THE ARCHITECTS APPROACH TO THE PROJECT OF ENERGY EFFICIENT OFFICE BUILDINGS IN WARM CLIMATE AND THE IMPORTANCE OF DESIGN METHODS

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ABSTRACT

This article aims at a better understanding of how decisions are taken to improve energy performance of office buildings in warm climates and why energy tools are not popular among the architects. A survey was developed based on theory of designer's thinking and activities. Most of the survey consists of statements that can be weighted on a scale of 1 to 5, during specific stages of design: pre-design, sketch and detail phases. The survey is split in four groups of architects: post graduate students, lecturers, architects with expertise in sustainable environment design (ESD) and recognized architects.

INTRODUCTION

The conception of a survey to explore the design process began during the thesis development "integration of low energy strategies to the early stages of design process of office buildings in warm climate" (Pedrini 2003). The initial sketches wonder if it could be possible to represent the design decisions, the mechanisms, the inputs and outputs in a very transparent way, such as the codes proposed in the IDEF0 method (Austin, Baldwin et al. 1999). However the involvement with case studies lead to another level of understanding. The flow of information becomes more complex to be organized while the level of details increases. Not everybody is able to accept such rational method to represent their actions, exposing the risks and mistakes of design decisions.

METHODOLOGY

The survey

To avoid the misuse of theories and techniques as well as the misreading of expressions of designers, traces of design behaviour that may lead to the integration of energy prediction are converted to straight questions in a survey format. It consists of statements that can be weighted on a scale of 1 to 5. The questionnaire is based in Temple-Heal et al. (2000), Lam et al. (1999), Lima (1997) and Radovic (2000), and it went through many alterations, thanks to the support of collaborators.

The 18 topics aims to quantify the importance that architects attribute to the following methods during the three main stages of the design process:

1. Use of intuition, experience or/and human feel. Recognition[1], guessing and intuition which emphasizes experience and background are very common behaviour in design practice (Broadbent 1968; Lawson 1997). This behaviour seems common in 'green design' and Bay (2001) exposes it in 'A case study of a specific building project' (page 99). In seminar promoted by AGO, 'Moving to Mainstream' (Vale, Vale et al. 2002), the speakers emphasized the use of common sense instead of calculations. At the end, Robert Vale suggested that there is no need of computer simulation or more calculation than what could be done 'in a back of envelope' to reach a sustainable design[2].
2. Established techniques and proven solutions. Is the designer using the conservative 'professional know-how' method, based on precedents? This would indicate how much he/she is receptive to incorporate new methods and, more important, how important is to have a good understanding of previous experience and proven 'solutions'. Although the examination of an architect concerns the 'understanding of thermal proprieties of building, heat transfer and the factor involved in the analysis of the thermal and ventilation loads of spaces' (RIBA 1972), the current scenario leads to doubts: architecture science is in crisis (Szokolay 2002) . Consequently, the methods of energy diagnostics and the appropriate assessment may have considerable influence.
3. Rules, routines and methods previously tested. How important are the methods based on straight information that rule the design decision process? If they are important, a parametric

[1] Recognition ('knowing the answer'): basic procedure of unselfconscious design and the most common penultimate stage of more complex design procedures (Broadbent 1966).
[2] The seminar concerned house design and not office.

analysis is appropriate as well as the development of a method to deal with them in further developments during the design process. A parallel in energy tools equals to the availability of a construction library, Availability of codes and guidelines.

4. Pictorial precedents (what the building is going to look like), such as in periodicals and books. Involves searching innovations and finding solutions already applied in previous designs, however emphasizing images instead of deep analysis (and long texts). This behaviour evokes the influence of such common media among architects, which is totally neglected by energy tools.

5. Following earlier designs (tested), learning from case studies. Frequently, case studies discuss the questionable support that case studies may provide, there is no doubt that they may support design decision. Energy tools could be more useful if representative buildings were modelled and shared among users, instead of fictitious base cases, similar to 'shoe box'.

6. Use of guidelines and rules-of-thumb. The use of guidelines and rules of thumb are simple and accessible for designers with low experience. Pragmatic for a brief, these methods may be simplistic for later stages. Considering that they are usually products of parametric analysis, energy tools also could provide similar approach using simplified outputs.

7. Rational or scientific thinking, based on prior analyses. Scientific analysis followed by synthesis is a theory largely accepted by engineers and scientists. The issue is polemic when extended to architects and apparently there are not many supporters[3]. However, it may happen in many situations of 'low energy' design, mainly during parametric analysis, which may be provided by a consultant.

8. 'Lateral' thinking (searching for different ways to solve problems, avoiding dominant and established ideas). Lateral thinking: is an alternative to the linear scientific thinking (also referred to as vertical thinking) and possible closest to the way of some architects think. For example, Leo (2001) makes large use of such concept and many times demonstrated total objection to any other design method. An example of explicit reference to the method is found in the introduction of 12 Cribb St Office Building Alter & Ext: '… Ceccato Hall+Associates in association with Tony John, Architect, put on their lateral thinking caps and reconfigured the building in a way that addressed all the buildings functional and technical shortcomings…' (RAIA 2002). The implication of this method is the test of hypothesis it happens in the previous method.

9. Hypotheses followed by test. The test of hypothesis concerns many situations. It may be a natural consequence of the previous topic (guessing) as well as a structured or predictable sequence of actions[4] [5]. Most of the energy tools have a potential to fit to this approach because hypotheses may be converted in models and then assessed through simulations.

10. Breaking down problems into smaller parts. Alexander's theory attempted to break problems into its tiniest parts.

11. Development of alternative solutions for elimination/ combination. The creation of alternatives is often proposed in the literature, even if designers do not largely adopt it. Energy tools such as VisualDOE and similar provide specific features to facilitate it, as a basic procedure of investigation.

12. Diagrams, charts and mathematical models. The use of tangible methods to support decisions, which might be associated with A/S (analysis and synthesis) and C/T (conjecture and test), may not be popular among architects. However they must be taught and they are presented in energy codes.

13. Volumetric (3-D) thinking. Few energy tools have 3-D capabilities of modelling/visualization, which usually happen with some level of restriction. Nonetheless, '6B[6]' sketching shows how necessary 3-D visualization is to develop ideas and even to precede 2-D refinement.

14. Plan (2-D) thinking. Many energy tools have a simplified representation of buildings, usually in 2D, however there is a belief that the integration of commercial CADs to energy tools could facilitate the use for designers. The intention is to check how much useful is it useful for a designer.

15. Integration with other consultant professionals. Considering that the creativity is very much personal, the integration with other professionals may indicate how the design is able to share decisions and the efficacy of such proposition.

[3] The affirmative is based on contacts in the department of architecture and some professionals contacted before the survey.

[4] Popper's theory, detailed in Bamford (2002).
[5] Test of hypothesis is recommended in different theories, as advised by deBono (1971) in the use of lateral thinking.
[6] 6B relates to a pencil with soft graphite.

There is no doubt about the importance in to work with consultants for specialized tasks, however personal experiences have been showing how frustrating it can be in terms of results.

16. Considering the ‘meaning’ of the building itself for the client, architect, occupants and the surrounding environment. This relates to the ‘symbolic linguistic’ idea and looks for the importance of building ‘meaning’. For example, Cox Rayner Architects assumes “… the building's expression is an evocation of the client's focus in environmental, mining and construction sectors through combination of passive energy systems, 'raw' materials and finessed detailing”, regarding The Thiess Centre (RAIA 2002).
17. Consideration of the impact of the design on interior conditions (e.g. light and thermal) and its interaction with the occupants. It indicates how designers deal with internal environmental control and occupants’ behaviour.
18. Dominance of a central idea (an ‘organizing principle) that influences the whole design conception. The last one reflects when the designer chooses (if chooses) a dominant theme that drives the others decisions.

Selection of candidates to survey

Architects with practice in sustainable design[7] concerning office building in warm climates are the most suitable to support the survey. However there are architects without such practice, but able to contribute in some way. The survey is split in four groups, with different purposes.

1. Architects with knowledge in low energy design. The postgraduate students involved with sustainable design have experienced the most up-to-date methods to improve energy efficiency in buildings (most of them, for residential). Their survey aims to collect impressions of the suitability of the low energy interventions.
2. Architects with understanding of sustainable design in the Department of Architecture/ University of Queensland and Queensland University of Technology. The course of architecture at UQ is well known for the emphasis on design. The majority of the staff has practice in some area and their consciousness of the importance of sustainable design is unquestionable. Their profile as well the academics of QUT suits the analysis of the design process and low energy strategies rather than the application of energy tools.
3. Architects with expertise in sustainable environment design (ESD). This is the most representative group of surveyed because it includes professionals with different levels of knowledge, as discussed by Wittmann (1998). Apparently there are professionals with low expertise who are using or will use low energy strategies and there are others with some level of expertise who are already practising in this manner. Both types of designers are or will be interested to make use of energy tools. Consequently, it is expected to diagnose the most common actions during the design process, when the architectural decisions are taken, what support the adoption of low energy strategies and when they are decided. Considering the broad type of professionals’ knowledge, the intention is to find the most relevant obstacles to the integration of energy tools into the design process. The group is defined through searching the RAIA website. What is required is architects with expertise in office building and ESD, for Brisbane area. The result is 65 contacts[8], most of them known by staff members of the department of Architecture.
4. Architects with recognized knowledge in low energy strategies. It concerns architects recognized by achievements in low energy design. Due the low number of architects that fit such condition, the intention is to find out how each one interacts with energy tools rather than to look for a cause of mismatch. The selection of the group is simple because buildings with low energy strategies are well known. Furthermore, the RAIA website endorsed most of the following choices.

RESULTS

Acceptance of the questionnaire

The questionnaire had a reasonable acceptance from the four surveyed groups. As expected, some architects are more receptive to the issue than others. Another factor that contributed to the response was the relationship of the researcher and the surveyed. The closest ones provided more feedback. For example, 90% of the ‘post graduate students group’ and 71% of the ‘recognized architects’ to whom Dr. Szokolay introduced the survey returned the answers, sometimes with comments. In comparison, 33% of the ‘recognized architects’ who were invited to

[7] Although ‘sustainable design’ is not necessarily ‘low energy design’, ‘sustainable design’ was chosen as criterion of selection of architects’ expertise because it was the closest term (related to the subject of analysis) in the RAIA’s website.

[8] The search occurred in June 12, 2002.

collaborate with the research by other means returned the questionnaire.

The average response of 'recognized architects' was 54%. The 'ESD architects' had a 56% of response which is very satisfactory considering that this group is the most diversified in terms of expertise related to low energy strategies.

The staff members of the Department of Architecture produced a very low response with 36%, while 43% of the staff members of QUT responded.

Importance of methods and routines

As displayed in the Table I, the importance of methods and routines that influence design decisions are roughly similar for the four groups: intuition is highly rated while charts and diagrams are not. The differences are more noticeable in relation to the importance during the design phases, however 13% of the surveyed express similar or identical importance to issues.

The methods and routines for the pre-design phase are ordered in Table I and the notes are followed:

- the meaning of the building is the most important driver for design decisions for 'PG students' and for 'Staff members' while it is the third most important for the other groups;
- 'ESD' architects prefer intuition to any other method;
- 'recognized' architects ranked development of alternatives as the most important method, which is of an average concern for 'PG students' and 'staff members' and a low concern for 'ESD' architects;
- lateral thinking is a common method for the groups, mainly for the 'ESD' and 'recognized' architects;
- the use of test of hypothesis is important for the 'staff members', however is one of the lowest routine for 'PG', 'ESD' and 'recognized' architects;
- among the groups, scientific method is more popular for 'PG' students (11th), while other groups classify it as one of the lowest importance;
- diagrams and charts are the lowest preference, by all groups;
- on average, integration with other professionals is of a medium preference, although the 'staff members' classify it as the least important.

Ordering the methods and routines for the schematic phase, Table II, the most relevant notes are:

- 3-D thinking and intuition are the most important bases for design decisions for 'ESD' and 'recognized' architects, followed by the meaning of the building and its impact;

Table I
Importance of methods and routines for pre-design stage

	PG	STAFF MEMBERS	ESD ARCHITECTS	RECOGNIZED ARCHITECTS
1	'Meaning' of the building	'Meaning' of the building	Intuition	Development of alternative
2	Impact of the design	Impact of the design on	(3-D) thinking	(3-D) thinking
3	(3-D) thinking	(3-D) thinking	'Meaning' of the building	'Meaning' of the building
4	Intuition	Intuition	Impact of the design on	Intuition
5	Dominance of an idea	Breaking down problems	**'Lateral' thinking'**	**'Lateral' thinking'**
6	**'Lateral' thinking'**	**Hypotheses and test**	Guidelines and rules	Dominance of an idea
7	Development of alternative	**'Lateral' thinking'**	Dominance of an idea	Impact of the design on
8	Pictorial precedents	Development of alternative	Established techniques	Guidelines and rules-of-thumb
9	Plan (2-D) thinking	Established techniques…	Plan (2-D) thinking	Earlier designs
10	*Integration with others*	Earlier designs	Earlier designs	Rules, routines
11	**scientific thinking**	Guidelines and rules	Rules, routines	Plan (2-D) thinking
12	Earlier designs	Dominance of an idea	*Integration with others*	*Integration with others*
13	Established techniques…	Rules, routines	Development of alternative	Established techniques
14	**Hypotheses and test**	**scientific thinking**	**scientific thinking**	Breaking problems
15	Rules, routines	Plan (2-D) thinking	Breaking problems	**scientific thinking**
16	Guidelines and rules	**Diagrams, charts**	**Hypotheses and test**	Pictorial precedents
17	Breaking problems	*Integration with others*	Pictorial precedents	**Hypotheses and test**
18	**Diagrams, charts**	Pictorial precedents	**Diagrams, charts**	**Diagrams, charts**

- ‘staff members’ and ‘PG’ students have similar tendency, with difference in relation to the order but not much in terms of ratio;
- the use of hypothesis and test, diagrams and charts and rational or scientific thinking are the lowest preference of ‘ESD’ and ‘recognized’ architects;
- ‘PG’ students have similar preference, however they emphasize a little more the use of scientific thinking;
- ‘staff members’ agrees with the lowest score for the use of diagrams and charts, however classify the use of rational or scientific thinking in 10th and the use of hypothesis and test as 7th, i.e. these two last methods are not related with the use of charts.

Table II
Importance of methods and routines for schematic stage

	PG	STAFF MEMBERS	ESD ARCHITECTS	RECOGNIZED ARCHITECTS
1	Impact of the design	‘Meaning’ of the	(3-D) thinking	(3-D) thinking
2	‘Meaning’ of the	Impact of the design on	Intuition	‘Meaning’ of the building
3	(3-D) thinking	Intuition	Impact of the design on	Intuition
4	*Integration with others*	(3-D) thinking	Established techniques…	**‘Lateral’ thinking'**
5	Intuition	**‘Lateral’ thinking'**	‘Meaning’ of the building	Impact of the design on
6	Dominance of an idea	Dominance of an idea	**‘Lateral’ thinking'**	Development of alternative
7	**‘Lateral’ thinking'**	**Hypotheses and test**	Guidelines and rules-of-thumb	Dominance of an idea
8	Plan (2-D) thinking	Development of alternative	Dominance of a central idea	*Integration with others*
9	Development of alternative	Established techniques	Plan (2-D) thinking	Established techniques…
10	**scientific thinking**	**scientific thinking**	Rules, routines	Guidelines and rules
11	Established techniques…	Breaking down problems	*Integration with others*	Rules, routines
12	Pictorial precedents	Earlier designs	Development of alternative	Breaking down problems
13	Earlier designs	Plan (2-D) thinking	Earlier designs	Earlier designs
14	Rules, routines	Rules, routines	**scientific thinking**	Plan (2-D) thinking
15	Guidelines and rules-of-thumb	*Integration with others*	Breaking down problems	**scientific thinking**
16	Breaking down problems	Guidelines and rules-of-thumb	**Hypotheses and test**	**Hypotheses and test**
17	**Hypotheses and test**	Pictorial precedents	**Diagrams, charts**	Pictorial precedents
18	**Diagrams, charts**	**Diagrams, charts**	Pictorial precedents	**Diagrams, charts**

Ordering the methods and routines for the detailing phase, Table III, the most relevant notes are:

- the most important influences in this phase are similar to the previous one, however the ‘recognized’ architects bring the importance of integration with others professionals to a second place;
- for ‘PG’ and ‘ESD’ architects, rational or scientific thinking becomes the 9th in importance, the highest score so far, while ‘recognized’ architects classify it as one the lowest importance;
- ‘PG’, ‘ESD’ and ‘recognized’ architects classify the use of hypothesis and test and use of charts as the least important.

Table III
Importance of methods and routines for detailing stage.

	PG	STAFF MEMBERS	ESD ARCHITECTS	RECOGNIZED ARCHITECTS
1	Impact of the design	Impact of the design	(3-D) thinking	(3-D) thinking
2	'Meaning' of the building	(3-D) thinking	Impact of the design	*Integration with others*
3	Established techniques	Intuition	Established techniques	Rules, routines
4	(3-D) thinking	'Meaning' of the building	Rules, routines	Established techniques…
5	*Integration with others*	techniques…	*Integration with others*	'Meaning' of the building
6	Rules, routines	Rules, routines	'Meaning' of the building	Intuition
7	Plan (2-D) thinking	**'Lateral' thinking'**	Intuition	Impact of the design on
8	**'Lateral' thinking'**	Breaking problems	Plan (2-D) thinking	Breaking down problems
9	**scientific thinking**	**Hypotheses and test**	**scientific thinking**	Dominance of an idea
10	Guidelines and rules-of-thumb	Dominance of an idea	Breaking problems	**'Lateral' thinking'**
11	Dominance of an idea	**scientific thinking**	**'Lateral' thinking'**	Development of alternative
12	Development of alternative	Plan (2-D) thinking	Guidelines and rules-of-thumb	Earlier designs
13	Earlier designs	*Integration with others*	Development of alternative	Plan (2-D) thinking
14	Intuition	Development of alternative	Dominance of an idea	Guidelines and rules-of-thumb
15	Breaking problems	Earlier designs	Earlier designs	**scientific thinking**
16	**Hypotheses and test**	Guidelines and rules-of-thumb	**Hypotheses and test**	**Hypotheses and test**
17	Pictorial precedents	Pictorial precedents	Pictorial precedents	Pictorial precedents
18	**Diagrams, charts**	**Diagrams, charts**	**Diagrams, charts**	**Diagrams, charts**

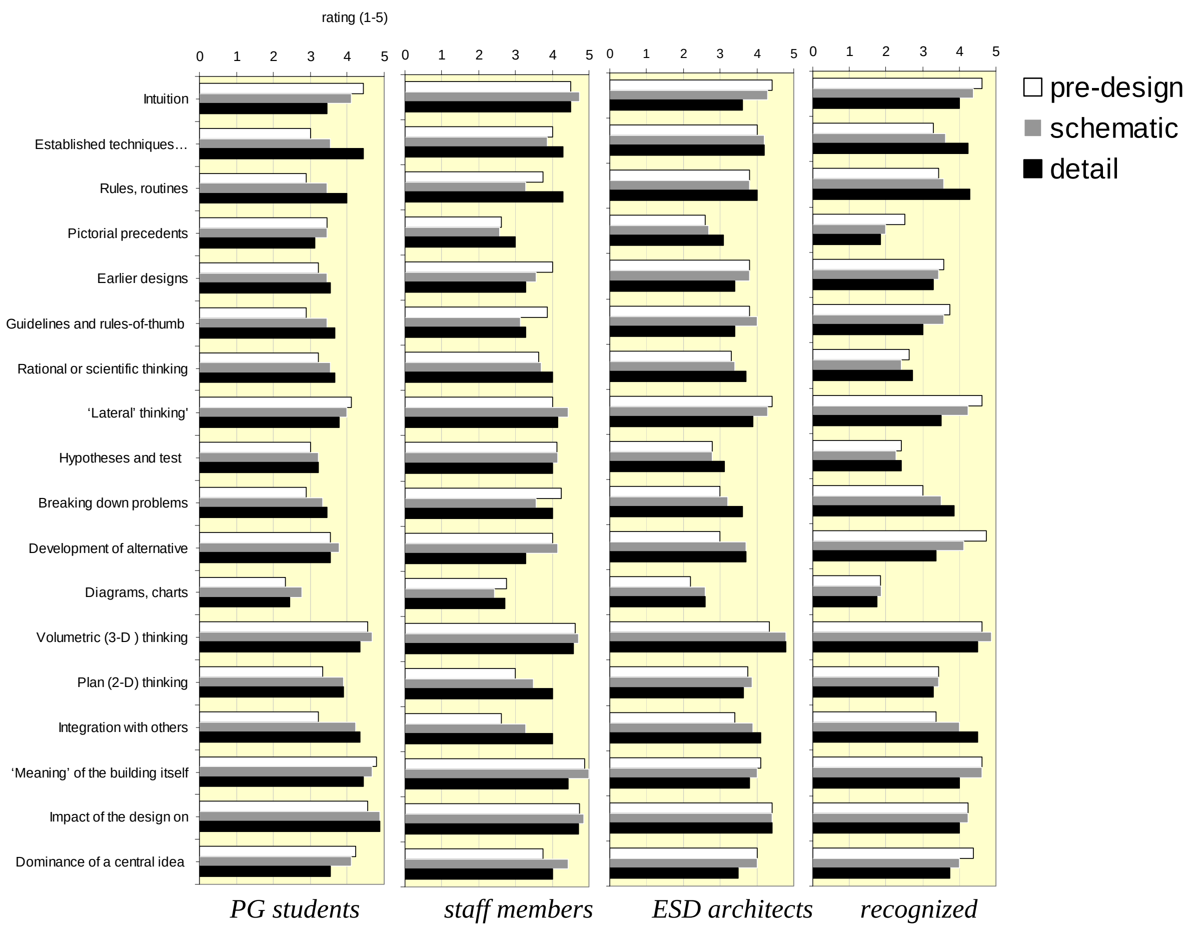

Figure 1 Importance of methods and routines.

The analysis of the Figure 1 allows comparing how the same method or routine varies in relation to the design phase:

- every group agrees that the integration with other professionals becomes more important as the design progresses;
- the use of rational or scientific thinking also increases in importance with the progress of the design, with the exception of the 'recognized' architects;
- intuition becomes less important with the design progressing, with the exception of 'staff members';

In general, the methods and routines have a similar importance in relation to the design stages; most of them vary less than 1 (scale 1-5). For example, intuition has a minimum of importance of 4.5 during pre-design and a maximum of 4.8 during detailing for the 'staff members'. For 'PG students' group, the exception is the use of *established techniques*, which varies from 3.0 during briefing to 4.4 during detailing. For 'staff members' group, the exceptions is use of 2-D thinking, which varies from 3.0 during pre-design to 4.0 during detailing. Exceptions for the 'recognized' architects group are:

- use of lateral thinking, which varies from 4.6 during the briefing to 3.5 during detailing;
- development of alternatives, which varies from 4.8 during the briefing to 3.4 during detailing.

CONCLUSIONS

The survey of the group and the cases studies confirm that architects generally use types of knowledge different from those required to operate energy tools. The major preference is for intuition, simple and straight forward methods that can be easily assimilated.

Practitioners have a clear tendency to emphasize the use of intuition and guidelines during the early stages of design, which decrease as the design progress[9] (Figure 2). The rational thinking and rules have the opposite tendency: they increase as the design progresses. This tendency is more evident for the 'recognized' architects, which may indicate the importance of their experiences. Although such behaviour implies a massive use of assumptions, they not necessarily make use of tests (*hypothesis and test*). Therefore, the item *impact of the design on the occupants* can be considered as a routine strongly based on *intuition* and *assumptions*.

Diagrams and charts are the least preferred methods to support design decisions. This tendency occurs among the four groups and during all three design phases. This result is a strong argument to reject the use of energy tools, considering that the graphics and charts are the most useful resource available in software packages to understand the behaviour of the designs or to explore the potential of climate, such as the CPZ method (Szokolay and Docherty 1999). The uses of *guidelines/rules-of-thumb*, which could be directly or indirectly produced by energy tools, are not very important for the architects. With few exceptions, neither the use of *rational thinking* or *tests of hypothesis* are classified as priority methods, although they become slightly more important during the design development.

Based on the results and other issues discussed in Pedrini (2003) (available for download at http://www.labeee.ufsc.br/arquivos/publicacoes/PhD-AldomarPedrini.pdf), the recommendations to make energy tools more suitable for early stages are:

- The geometric modelling should be compatible with the schematic phase. It could emphasize the use of 3D model from the beginning of the process, adopt representative defaults, make use of intuitive interface, especially for drawings, and the level of geometric details could gradually increase.
- Parametric analysis could be optimized if the user defined the range and the interval of values that a specific variable can assume. Then, the alternatives would be automatically created and simulated.
- The architects look for simple answers and the outputs should make the comparison of different solutions easy and fast. Frequently, the most important output is the performance based on the local energy code requirements.

Although tools may be improved, they will be wasted if professionals ignore basic elements of building energy behaviour and scientific methods. Architects should be introduced to the use of these tools during their education to learn how to integrate them in their own practice. Hopefully, a design shift to include scientific approach may be finally triggered by the mandatory codes.

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[9] Nsofor (1993) found similar tendency in his survey of methods to predict use of daylight.

Peters, Noel Robinson, Richard Sale, Harry Seidler , Caroline Stalker, Mark Thompson, Wilson Architects and so many others who preferred anonymity.

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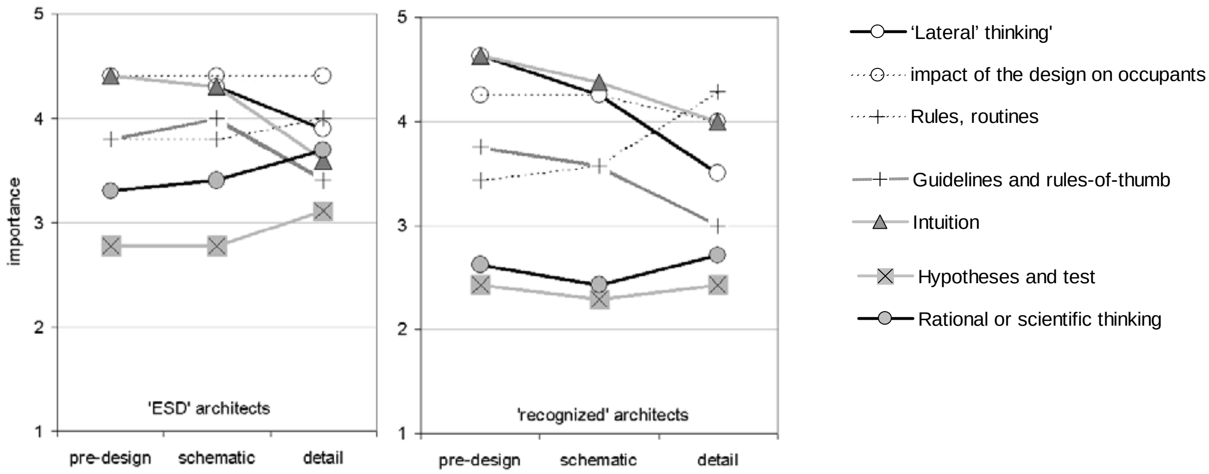

Figure 2 Comparison among issues related with intuition and rational thinking.

REFERENCES

Austin, S., A. Baldwin, et al. (1999). "Analytical Design Planning Technique: a model of the detailed building design process." Design studies **20**(3): 279-296.

Bay, J.-H. (2001). Cognitive biases in design: the case of tropical architecture. Technische Universiteit Delft. Delft, The Design Knowledge System**:** 248.

Broadbent, G. (1968). "A plain man's guide to systematic design methods." RIBA Journal(May): 223-227.

Lam, K. P., N. H. Wong, et al. (1999). A study of the use of performance-based simulation toos for building design and evaluation in Singapure. Building Simulation '99 - Sixth International IBPSA Conference - International Building Performance Simulation Association, Kyoto, Japan.

Lawson, B. (1997). How designers think: the design process demystified. Oxford; Boston, Architectural Press.

Leo, M. (2001). Guitar Buildings. Melbourne, Master Builder Association.

Lima, F. M. A. (1997). The intelligent building and its influence on the design process. St. Lucia, Qld.**:** 1 v.

Nsofor, C. N. (1993). Daylight availability and design in Nigeria. St. Lucia, Qld.**:** 300.

Pedrini, A. (2003). Integration of low energy strategies to the early stages of design process of office buildings in warm climate. St. Lucia, Qld., University of Queensland**:** 300.

Radovic, D. (2000). Green office building. PLEA 2000, Cambridge, United Kingdom, James and James (Science Publishers) Ltda.

RAIA (2002). architecture.com.au Projects, The Royal Australian Institute of Architects. **2002**.

RIBA, Ed. (1972). Guidance notes and regulations. London, Royal Institute of British Architects.

Szokolay, S. V. (2002). Teaching or Preaching: Architectural Science, the profession and teaching. ANZAScA 2002 - Architectural education: from pedagogy to andragogy, Deakin University Geelong, Victoria, Australia.

Szokolay, S. V. and M. Docherty, Eds. (1999). Climate Analysis. Passive and Low Energy Architecture International Design Tools and Techniques. Brisbane, PLEA in association with Department of Architecture, The University of Queensland.

Temple-Heal, P. J., S. Curwell, et al. (2000). A preliminary survey of te implementation of environmental performance Assessment system for buildings**:** 30.

Vale, B., R. Vale, et al. (2002). Sustainable Housing - moving to mainstream. Abel Smith Lecture Theatre, University of Qld - St Lucia Campus, Brisbane AU, The Australian Greenhouse Office.

Wittmann, S. (1998). "Architects' Commitment Regarding Energy Efficient/Ecological Architecture." Architectural Science Review **41**(2): 89-92.