force, people to move or do things”, it can “induce a calming effect, to introduce a certain composure”. An atmosphere, depends heavily on "the material presence of things". Such a presence has a sensual effect on people. The materials are literally the body of architecture, which can touch us. In order to produce an atmosphere a delicate combination of those materials is required. Materials can collect or release heat, or smell; Materials and their surfaces have the power to modify how light and sound behave.

Buildings have a particular sound. “Listen!”, says Zumthor, “Interiors are like large instruments, collecting sound, amplifying it, transmitting it elsewhere (and) that has to do with the shape peculiar to each room and with the **surfaces** of the **materials** they contain, and the way those materials have been applied” (p. 29). The wrong choice of materials may kill the musicality of a potential atmosphere.

The creation of atmospheres rely on the control of temperature as well, and while this depends on many factors, materials, in the eyes of Zumthor, play a central role. He refers to both, the physical temperature, and the psychological too, presumably built on prior real thermal experiences.

An atmosphere usually establishes a “tension between interior and exterior” and this means the existence of “thresholds, crossings, the almost imperceptible transition between the inside and the outside, an incredible sense of **place**, an unbelievable feeling of concentration where we suddenly become aware of something enveloping us” (p. 47). A transition in architecture is, inevitably, an environmental event. This is as important in a church as it is in a house.

An atmosphere usually exhibits a particular quality of light, natural and artificial.

Architects should "factor light in from the beginning". Zumthor suggests two methods for lighting design: the first, carving light from a dark **medium**[72], and the second, to go about the lighting materials and **surfaces** systematically and to look at the way they reflect and to fit everything together on the basis of that knowledge".(p. 59).

And finally, buildings have a form. Yet Zumthor stresses that such a form can not be simply imposed, instead it has to be found, according to the atmosphere the architect is seeking to achieve. An appropriate way of putting this is: "the idea of things coming into their own, of finding themselves, because they have become the thing that they actually set out to be". So, he says "form is not something we work on -we apply ourselves to all the other things. To sound, noises, materials, construction..." A building emerges because "it has found its form".

6.3.3 Alternative order of the design process

As a way to overcome the belated introduction of environmental phenomena in the design process of students, Cabrera, coordinator of 4th year, suggested an interesting metaphor of an architect designing a *place* as it were a *tree* for a sunny region. "When designing the tree, we must imagine **the shade in the first place**, then we must imagine the small leaves blocking the sun, then the bigger ones, then the small branches that hold the leaves, then the more robust branches supporting the small ones, then the trunk, and finally the roots". The moral is that the yearning for the shade is what motivates the rest of the process (Martinez et al. 2008). Cabrera's metaphor intended to reveal, before the eyes of the students, that places contained in buildings, like Zumthor's atmospheres, were largely defined by environmental attributes, and that the longing for those

72 Interestingly, Zumthor, uses the same nomenclature suggested by Gibson.

environmental attributes was a potent trigger of the design process.

In Cabrera's proposal, the order of the process was somehow unusual. Students were encouraged not just to integrate environmental issues in early stages of the design process, but to use those attributes as design concepts, or better, as design generators (Darke 1978). Clearly, this had a beneficial effect in the integration process. Students started to consider thermal, acoustic, olfactory, and other sensory experiences as strong and valid concepts.

6.3.4 Comfortable vs. memorable

While the idea of comfort was not excluded from the pedagogic experience of the DML, it was assumed with a degree of caution. Comfort is certainly a primary feature that attracts us to places, like the cool shade under the tree in summer, or warmth around the campfire. However, comfort is a concept that is related with the search of an ideal environment, and as Bloomer et al. (1977) remarked, an ideal environment is easily confused with lack of sensation, therefore very close to a meaningless atmosphere. Bloomer et al. suggest that "to at least some extent every real place can be remembered, partly because it is unique, but partly because it has affected our bodies and generated enough associations to hold it in our personal worlds". Comfort instead tends to neutralize environmental attributes, and therefore minimizes features that make places different and significant.

The search for silence in the last exercise described in section 3.2, for example, is not aimed only at neutralizing noise, but at creating a place where sounds, lost to modern-day inhabitants, can be recovered in the midst of the metropolis noise. The goal of environmental design in this case, is aimed at creating an environmental experience of delight, that exceeds the mere comfort. As Heschong (1979) has eloquently sustained, the idea of memorable place is more readily associated with delight, rather than with comfort.

Within the studio, the idea of conceiving a distinct place is a powerful incentive for students. Conversely, creating a neutral place was unappealing. Students, on the contrary, tend to distinguish their proposals from the already seen, and propose the new. Much of the spell of studying architecture consists of this challenge. In the experience of DML this also applies to the creation of 'unusual environments'. In these cases the motivation of students increases significantly.

In the Memorial to the poet Pablo Neruda (p. 171), the wind is allowed to break into the building at certain moments in order to produce sound. Wind speed exceeds the comfort index. This is, however, deliberately sought, and contrasted with spaces within the building, where wind is kept off, and where it is possible to develop activities that need calm and tranquillity. Users can move across various environments, with varying levels of comfort.

6.3.5 Calibration of Materials

The intention of creating 'unusual environments', wherein some phenomena are exaggerated, responds to a strategy of motivation of students in the early years. Along with this strategy, phenomena are artificially 'isolated', in order to make students focusing on a particular one. In this introductory stage students are, as mentioned above, expected to manipulate shape and environmental phenomena from the start of the design process. This is called dynamic modeling, since the definition of form and the manifestation of the phenomena are mutually co-determined, unlike what usually occurs in a typical design process, in which environmental attributes are added on to the form later.

The manipulation of form, in order to make environmental attributes manifest, is then, a central objective of the DML. However, while this approach is suitable for novice students, it was less suitable for advanced ones, since form and extension characterize a place only partially.

A given place may be described as intimate because its scale, in relation to its occupants, is small, and its shape is concave, yet such attributes of space, by themselves, do not account for the whole intimation feeling. Environmental attributes are also dependant on the specification of materials, and how they are combined. In this sense, a correct specification of materials is situated in the core of environmental design. In other words, environmental design, aimed at creating places, can not be developed without understanding the qualities of materials, and how they influence the making of an environment.

Achieving this objective in school is admittedly very difficult, for it requires a sensitivity that is usually gained at mature stages of professional practice (Pallasmaa 2009; Sennett 2009). However, the school is where the seed of such skill can be planted.

6.4 Conclusions Chapter 6

In this Chapter the pedagogic experience of the Dynamic modeling Lab (DML) and its key strategies were described. Chief among these was that environmental design involved the creation of places, a goal that could be achieved by actual manipulation of their environmental attributes. The notion of memorable places, linked to environmental attributes, provided a conceptual framework in which environmental design appears essential to the architect's work, and not less important, motivating to students.

6.4.1 A guiding idea and Two Strategies

The exercises described here were not aimed at technical accuracy, nor they were a meaningless play of shapes and random physical phenomena. Their intention was to incorporate environmental phenomena in the palette of design materials of students, through motivating and practical undertakings. Students approached the idea of architectural space, not as a void between solids that needs to be ‘stuffed’ with environmental attributes at some future point. Instead, they started from envisioning a memorable place, because of these attributes. As a consequence, environmental issues were considered essential from the beginning.

The adoption of the idea of atmospheric plenum, or medium, may seem less relevant in terms of design outcomes, but its relevance is clear in terms of process. This is clearly reflected in the importance of modeling of environmental phenomena. By modeling the phenomena, and not their representation, they became valid participants from the beginning in the 'conversation' of students with the materials of the situation.

The exercises respond to a guiding idea and 2 principles related to two areas: Pedagogy and Design. The lack of any of these elements, it is argued in this thesis, could jeopardise the implementation. In this section a preliminary description of them will be provided.

Guiding Idea

The contribution of humanities was essential to maintain an 'architectural' perspective of the activities of modeling. Fortunately, one of the studio leaders was also lecturer of Architectural History. This fact, along with the contribution of other lecturers, helped the community to maintain a contextual vision of the project. While modeling environmental phenomena was a core activity, this was understood in a larger context of architectural undertakings. Thus, assignments were carefully devised in order to inspire the experiments with a view on human habitability and poetry.

The concept of place and place-making, borrowed in part from Phenomenology, was permanently alluded to in the briefs, and played a fundamental role in keeping the process within architectural boundaries. In other words, all experimenting and modeling had as a goal the creation of places. While it was clear that the designer is not the final responsible for the actual place-making, it was equally clear that he performs an essential role in setting the scene for this to happen.

Pedagogical Strategy

Learning in the Environment

The fostering of the studio/lab as the learning environment *par excellence* is a key feature of the DML project. In the first place because it is the physical locus in which knowledge can be situated. A studio/lab when is well equipped provides the basic facilities of a standard learning environment -furniture, ventilation, lighting, etc. - but most important, it provides the specific necessary elements to carry out the design process as a journey of exploration and discovery. Particularly relevant in this respect were the artifacts and tools that learners could manipulate, more so when these elements were so central in the modeling of environmental phenomena.

Similarly, the studio is relevant as a learning environment because it is a social setting in which the student develops a sense of belonging. Through the studio, the student is also inserted in the school that is a larger community of learners. This is important because it is clear that much learning occurred due to the exchange of information among peers. Most of this information is shared verbally, in informal conversations, but a large part of it is also available and visible throughout the design processes, in exploratory models, drawings, or written thought. While the artistic tradition of the studio drastically forbids imitation among students, in reality, a valuable learning process occurs by this behaviour.

Educating the Attention of students

A strong will of the instructors in order to limit the scope of problems can be observed, in particular, in the first three exercises. For instance, students were brought to work in the same assignment, with very straightforward pedagogic questions; or were imposed the same modeling technique.

While this attitude was criticized as highly prescriptive, by school staff at the time, the vision of the DML was certainly different. Limiting the type and number of problems that students had to confront, was absolutely necessary. It was not possible to educate students' attention and intentions in a field of unlimited possibilities. Thus, in these examples, the brief appeared as an exceptional tool to canalise students' attention and intentions, rather than being just the assignment of an abstract design problem to be solved as they see fit.

The brief for a professional designer can be considered as “a map to explore an unknown territory” (N. Cross 2007), in education, however, the territory to be explored should be partially narrowed by the educator. A learner acts within the attenuated reality of the studio, and the pedagogical questions set the boundaries of reality in order to guide the view of the students towards a phenomenon. The utilization of an abstract approach to form-making in the first exercise (p. Error: Reference source not found), for example, did not respond only to a need of aesthetic expression, but rather to a pedagogical need to focus on one specific problem: the shade. Similarly, the choice of a dramatic environmental context for the Memorial for poet Pablo Neruda (p. 171), was aimed at focusing student's attention on specific environmental phenomena.

Design Strategy

Through the exercises described in this Chapter, the creative process appears distinct of the artistic conception of architectural design, in which the designer has an almost mystical role, and the outcome depends largely on a one-way creative flux that goes from the mind of the designer-creator to the object created. This does not mean that the work of the student is devoid of art, but the idea of art behind the exercises, is closer to the idea of skill in handling a construction problem in situ.

Students were encouraged to engage in a relation with the materials of the situation, as described by Schon(1991). This involvement was to be as tangible as possible, and this was more easily achieved, when such materials were not 'represented', but were present as such, i.e. shade in the first exercise, wind in the second, heat in the third, were actual modeling materials. Students had to actually manipulate them as part of the form finding process. The more tangible the 'materials', the better the conversation with them is. The less tangible the materials, the higher the risk in engaging in a solipsistic way of design.

While the label 'dynamic modeling' is somehow redundant -inasmuch exploratory modeling is always dynamic- the intention was to promote the modeling of the phenomena in conjunction with the modeling of the shape. In this sense, a dynamic modeling process is better conceived as a self-corrective process in real time, rather than a translation into the physical world of a mental preconception. The solution emerges as a discovery, rather than being imposed unilaterally.

By describing four exercises, this Chapter set out to illustrate the kind of activity the DML promoted in the studio. A central role in the integration of knowledge in the studio is assigned to practice. While 'information' can be stored and separated from practice, knowledge is situated in practice. This is, knowledge is 'grown' from practice.

The Chapter also shows the principles on which this experience is based. As stated above this research has identified two areas in which they belong: Pedagogy and Design. However, these principles are not enough to ensure a good implementation of environmental design in the studio. A guiding idea, that in this particular case was the creation of Places through the manipulation of environmental variables, was an essential component of the project.

The manipulation of environmental attributes is not something that has not been done in similar integration experiences in other schools. What seems to be different in these exercises is the order in which these attributes appear in the design process. Here, the final form is sought and found, in view of achieving environmental attributes. The process is triggered by the 'longing for environmental attributes'.

Chapter 7. General Conclusions

The problem of implementation of environmental design in the studio has been identified as a disconnection between the delivery, or transmission, of information and its application in the design process of students. This thesis agrees in part with this diagnosis, but has adopted a slightly different point of departure, informed by the views of Donald Schon and other educators. The disconnection between transmission and application is not the underlying problem, but the manifestation of a positivist view of knowledge that sees 'knowing' as separated, and separable, from 'doing'.

In this view, the task of the student is to apply the 'known' environmental concepts in their design projects. Therefore, it is assumed that students need to 'know' first, and 'do' later. Designing, on the other hand, is an activity in which 'knowing' and 'doing' blend into a single act. Here, the student 'knows' by actual performing. This paradox motivated the following hypothesis: 'Environmental knowledge can be generated in the studio, by adopting the logic of design'.

In order to inform the present understanding, the enquiry proceeded by reading extensively literature concerning both learning theories and *design*. In light of that reading, the idea of 'situated knowledge' in connection with the notion of 'design as a conversation', emerged as a plausible explanation of the difficulties in implementing environmental design in the studio. Among the theories studied, the ecological approach to learning helped to understand the relevance of the learning environment, and the activity of experimenting with real environmental phenomena during the design process.

This work suggests that opportunities for implementing successfully environmental design in the studio arise when the split between *knowing* and *doing* in modern education is factored in the problem. A better implementation seems much achievable if such split is overcome. In addition, this work suggests that opportunities for integration of knowing and doing environmental design, arise when this pedagogical undertaking is assumed as an instance of 'situating knowledge in a practice'; and second, when principles of 'ecological learning' inform this implementation.

This Chapter comprises 3 sections. The first suggests a rationale to implement environmental design in the studio based on the idea of 'growing environmental knowledge' from the very act of designing. To achieve this, environmental phenomena should be given access in the design process as a participant of the conversational nature of design. The second section discusses the idea of an orchestration of new affordances of the learning environment. The third section suggests new avenues of research.

7.1 Situating Environmental Knowledge in an Exploratory Conversation

The basic meaning of the expression 'situated knowledge' is that knowledge is not produced in the abstract, but in a specific place and occasion. However, in a deeper sense, knowledge is *situated* when is not imposed from without a practice, but when is 'grown' from within (J. S. Brown et al. 1989). This claim may be interpreted in three ways, relevant to this thesis.

The first is that 'knowledge' can not be considered as external or prior to the practice of environmental design, but as one of its outcomes. Knowledge is the offspring of practice, not the opposite. The student knows how to design as a result of actual design performing, and this applies also to environmental design, if our intention is to implement it in the studio.

The second interpretation relates to the idea of 'growing' knowledge. 'Growing' implies that knowledge is not a static thing, embedded instantaneously in the mind of the knower and kept there unchanged, but something that is gained progressively, and perfected through the very practice.

The third interpretation has to do with understanding practice as a customary way of operation or behaviour that characterizes a community of practitioners. In this third sense, situating knowledge in a practice means adopting the customary way of knowing of a community of practitioners, this is, the way in which that community frames the problems of its practice and sets out to solve them.

In architectural training that community of practitioners are architects, although in a wider sense they are designers[73]. Consequently, it can be concluded that, in order to situate 'environmental knowledge' in architectural training, it is necessary to adopt the way in which designers produce knowledge. This claim calls in turn for an understanding of that particular “way of knowing”.

73 Though some architects perceive themselves as artists, researchers identify architects, clearly, as designers (N. Cross 2007; Lawson 2004).

A vast body of research substantiates that the essential way of knowing of designers is “transactional” (Lawson 2006; N. Cross 2007; Schon 1991). The designer gains knowledge in a negotiation between the design situation and himself. This negotiation, or transaction, is not the imposition of the artist's will on his work of art, nor it is the neutral attitude of the scientist in describing an extant phenomenon of reality.

While several authors characterize design as an activity basically conversational (Schon 1991), or transactional (Lawson 2006), it is possible to find at least two instances in which design does not unfold in this way. Clarifying this point is important since situating a knowledge in the practice of design arguably depends on its conversational nature. These two instances in which design is not conversational are related to the central paradigms of Art and Science of the Western culture. The choice of design as a conversation in which we intend to situate knowledge, therefore, involves a step back from both. First, the conversational model of design is incompatible with an artistic model because in the latter, designing can occur as an internal process from beginning to end, without further recourse than the architect's imagination. While the designer is deeply involved with his work and the design is considered as the fruit of his artistic genius, the designer imposes his/her will on the design. The relationship between him/her and the design is strong, but this relationship is unidirectional. Designing, in this perspective, unfolds in a similar manner of a solipsist meditation, or a 'monologue' that can be fully imposed on the situation the designer wants to change.

The second instance in which design is not a conversation is closer to the scientific paradigm. In this one, the designer is assumed to follow the dictates of algorithms that lead inevitably to an optimum result. Unlike the artistic paradigm, the designer must be separated from the problem. While the procedure is dictated by a 'map', the inevitable contingencies must be resolved objectively. Solutions must be sought avoiding personal views or prejudices. In this case, despite this emotional separation of designer and design situation, the designer does listen to the backtalk of the situation, but remains sceptical, always at a safe distance from it, firmly sticking to a scientific logic of disconfirmation of hypotheses.

In reality, design unfolds in a different way. As Schon has appropriately termed the act of designing, the designer establishes a **conversation** with the design situation, that is similar to a dialogue between people, comprising questioning (exploration), reflection, and opportunism (N. Cross 2007).

This conversation is, nonetheless, purposeful. When designing, the student/designer is at the same time talking and listening to the situation, and exploring an unknown territory (N. Cross 2007). Then, a better description of this way of knowing is exploratory conversation. The previous initial conclusion may, consequently, be rephrased in the following way. Situating 'environmental knowledge' in architectural education involves 'growing it' from within the conversational and exploratory nature of design.

Establishing a successful exploratory conversation is a skill that is completely mastered in mature stages of professional practice. When designing, the experienced designer is deeply involved with the materials of the situation in a similar way as the artist is involved with his work of art, but the relationship between the designer and the situation is not unidirectional. The designer does not want to impose a monologue upon the situation, but to establish a dialogue with it. Likewise in a real conversation between people, the designer listens to and observes the other participant with personal interest.

In order to start the exploratory conversation, the designer frames the problem and establishes a crude hypothesis of design, expressed as a basic diagram, a drawing, or a rudimentary model. His/her attitude towards this hypothesis is, however, biased, but this is part of the nature of the conversation. Unlike the scientist, the designer does not want to disconfirm his/her hypothesis, on the contrary, he/she wants it to become true. Thus, the exploratory conversation proceeds by successive adjustments of the experimental conditions to make the hypothesis fit[74]. Yet this 'unscientific' attitude does not mean that the designer proceeds blind towards a predetermined goal. The goal that is a moving target is revealed in the very process.

Novice students do not have this skill in full, although they are in the process of acquiring it. In the school, they are exposed to plenty of opportunities to gain this skill, from the very beginning of their studies. By this continuous exposure to design situations, students start to develop the skill of prompting the conversation, talking and listening to the situation's backtalk.

An essential characteristic of the exploratory conversation is that it is mediated by artifacts that represent real situations, made in the controlled and familiar environment of the studio. By means of this 'virtual world' of models and drawings the student can operate in the real situation, modifying it, and thus inciting the situation's backtalk.

Whereas the student's imagination (his inner world) plays an important role in this process, he depends on the situation's backtalk, through drawings and

74 The scientific objectivity though, does not apply in design because the designer does not want to describe an extant reality, but to produce the transformation from one state of this reality to a better one

models in the world outside to progress. This process is not dictated by rules in advance, but is dynamically built according to the reciprocal flow of information between the student and the situation, through the virtual world of models and drawings.

In light of this considerations, situating environmental knowledge in the design process demands embedding environmental phenomena within the system of frames, hypothesis, and testings by which this conversation proceeds. In more simple terms, it demands modeling the actual phenomena in the logic of the exploratory conversation. By modeling the phenomena, students are not taught how the phenomena behave, but the phenomena themselves are revealed to them within a process of active perceptual engagement.

A very important property of this exploratory conversation is that it unfolds within the boundaries of the practice[75]. Student are being trained to confront problems by adopting the way of inquiry of the community to which they belong, and will try to bring the problems to be solved in their environment of practice, employing the customary ways of knowing of their community. Another way of putting this is that designers, and by extension design students who are learning the skill of the conversation, prefer to 'invite' the materials of the design problem to their familiar environment of practice, rather than abandoning their environment and adopting another way of knowing (Waks 2001). Catalan architect Antoni Gaudi epitomised this attitude when he brought in his atelier the complex problem of structures of the Church in Park Guell, illustrated in Chapter 6 (p.176). The designer in such a familiar environment can operate with

75 For Schon, the meaning of the expression 'knowing in action' is twofold. The first is that knowing take place while performing. The notion of 'knowing in action' is thus consistent with the ecological notion of knowing in a perception/action intertwining. While this is the basic idea, the expression 'in action' also means 'in practice', or rather 'within the boundaries of the practice' (Waks 2001).

confidence. This reluctance to abandon the environment of practice and the peculiar way of inquiry of the community indicates that, in order to grow environmental knowledge, environmental phenomena should be invited in the familiar environment of the studio or laboratory, as new materials of the situation.

Not less important is the fact that knowledge in the logic of design is the outcome of an exploration, and is revealed in the guise of discoveries (N. Cross 2007; Schon 1991). Considering this fact, a strategy of implementation should introduce environmental knowledge as something to be discovered in the exploration, rather than 'transported' from the lecture theatre to the studio.

Environmental phenomena are not foreign to the architectural training environment today. Occasionally we see their labels in the design projects of students, but they seem to be rather unbidden guests, and their participation in the design process is, with few exceptions, peripheral. The difference is that when invited to a genuine conversation, phenomena are not just present, but contribute to the student's creative discerning by backtalking. In order to achieve this, phenomena need to have a real presence and visibility in the process. The DML experience (Chapter 6, p.158) shows that 'environmental knowledge' can be grown in the studio, bridging the gap between *knowing* and *doing*, when environmental phenomena are granted access to, and presence in the exploratory conversation of design, on a par with other materials.

In the light of this reflection, informed by the views of Donald Schon, James Gibson and others, and the experience of the DML, we may conclude that the conversational nature of the design process offers a natural opportunity for situating environmental knowledge in the studio, growing knowledge from the practice, yet this new 'materials' need to be properly invited to the place wherein the conversation occurs.

Bringing environmental phenomena as proper materials in the studio, may involve questioning some pedagogical concepts or labels. The taxonomy of models proposed by Dunn (2007), for example, separates exploratory models from predictive models assuming a clear cut between both. In the experience of the DML, a model can be used to predict the behaviour of environmental phenomena and, for this very reason, it becomes an advantageous exploratory model. Exploration in this case exceeds the aspects of form, or rather, it confronts environmental phenomena, such as temperature, sound, humidity, or any other, as elements inseparable of form.

7.2 Aspects of the implementation from an ecological approach to learning

As it was discussed in Chapter 4 (p. 73), the fundamental premise of the ecological approach to learning is that learners and their environments form systems that know and learn. The role of the environment is providing information to the learner, and the role of the learner is to respond to that information, acting accordingly upon the environment. The information the environment provides to the learner is expressed as opportunities for action, or affordances. The learner detects this opportunities for action in objects, places, and events of the environment and responds thanks to his/her set of effectivities. The Ecological Approach to Learning thus provides us with a new perspective to see our learning environments as sets of affordances for the student to act upon. From this point of view, it is possible to argue that the problem of implementation, in part, rests on the lack of affordances of the studio. But before seeing what is missing in the studio, it is worth remembering what the studio does offer in terms of a learning tradition.

As mentioned in Chapter 2 , the studio belongs to a learning tradition born and developed before the establishment of the modern university. While the teaching model of the modern university assumes the premise that knowledge is of necessity prior to practicing, the studio assumes that knowledge springs from the involvement of the learners with their practice. Knowing and learning can not be conceived as being apart from practice, and such practice in our particular case is design. This is why understanding design is so important in a strategy of implementation of environmental design, or any other subject, in the studio.

Design, and this has to be emphasised, is the arena in which the learning ecology can be materialised for the student of architecture. This materialization would only happen if design is assumed as an exploratory conversation with a situation, and such situation is recreated in the environment of practice. Otherwise, if design is assumed as a process carried on entirely in the mind of the designer, the possibility of this ecology is gravely lessened. Equally, this learning ecology is not possible if the job of the designer becomes a mere application of data prepared in advance.

In implementing environmental design, the studio plays indeed a fundamental role as the physical locus of the learning process. Nevertheless, for the studio to become a virtuous learning setting, a series of affordances must be in place.

Affording a Conversation

From the ecological principle of reciprocity between the environment and the learner follows a close relationship of dependence between the environment and the activities of the learner who uses it. Environments and activities are mutually determined and co-evolve. The design process is, in the educational context of our discipline, the most important of these activities. If we adhere to the notion of design as a conversation, it can be argued that architectural training has favored 'conversations' concerning the form, function and meaning of buildings (Capon 1999). The conventional studio is therefore better prepared to afford conversations about these topics, which is evident in the physical characteristics of the studio and the objects it contains, as the type of equipment, furniture, artifacts and tools.

On the other hand, environmental design, which is commonly considered within the technical subjects of the curriculum, is usually left outside the range of preferred topics of conversation. Although environmental phenomena are starting to appear more frequently in the presentations of the students, they have not entered into the logic of design as an exploratory conversation.

Perhaps the most fundamental difficulty derives from the persistence of the positivist idea of knowledge that still permeates education in the modern university. In concordance with Positivism in education, concepts of environmental design should be lectured to students as pieces of universal truth, hence, as *unsituated* fragments of information, dissociable and dissociated of practice.

Being knowledge a transferable substance, the role of the educator would consist of assuring the highest rate of 'knowledge transfer', which is deliberately pursued by modern institutions of education. But more conflicting with the spirit of design, and following from the previous view of the educator as a transmitter of information, is the view of the student as somebody who has to *apply* correctly that knowledge in the design process. While the idea of *correct application of knowledge* seems logical and desirable, it leads to a conflictive conception of the design process in which its essence, that is to say, its exploratory and conversational nature, is neglected.

Relevant to this thesis is the fact that this obliteration of the exploratory and conversational nature of design is particularly strong when students have to deal with environmental phenomena. Studio assignments tend to be poorly designed in terms of making phenomena part of the conversation. Undoubtedly, dealing with materials that in normal conditions are invisible and intangible, makes the implementation of environmental design a challenging pedagogical task. Nonetheless, as some of the studio exercises in Chapter 6 (p.162) show, the solution to this problem depends mainly on the willingness of the educators to implement it, according to a pedagogical ethos.

Also, and not less important, the implementation of environmental design in the studio depends on the inventiveness of the educators. Such inventiveness is directly related to 'materialize' environmental phenomena as such in the design process, becoming in this way, effective materials of design. As the same examples of Chapter 6 show, (in particular the exercise involving convection p.175) the inclusion of actual phenomena diminishes the risk of a solipsistic design process, and increases the possibility of a conversation. A genuine conversation finally rests on the dynamic presence of such phenomena in the design process, and not just their static representations as it usually happens.

Design as ecological knowing

Designing in the spirit of a conversation implies a particular attitude towards *knowing* that is entirely different of the scientific attitude postulated by Positivism. On the other hand, it is also different, though just in part, of the attitude of the romantic artist. While the designer wants to know the situation, he/she does not perform a neutral corroboration of reality in line with the scientific paradigm, nor he/she imposes a personal view on the situation in line with the artistic paradigm.

From a technical rational (positivist) point of view, what is perhaps the most conflicting aspect of the conversational nature of design, is the fact that such design mode must allow for uncertainty. Problems and solutions arise unpredictably, and so the designer must be alert to the emergence of opportunities. It is not the solution alone that has to be discovered, as it were an extant reality of scientific type, but it is the discovery of both -problem and solution- in conjunction.

It is because of this sort of choreography between the designer and the coupling *problem-solution* that the design process can be said is a truly ecological way of knowing. Remember that the designer's behaviour is informed back by the modification of the situation, in a circular fashion. It is not a unidirectional process. And it is a truly ecological way of learning since the designer is recurrently confronting similar but always new situations, thanks to which he/she can refine their perceptual skills. In a wider sense, students/designers are *tuning* not just their perceptual skills, but tuning themselves as whole persons in order to better respond to similar but always new design situations.

The design situations, as Schon (1991) remind us, are represented by means of models and drawings of various types. This is of the utmost importance, for it is the presence of these elements, and the possibility of their manipulation, what affords the conversation between the student, but more precisely between what is in the student's mind, and the situation recreated in the learning environment. Conceived in this way, the design process can not be other thing than an instance of ecological knowing, but for this to happen it must be afforded by elements in the environment. When designing, the most of the time students find themselves manipulating objects, artefacts and tools, and such manipulation feeds back their own discernment.

While the learning environment of the student of architecture exceeds by far the 'mere' physical environment, including the artifacts and tools in it, it is clear that these elements play an essential role in the act of knowing. Furthermore, we can say that these elements are indissolubly linked to the student's 'way of knowing' (cf. Chapter 5, p. 141). Drawing, for example, is a fast and effective way of exploring forms, within the limitations of the bi-dimensional representation. Models, in turn, allow for three dimensional exploration of form. Similarly, the materials of which such models are made determine what and how students know. Different materials lead the design process towards different outcomes because such materials, when 'interrogated', respond in different and idiosyncratic ways. Digital models, for example, suppose an entirely peculiar 'way of knowing' having its own potentials and limitations. While these models offer evident advantages in terms of simulating and accelerating dynamic phenomena, their ontology remain 'inside the computer', at best becoming images on the screen. Students and the phenomena so represented do not share the same environment. They -students and computer representations- are not made of the same stuff, or using a Merleau-Ponty's expression, they do not share the same flesh (Merleau-Ponty 2002), which suppose an incomplete understanding.

This thesis does not intend to state that the incorporation of real materials and actual environmental phenomena is the only factor that would improve the implementation of environmental design, but from the perspective of ecological knowing and learning, extensively discussed in Chapter 4 (p.73), the real presence of things makes an immense difference in terms of affordances, moreover when the 'things' we are dealing with have an invisible and sometimes intangible nature. While it would be an exaggeration to attribute the problem of implementation of environmental design in the studio exclusively to a lack of affordances of the physical learning environment, in light of the ecological principle of reciprocity between the learner's activities and the physical environment, it is not possible to think of an integration of 'new materials', of the kind environmental design involve, without taking into consideration appropriate affordances. In particular, it is not possible to raise the idea of learning as 'growing environmental knowledge from within the practice' with equipment that is not conducive to discovering by experimenting, but rather to corroboration of predicted building performance. In such a scene, students have to conform to predetermined universal truths, which is opposed to the sense of design and to the sense of ecological learning.

This is not a problem caused by the students, nor it is a problem caused by the educators as individuals. As it has been discussed throughout this thesis, this is a problem of the whole educational system, clearly embodied in the modern university, founded on the basis of an old but persistent conception of knowledge acquisition. The way environmental design concepts are imparted, through lecturing separated from and prior to practice, is nothing but a consistent implementation of that system. The sequence of 'transmission' first and 'application' later, is very functional to the educational business in that it helps to maintain a high rate of information transfer, as if knowledge were a commodity for which students can be charged. However, this system that overemphasises teaching, fails to understand learning. Learning, in a more contemporary conception like the ecological one, is not instantaneously accomplished once 'knowledge' is placed in the head of the learner, but is an ongoing transformation of the whole person. In the ecological cast, this transformation is an increasing *attunement* of the whole learner to his/her practice, something that seems entirely desirable for an environmental designer.

Said all this, a question may arise. Is there room for such humanistic considerations in the teaching/learning of environmental design? Not seeing the link between humanities and technical subjects is perhaps our biggest failure as educators.

Directly linked to this conception of learning are the ideas of situated knowledge and situated cognition. Again the positivist view of knowledge occupies the opposite extreme. The concept of situated knowledge defies precisely the key idea of positivism that knowledge is universal and for this reason, transferable without problems from one head to other, or from one *situation* to other. Being situated means all the opposite. Knowledge emerges in a particular situation in which the learner is involved. Now it is worth remembering Schon's definition of design as 'a conversation with the materials of a situation'. The use of the term *situation* in his definition is not just a curious coincidence. Designing is an epitome of *situated* knowing and learning in which the learner is deeply involved. This is why this thesis emphasises design as the arena in which what we call *environmental design* should be situated.

For this to happen a fundamental condition should be met. The recognition that design is not something halfway between art and science, but a peculiar, legitimate and powerful 'way of knowing'.

Relevance of modeling

Students, seen as ecological agents in the environment, are active obtainers of information, and the evidence of their learning is their capacity to participate in the productive activities of their practice. They gain knowledge within an actual perceptual involvement with their environment of practice. While the learning environment of the student is bigger than the studio, models and drawings are essential constituents of that environment in the context of a conversational design process.

During that process, a bidirectional flow of information is produced between the student and the model. Students detect affordances of these artifacts that can be acted upon. As a result of the action, new affordances appear, triggering a loop perception action. This is the kind of relation that some researchers have called an 'extended cognitive system'(Clark & Chalmers 1998), in which student+model form a system that has the capacity to know and learn.

In order to detect the affordances of these artifacts, the student uses a complex set of perceptual systems, involving relevant exploratory activities that add information to the act of knowing that an static agent can not obtain (Gibson 1966). Much of the information in the objects does not exist as such until the student can perceive it by sensory exploration, and this occurs by getting physically involved in the act of perceiving.

In this account the body of the student assumes a key role, since it is the interface between his/her inner world and the constituents of his/her environment of practice. In order to act upon the affordances, students employ a set of body abilities, or effectivities (cf. Chapter 4, p.94). These are the means by which students can engage in major activities that yield meaningful information to them. Among other effectivities, the average student has outstandingly dexterous hand, with which he can manipulate and transform the artefacts of his/her environment of practice in many ways (F. R. Wilson 2000).[76]

The detection of affordances by means of the perceptual systems and the ensuing action upon these artifacts by means of the effectivities, render the student, in the trance of designing by modeling, as an active producer of information.

Knowing and learning, from a conventional viewpoint, entails the ability to acquire and transport *knowledge* in the head, from one context to another. In the ecological approach, learning is an improvement of the ability to detect opportunities for action, or affordances, and this improvement is gained through practice.

Every time students manipulate the objects of their environment they are in the process of achieving better levels of detection of affordances. Expert detection is finally incorporated into the whole person, as a biological and cultural being. The evidence of learning is not more information in the head of the student. Instead, is the very student, in his mental and bodily dimensions, better prepared to know and act, in new situations, because of his previous involvement with his practice.

76 This is particularly evident when we consider the range of materials these artifacts are made of, and their respective affordances. Students can fold 'foldable' surfaces like paper, metal sheets, acetate films, or other; they can give shape to 'shapeable' materials like resins, plaster or clay; they can cut and perforate 'cuttable' and 'perforable' materials, like cardboard, or plywood; they can stretch 'stretchable' materials, like elastic membranes; they can draw on 'drawable on' materials, like paper and other surfaces, etc.

In the light of this reflection, derived of the discussions in Chapter 4 and 5, 'design as a conversation with the materials of a situation', mediated by artefacts of the learning environment, reveals itself as a true instance of ecological learning.

While modeling environmental phenomena is not usually seen as belonging to the learning environment of the student of architecture, the experience of the DML would confirm that its embedding into the design process is essential to affording the generation of environmental knowledge in the studio. In the taxonomy elaborated by Dunn(2007), exploratory models are those that best capture the idea of exploratory conversation, but arguably a combination of exploratory and predictive models would play a major role in enabling environmental knowledge to be grown within the design process.

A particularly illustrative example of such a combination of exploratory and predictive models can be observed in the exercise of natural convection, described in Chapter 6 (p.175). By means of an ingenious modeling technique, heat, that is normally an invisible electromagnetic radiation, was given the affordance of being visible. Thus, the student could act upon this affordance observing the behaviour of the phenomenon. By acquiring the affordance of being visible, the phenomenon gained, in addition, the affordance of being manipulable. Because of this sequence of affordances -visibility and manipulability- the phenomenon could be incorporated into the design process as a participant of the exploratory conversation.

The incorporation of actual environmental phenomena in the design process seems justified, both from the point of view of the exploratory conversation, and ecological learning principles. Learning 'environmental concepts' conceived as purely mental reconstructions, on the other hand, does not provide the students with the opportunity to develop a fundamental skill of the ecological learner: the attunement to actual manifestations of the environment.

The role of the educator

> "We would claim, that all learning can be understood as the education of attention" (Gibson 1979, p.279)

In a conception of learning that is not based on transmission/application of information, the role of educators may appear uncertain, or irrelevant. What is the role of the educator if a knowledgeable person is not somebody who has a big amount of information accumulated in his head, but somebody who is able to do things? What is the role of the educator if learning is not the process of acquiring information, but detecting salient features of the environment in order to act? Yet, in this perspective, in which learners learn by attuning their perceptual skills to parts of the environment, it can be inferred that the educator's role is to put students in touch with such environment, showing delimited portions or manifestations of it. In this way, students can apprehend them directly.

Ingold (2000g) suggests that the work of an educator is primarily "to lift a veil off some aspect or component of the environment so that it can be apprehended directly". The following paragraph of his book "The perception of the Environment", summarises many of the concepts set forth so far.

> "Information, in itself, is not knowledge, nor do we become any more knowledgeable through its accumulation. Our knowledgeability consists, rather,

> in the capacity to situate such information, and understand its meaning, within the context of a direct perceptual engagement with our environments. And we develop this capacity, I contend, by having things shown to us. The idea of showing is an important one. To show something to somebody is to cause it to be seen or otherwise experienced – whether by touch, taste, smell or hearing – by that other person. It is, as it were, to lift a veil off some aspect or component of the environment so that it can be apprehended directly. In that way, truths that are inherent in the world are, bit by bit, revealed or disclosed to the novice. What each generation contributes to the next, in this process, is an education of attention. Placed in specific situations, novices are instructed to feel this, taste that, or watch out for the other thing. Through this fine-tuning of perceptual skills, meanings immanent in the environment – that is in the relational contexts of the perceiver's involvement in the world – are not so much constructed as discovered. It could be said that novices, through their sensory education, are furnished with keys to meaning".

Ingold suggests that while educators can still make use of propositions to communicate ideas, the sense of their work is to reveal, rather than transmit. To situate students within the environment of practice in order to promote a "fine-tuning" of their perceptual skills. Such a scene of learning, Ingold suggests, does not entail the imposition of meaning, but the discovery of it, immanent in the environment.

In the vision of Gibson, who has inspired Ingold's thinking, the work of the educator is to “educate the attention” of the learner. Gibson's suggestion makes sense in the contemporary environment in which students currently live, infinitely dynamic and varied, in particular around the student confronted with a micro-fragmentamtion of information (Kincheloe 2008). From this informative pandemonium it is necessary to disclose certain portions, so that the information inherent in the environment may emerge in front of the learner.

While educators can still make use of propositions to communicate ideas, the sense of their work is to reveal, rather than to transmit. Such a learning setting does not imply the imposition of knowledge as a truth, but rather the encouragement to discover it, immanent in the environment. Although showing the environment in education is not neutral, the educator tries to make students attend to a portion of the environment in order to promote a fine tuning of their perceptual skills.

7.3 Further Research

This work has, of course, many limitations. Perhaps its merit is the many questions it raises, rather than the answers it provides. The following are several aspects that this research has touched upon but deserve further attention.

Due to the emphasis of ecological learning in full perceptual engagement, this thesis has emphasized physical modeling; however, computers are being increasingly used to simulate environmental performance of buildings. Given that the affordances of computers suppose a peculiar set of effectivities very different of those needed to respond to physical modeling, it would be interesting to conduct a comparative study between the affordances of computer simulations and physical modeling of similar assignments. This comparison would help to identify the potentials of both in promoting learning of environmental concepts. Highly technological tools, Ingold suggests, may displace learners to the periphery of social relations. Can we claim that computers do such harm to the learning environment of architecture? And if so, what is the effect on the learning processes?

This thesis has focused on ecological learning, however there are several other theories that could shed light on the implementation of environmental design in the studio. Among others, Activity Theory, based on Lev Vygotsky's thinking, seems to be particularly appropriate to understand the relationship between activities, operations and artifacts. Some of the ideas discussed in this thesis relating to the link between cognition and artifacts could be reinforced, or otherwise adjusted. A question of such research could be, how different artifacts lead the design process in different directions, and how they determine different outcomes? Which are the best artifacts in order to promote the implementation of environmental design in the studio?

While this work has mentioned some concepts of learning in communities of practice, this is a fascinating realm that can help us to understand our own ways of learning in terms of social relations. Schools of architecture are indeed learning communities of practice in their own right, having sub-communities nested in them. The lens provided by Lave and Wenger (1991) seems promissory to start a study of how learning is produced in schools of architecture as communities of practice under the concept of "legitimate peripheral participation". The structure of such communities is not stratified as the normal curricular structure is, but centripetal. The questions would be, if the traditional curricular structure, divided in theory (knowing) and practice (doing) is not favouring the implementation of environmental design in the studio, does it exist another structure that naturally promote the implementation? Are successful pedagogical experiences implemented as communities of practice?

Donald Schon affirms that the old apprenticeship system of the studio is an anomaly in the modern university and this thesis has taken a critical stance regarding the role of the latter, however it would be naïve to suppose that such a powerful educational institution would change overnight its teaching structures to accommodate an old system. We know however that some experiences of implementation of technical subjects have been carried on successfully within traditional educational institutions. Using the words of Gelernter, those pedagogical experiences want to reconcile lectures and studio. Of such experiences of reconciliation there is no record of coincidences, similarities or differences, common patterns and strategies, and so on. It seems that there is a wealth of scattered information waiting to be compared and studied. Have these experiences overcome the rigid structure of the modern university? Is the reconciliation of lectures and studio a blend of two ways of learning? Is one of these ways of learning taking over the other?

In coincidence with the thinking of several scholars, this work has tried to emphasise the role of the body in the act of designing that is at the same time an act of learning. The architect, says Pallasmaa, designs with his whole body. Nevertheless, there is no doubt that the sense of vision has taken over the other senses in architectural design, and this does not seem to be changing in the short run. At the moment there is an emerging body of research about the advantages of visualization[77] in education (Gilbert et al. 2008). Being environmental phenomena generally invisible, the mentioned body of research is creating a basis on which we can raise our own specific questions. What is the

77 Visualization understood as making visible certain phenomena which in normal conditions are invisible.

cognitive relevance of visualization in our own discipline? Are there any risks in trusting visualization instead of actual observation?

Finally. This research did not explored the strong link between Phenomenology and environmental design, and this is certainly a topic that calls for another investigation. Phenomenology may contribute to further dignify environmental design as one of the main responsibilities of the architect. The truth is that much reflection exists about the relationship between Architecture and Phenomenology, however, there is no study of the specific relationship between environmental design and Phenomenology (in particular of the Phenomenology of Perception of Maurice Merleau-Ponty). The challenge of such investigation would be to find concepts and overlapping areas that could help to situate environmental design among the concerns of the student of architecture not just as a technical subject, which it truly is, but also as an inalienable professional responsibility.

7.3.1 References

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