592: Learning from practice: a model for integrating sustainable design in architectural education

Maureen Trebilcock

Depto. Diseno y Teoria de la Arquitectura
Universidad del Bio-Bio, Concepción, Chile
mtrebilc@ubiobio.cl

Abstract

This paper proposes a model for integrating sustainability concerns in architectural education that derives from the analysis of sustainable design in practice. The methodology was based on five case studies of contemporary architectural practices in Europe that are considered to be leaders in the field of sustainable design. A specific non-domestic sustainable building designed by each practice was chosen as an embedded unit of analysis with the intention of mapping its design process from early stages until completion. The data collection strategies included interviews with architects, engineers and clients; as well as compilation of graphic information including drawings and reports; and observations.

The findings of this work resulted in a theoretical model of the design process that suggests that the integration of sustainability crosses over intuitive, analytical and social dimensions of the process. The model for integrating sustainable design in architectural education organises attitudes, explicit knowledge, tacit knowledge and skills around these three dimensions, bringing to light the idea that the base stone of the process is commitment to sustainability that is essential to the development of necessary knowledge and skills.

Keywords: design process, intuition, knowledge, ethics

1. Introduction

This paper proposes a model for integrating sustainability concerns in architectural education that derives from the analysis of sustainable design in practice.

The methodology was based on the qualitative research tradition of case studies, which proved to be valuable in retaining the holistic and meaningful characteristics of the design process as a real-life event. The case studies are drawn from the work of five contemporary architectural practices in Europe that are considered to be pioneers and leaders in environmentally sustainable design. Each case study contains an embedded unit of analysis consisting of the design process of a non-domestic sustainable building designed by each practice: Feilden Clegg Bradley Architects and Heelis; Hopkins Architects and The Business School at the University of Nottingham; Edward Cullinan Architects and Downland Gridshell; Mario Cucinella Architects and Hines building; and Behnisch Architekten and NORD/LB (Fig 1).

The design process of each building was mapped using multiple sources of information, rich in context. It included semi-structured interviews with architects, engineers and clients; compilation of various types of documents that recorded the design process (architectural drawings, sketches, reports, multimedia presentations, etc.) and observations of the buildings.

Heelis, UK
Feilden Clegg Bradley Architects
Max Fordham Engineers

Business School, UNott, UK
Hopkins Architects
Arup Engineers

Downland Gridshell, UK
Edward Cullinan Architects
Buro Happold Engineers

Hines, Italy
Mario Cucinella Architects
Arup Engineers

NORD/LB, Germany
Behnisch Architekten
Transsolar Engineers

Fig. 1: Case studies

2. Learning from practice

2.1 The Intuitive/ Analytical/ Social Model

The analysis of the case studies suggests that the integration of sustainability issues in architectural design occurs as two complementary processes of intuition and analysis within a framework of social interaction. The intuitive process is based on knowledge and experience of the members of the design team and guides early and fundamental design decisions. The analytical process is dominant at late stages of the process and is guided by the use of design assisting tools to inform and check design decisions.

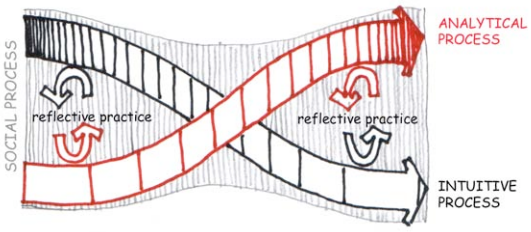


Fig 2. The Intuitive/ Analytical/ Social model of the design process

It is important to note that design process in practice is much more unsystematic and messy, as the situation is more fluid and unbounded than what the diagram shows (Fig 2). The diagrammatic representation is a heuristic device rather than an accurate representation of the nature of the process in all situations, but it certainly helps to identify the main dimensions on the process.

The case studies suggest that the generation of the first idea is the result of a social process of interaction of differing expertise. Architects and engineers start working in close collaboration from the beginning of the design process to the point where on occasion both parties share the authorship of the first idea. In addition, analysis plays a crucial role in the design process, going beyond the common notion of analysis as the process of qualitative appreciation and re-appreciation of the design situation [1], into a process of quantitative assessment that informs design decisions, supported by tools. Quantitative analysis is intrinsically linked to the technical challenges of sustainable architecture and it was present in all case studies, but at different levels of sophistication depending on the complexity, innovation and risk involved in the project. The role of the analytical process is particularly important during the middle to late stages of a project, and the whole process may be understood as a reflective interaction between intuition and analysis. Before embarking on extensive analysis, the design team would use intuitive elements to generate ideas, while subsequent analysis would allow them to get a better understanding of the environmental problems to iterate back again in reflective practice.

2.2 Knowledge and experience

The intuitive process of design does not mean that design decisions are taken arbitrarily or capriciously, rather they are taken without the intervention of any reasoning process. Although many people assume that intuition is instinctive or innate, it rather depends on previous experiences that generate learned responses.

Many authors agree on the important role that knowledge and experience play in architectural design. Architects generally face the design project with a store of knowledge about what has lead up to it [2] and with a certain level of maturity that allows them to practice design well [3]. Both knowledge and experience in architectural design are closely interrelated. Unlike other disciplines, design knowledge is deeply dependent on experience because designers acquire and use predominantly experiential knowledge in a process famously described as *"designerly ways of knowing"* [4].

Design knowledge can be conceptualised as tacit knowledge as opposed to explicit knowledge [5]. Tacit knowledge is acquired over time and rooted in experience, so it is deeply embedded in the knower. On the contrary, explicit knowledge relates to academic and theoretical knowledge, rooted in research [6].

The case studies suggest that the innovative and experimental nature of sustainable architectural design places great importance on both tacit and explicit knowledge. Not only the knowledge that the designer acquires through experience is important when making a design decision, but also the knowledge obtained from the academic and research environment. The interviewees prove this fact when they claim that they gain knowledge in sustainable design by reading and attending seminars and CPD courses on latest technologies and methods, while they share and develop their knowledge in practice. In addition, some of the architects and engineers are actively involved in research as well as in practice.

The relevant explicit knowledge in sustainable design identified by the architects was very broad, covering a variety of aspects from comfort and energy efficiency to cost analysis. Explicit knowledge is broad and dispersed, and its sources of information could be sometimes questionable. Some interviewees identified this problem as a major barrier to sustainable design and point out the need of consensus regarding valid knowledge that could help to guide practitioners in the right direction.

Remarkably, every architect and engineer interviewed in this study claimed that their early conceptual schemes were based on knowledge and experience, rather than on any specific design-assisting tool.

In addition, most interviewees believe that commitment to sustainability allows the designer to develop the relevant knowledge and experience. It is the essential driver for the work of both the experienced and the novice designer.

Based on these facts, the diagram in Fig. 3 proposes the foundation stones of the design process, where commitment is the base stone;

knowledge and experience come on a second level and sustain the third row of stones composed by explicit knowledge (based on research); tacit knowledge (based on experience and research) and skills (based on experience).

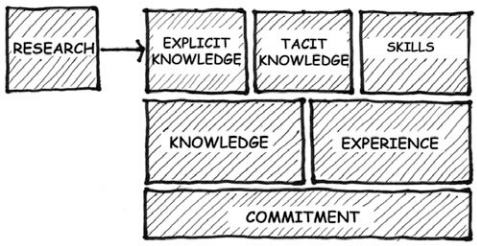


Fig 3: the base stones of the design process

The case studies help to explain the role that experience plays in the inclusion of sustainability issues in the design process. Although all five architectural practices were chosen to provide case studies for their expertise in sustainable design, which could introduce a degree of bias in that respect; it is interesting to note that every architectural practice chose an engineering practice of experts in sustainable design to join the design team. Buro Happold, Transsolar, Arup and Max Fordham have an international reputation for their vast knowledge and expertise in the field, illustrated not only by their building projects but also by their research and publications. In some cases, other members of the design team were also chosen for their accumulated experience in sustainable buildings, such as the project managers Buro Four; the spec writers Mace; the QS David Langdon, etc. Setting up an experienced design team was the first fundamental decision that every architect made to face the challenge of designing a sustainable building, by enhancing the collective knowledge and experience.

In most cases the architects were the drivers of sustainability; their expertise and commitment had the fundamental role of introducing and pushing the sustainable agenda from the moment they were appointed.

During the design process, the architects' approach to uncertainty, ignorance and innovation relied on finding an expert to assist them to deal with each specific problem. The approach was expert-based rather than tool-based; instead of looking for another tool or guideline, the architect looked for an expert, who in turn uses his/her own experience for dealing with the design problem and complements the experience with an appropriate analytical tool.

The case studies also suggest that the practice of sustainable design maybe undergoing a period of transition where the increased knowledge and experience of the practitioners result in increasingly less reliance on analytical tools. An engineer interviewee gives an interesting example to this phenomenon when he states that when they have worked with architectural practices that are open to environmental sustainability issues but less knowledgeable in the field; they have been forced to do simulations just to show the architects that certain strategies could work. In contrast, when they work with experts they don't need to perform much analysis, starting at a different level that is totally based on knowledge and experience.

The intuitive and the analytical processes are interrelated in a way that the increased intuitive abilities of the designers result in less reliance on the analytical process in the same way that less intuitive abilities result in a stronger role of the analytical process.

2.3 The role of the precedent

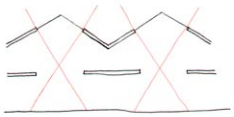
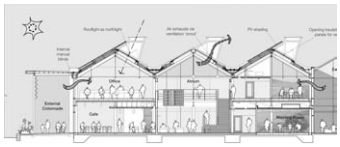
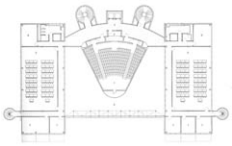
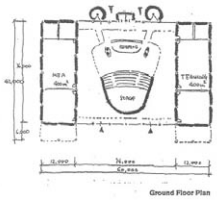
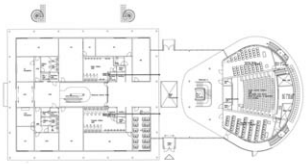
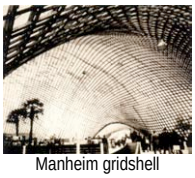
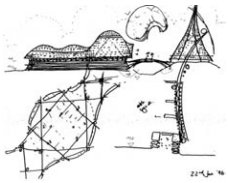
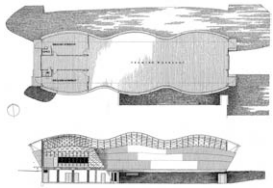
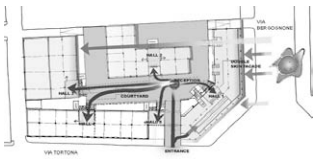
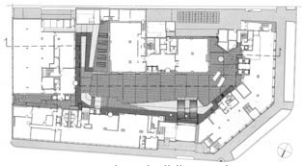
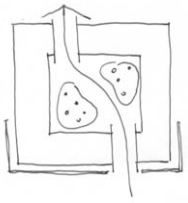
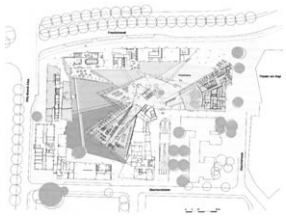
The architectural precedent is recognised as an important source of knowledge in the design process because it embodies tacit knowledge developed from previous design experience. It is important to distinguish here between two kinds of architectural precedents: 'internal precedents' that refer to the designer own past architectural projects and 'external precedents' that refer to projects designed by other design teams. Architects have long relied on both kinds of precedents, either because the works of the past naturally influence their new work, or because they gradually develop their own unique style in architecture. Internal precedents embody mostly tacit knowledge that the designers have acquired from previous projects, while external precedents embody mostly explicit knowledge acquired through visits to the buildings or review of published information.

Usually, authors use the term 'precedent' to refer to historic architectural examples, but nowadays architects and students of architecture employ the term to refer also to examples of the recent past. The case studies revealed that the design teams referred mostly to examples of the recent past, usually designed during the 1990s. This is probably due to the innovative nature of sustainable buildings that need to refer to latest developments and cutting edge technologies, while also maintaining a contemporary appearance. Only the nineteenth century industrial buildings of Swindon served as historical precedent for Heelis that responds to the setting of the new building, which posed more pressure on the contextual-historical side. However, these historical buildings also provided interesting environmental principles to the new building, proving that basic environmental principles have informed the design of buildings over many centuries.

Precedents can be grounded in three realms of choice: place, type and principle [7]. Precedents by place help to link new work with the physical context; precedents by type refer to culturally rooted form-function analogues and precedents by principle connect new work to previous work by applying techniques that have proved to be effective under a variety of conditions.

Table 1 summarises the precedents embraced by each case study and categorises them against their internal or external nature and by the realms of choice.

Table 1: precedents and drawings

Precedents	First sketches	Final drawings
 19th century buildings external precedent precedent by place and by principle  Lords Cricket internal precedent (eng) precedent by principle	 Heelis, UK	 Heelis, UK
 Jubilee Campus internal precedent (shared by arch and eng) precedent by principle, type and place	 Business School, UNott, UK	 Business School, UNott, UK
 Hooke Park Internal precedent (arch) precedent by principle  Manheim gridshell Internal precedent (eng) precedent by principle	 Downland Gridshell, UK	 Downland Gridshell, UK
No explicit precedent	 Hines building, Italy	 Hines building, Italy
 Bank in Stuttgart Internal precedent (arch) Precedent by type and by principle  Research Centre Internal precedent (arch) Precedent by principle and by type	 NORD/LB, Germany	 NORD/LB, Germany

It shows that internal precedents were more dominant than external precedents, suggesting that expert designers rely more on their own experience than on the experience of others in the field. In addition, the use of internal precedents helps to build a 'continuous design process' where each project is seen as the continuation of a previous project, based on the experience acquired.

It is important, however, to question the heavy reliance on knowledge and experience that some of the case studies show. It is also questionable to rely so heavily on precedents as a form of knowledge and experience as there is usually a high level of uncertainty in the final performance of some buildings due to the lack of post-occupancy evaluation. Most of the buildings that form part of this thesis have not been evaluated at post-occupancy stage, and only a few sustainable buildings previously designed by the architects have been evaluated. However, the evidence suggests that there is a process of 'informal feedback' from most buildings, based on comments from the users. There is an informal thread that feeds the architect and engineer back and helps to build their tacit knowledge.

3. A model for education

The analysis of sustainable environmental design in practice has important implications for architectural education as it highlights the necessary attitudes, knowledge and skills that the architect needs to acquire to integrate sustainability in the design process, while also pointing out the appropriate tools. The Intuitive/ Analytical/ Social model of the design process reveals that architectural education might focus on developing attitudes, knowledge and skills that

cross over intuitive, analytical and social dimensions.

Considering that education in the context of sustainable design is a complex issue, this paper only intends to point at essential aspects that were identified in the architectural practices that comprise the case studies of this work, as well as some emerging trends. Table 2 organises attitudes, explicit knowledge, tacit knowledge and skills around the three dimensions of the design process, highlighting only those that are essential for integrating environmental sustainability issues in architectural practice. Evidently, there is no real delimitation between the three dimensions of the process and attitudes, knowledge and skills are strongly related, crossing over different dimensions. In this way, knowledge of the principles of sustainable design is essential for the development of analytical skills; just as environmental ethics is necessary for engaging the client and team with the sustainable agenda.

Table 2: model for education

	Attitudes	Explicit knowledge	Tacit knowledge	Skills
Intuitive process	Environmental ethics	Principles and strategies of sustainable design Rules of thumb	Critical appraisal of case studies	Design integration
Analytical process		Architectural sciences	Quantitative analysis of case studies and design projects	Use of analytical tools
Social process	Social engagement			Interdisciplinary teamwork Effective communication

3.1 Attitudes

The cross case analysis brings to light the idea that the main base stone of the intuitive process is commitment to sustainability, which architects consider to be the essential driver to the practice of sustainable design and to the development of the necessary knowledge and experience. This finding is meaningful, as education in sustainable design usually concentrates solely on the acquisition of specific knowledge and skills, leaving ethical issues aside. The first implication for education should be to embrace an ethical agenda that helps students to build their commitment to sustainability.

Environmental awareness and social connection is the base for engaging the client and rest of the team with the sustainable agenda. This is also related to effective communication and leadership.

3.2 Explicit knowledge

The development of explicit knowledge is probably the most common approach to the inclusion of sustainability in education due to the fact that it is easy to include certain matters in the existing courses without altering the overall curriculum. However, this knowledge cannot be confined to the technology courses and has to be integrated into the design studio. There is no easy strategy to achieve this aim, but the general criteria should be to introduce principles and strategies in sustainable design from the beginning of the design studio and throughout the years of education. This idea is totally dependent on the commitment of the academics and their willingness to generate teamwork.

3.3 Tacit knowledge

The development of tacit knowledge is probably the most difficult area to define in terms of concrete actions, as all the educational experiences that the students undergo would help to build their tacit knowledge. This work identifies critical appraisal and quantitative analysis of case studies and the students' own design projects as a specific source of tacit knowledge that is distinct from the explicit or theoretical knowledge that they would find in books. The case studies could involve a wide variety of ranges, from vernacular to high-tech, and from historical to contemporary buildings. The choice of vernacular o historical cases is very important in reinforcing the environmental and cultural contexts, understanding that sustainability is neither totally new nor entirely technical. There is great opportunity in generating a better understanding of environmental issues by analysing their application in simple buildings that were designed with locally available materials before the time of abundant and cheap energy. Contemporary cases might help to identify the state of the art of sustainable architecture and ideas for future development. Following the idea of fully integrating sustainability in the architecture curriculum, the critical appraisal of case studies from an environmental perspective could be included in history and theory courses by engaging academics on these matters. The idea of looking at these cases with a critical perspective is absolutely crucial for students to develop their own agenda of sustainability, moving away from the idea of simply applying principles and strategies without careful reflection.

The important role that iconographies derived from internal and external precedents play in the generation of the first idea stresses the role of case studies as a way of generating knowledge and a repertoire of images to recall. Although the idea of using iconic models can be contested as sustainable design is usually against the predominance of visual seduction in contemporary architecture, it is a fact that even architects who are deeply committed to sustainability recall iconographies when designing. The point here is to look at examples

that successfully combine sustainability and aesthetics. However, it is important to be cautious when using iconographies in education, as some elements of sustainability could be deliberately iconic, while having a limited impact on performance. It is also important to guide students in placing iconographies within a wider knowledge of the case study, understanding principles, strategies, context sensitiveness, climate, etc.

Quantitative analysis of case studies can act as a complement to the critical appraisal and can include the same wide diversity of buildings. It might allow students to identify those strategies that have a positive effect from those that are not contributing to achieve the desired outcome. Quantitative analysis of their own projects might help students to understand the implications of certain design decisions and to explore different alternatives in an iterative process of intuition and analysis.

3.4 Skills

Quantitative analysis is based on the development of skills in the use of analytical tools, which is extremely useful for understanding the principles of environmental sustainability. User-friendly tools, such as Ecotect, are proving to be excellent educational tools in architecture. Although the architects of the case studies do not generally use analytical tools, the scenario seems to be changing towards the increasing inclusion of user-friendly tools in architectural practice, while sophisticated tools will remain in the domain of expert consultants. Therefore, architectural education should consider the development of simple analytical skills, while engineering education or specialised training can cover skills for sophisticated analysis.

The case studies also suggest that the visual interfaces of simple analytical tools have proved to play an important role as instruments for client persuasion. Therefore, the development of skills in the use of simple analytical tools is not only useful for quantitative analysis, but also for the development of skills of social engagement.

It is important that architectural education provides a solid base of knowledge for the use of analytical tools because there is a risk of getting excited by the visual capabilities of the tools without understanding the implications of the results. In that respect, it is important for the students to know the basics of architectural sciences in order to be able to interpret the results and to compare them against benchmarks. In addition, knowledge of architectural sciences provides the skills of being able “to speak the language of the engineers”, which is useful for enhancing communication within interdisciplinary teams.

The development of skills in interdisciplinary teamwork should also be an important task for architectural education. Project-based activities involving students from different disciplines grouped together might allow them to play the roles that they would play at practice. The design studio is probably the best platform for this type of activities, where students can apply their different expertises in a particular project.

4. Conclusion

The model for integrating sustainable design in architectural education is holistic as a result of the complexity of the matter in practice. The case studies suggest that architectural education requires the development of attitudes, knowledge and skills crossing over intuitive, analytical and social dimensions in order to face the uniqueness and complexity of sustainable design.

The holistic nature of the matter suggests that it is necessary to fully integrate sustainability in the architecture curriculum, not as an add-on to every single part. This integrated curriculum requires the commitment to sustainability of the entire staff. Sustainability should be at the core of the theoretical, technological and studio based modules.

5. Acknowledgements

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