Building's environmental design:

Proposal for an assessment help method.

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Abstract. This research concerns the development of an environmental quality assessment in the early design. We suggest a global, progressive and contextualized approach. The method consists of various assessment criteria, considers the context and the project progress that guide and adapt the environmental assessment. This paper deals firstly with taking into account various aspects such as the progressivity and the contextualization in the method. Secondly, we present the application of the method in a tool.

Keywords. Environment; architecture design; assessment method; qualitative criterion.

Introduction

The environmental issue is challenging the future of our planet. The world of construction is all part of this concern. Sustainable development issues become central to the domain of building and more particularly to architecture.

A number of treatments have been set up little by little, both at national and international level (from Kyoto-1997 to Copenhague-2009) to incite countries to reach defined objectives.

To answer this request, assistant methods for " good environmental practices " in the building have appeared, ranging from inciting by certification, to anticipation by simulation of construction behaviour as well as offering suggestions by guides and typical solutions.

Assessment methods of certification and labelling (BREEAM, LEED, GNGB, HQE) are based on references serving as a base for evaluation. They are generally used after the design, even after the construction, to validate a performance and deliver a label.

Methods of anticipation mostly exemplified by simulation software (Ecotecte, pleiads-Comfie, daylight 1.2.3) are used to estimate, during design process, the future behaviour of buildings. They focus generally on one or two aspects of the environmental problem (thermal, light, etc.).

The approaches by guides and typical solutions have the particularity of proposing architectural solutions and axes of construction or techniques. These approaches are either general such as the Ademe guide charts [1] (France) or the IDEA energy practice guide [2] (Spain), or very specialized in an environmental domain such as Mahoney's tables (Mahoney and al., 1971) that indicate the axes of bioclimatic building in relation to climate.

Although these methods are a means of structuring objectives, enabling an interesting debate and thus encouraging better practice (Cole and al., 2005), we note several limitations.

These different methods remain little adapted to early phases of architectural design and are often used in end design (Ding 2008). It is now indisputable that to have relevant answers, it is important to consider the environmental problems as soon as possible in the design process.

The criteria of evaluation are essentially quantitative and technical solutions that are more easily measurable are privileged. They deal with precise values, unavailable in early phases of design.

The context is too briefly presented or not considered. It does not allow the recognition of the particular quality of each project. The weighting that could guide the criteria and evaluation are often absent or fixed (Soebarto and Williamson, 2001), and rarely depend on the context of the project**.**

All these limitations hinder the emergence of efficient architectural solutions.

Researchers are attempting to answer these questions. Chatagnon and Gérard (2000) distinguish two different levels of assessment of environmental criteria, but the model called "simplified" remains largely oriented towards engineering and it is inappropriate to architectural design. Further work is oriented more towards the integration of a valuation method within a BIM (Biswas and al., 2008). However, the difficulty of assessing qualitatively persists and methods are quantitative oriented.

In view of these limits, we propose an assessment method adapted to the first phases of architectural design, which is based on a global and qualitative model of environmental criteria that takes into account the specificities of every project.

This method is developed in the next section.

Method

Manon Kern (2004) proposed a first approach of this evaluation method by taking into account on twenty-four environmental targets integrating various phases of the life of a building (from the preparation, to the end of the life of the building). From a project evaluation made by independent experts, the values assigned to each of the targets (from 0 to 4) can be visualized by a radar diagram, which allows us easily to compare the environmental footprint of the various buildings.

This proposition served in particular to estimate participant projects at the " best environmental project prize" organized by LQE (Lorraine Qualité Environnement, France).

Although this first method is based on a global approach, critics and returns based on its use led us to improve this method in several directions.

First, the lack of hierarchy and the ambiguity of the environmental targets led us to define two levels of criteria instead of one.

Secondly the method does not allow us to take into account sufficiently the specific situation of each project, which is why we set up a system of weighting to contextualize the assessment.

Thirdly, the method is not adequately adapted to the progress of design process, so we have conditioned the evaluation criteria depending on project progress.

To summarize, we want to develop a method for assessing the environmental quality of buildings that includes the following features:

- Global and multi-criteria

- Qualitative
- Contextualized
- Progressive

Targets and assessment criteria

Environmental targets, previously established in the first method, have been redefined using a second hierarchical level we have named "assessment criteria ".
The definition of these criteria is based on research covering the analysis of the various existing methods. Therefore our method consists of fourteen targets redefined in sixty assessment criteria (table 1), thus forming a basic reference table. Our approach is multi-criteria (Peuportier 2003) or multi-dimensional (Ding 2008), allowing a global comprehension of the assessment.

IMPACT ON THE SITE	**DISTRIBUTION, ACCESSIBILITY AND FUNCTIONALITY**
Shadow on the neighborhood	Accessibility of the building
Right to sight in the neighborhood	Optimal flow or shared
To limit and manage cut-and-fill.	External extensions
Limit the effect of urban heat island	Respect for privacy.
Compactness and economy of land	Convenience and functionality
	Particular installation of the ground floor

Table 1
Example of two targets and assessment criteria.

The targets represent the major environmental issues associated with construction such as thermal comfort, acoustic comfort, the impact on and integration in the site, water management, etc. The reference table considers a range of environmental issues (targets and criteria) to gain a more global method possible. These criteria will be assessed qualitatively.

Contextualization

These targets and assessment criteria do not have the same importance depending on the situation of each project. For example, the concepts of noise pollution do not have the same effect in an isolated environment as in a dense urban environment. In order to adapt the more accurate method of assessment, we developed a weighting system called "coefficient of contexts".

These coefficients apply to each of the assessment criteria and allow the balancing of the global evaluation of every project according to its precise context. By context we mean all the circumstances surrounding a project. In our proposition we privileged the three following dimensions:

- The localisation of the building (site, climate, etc.)
- The type of program (use, construction, etc.)
- The specific local (punctual nuisance, natural risk, etc.)

The new approach thus consists of a system of assessment criteria organized into targets defining a « basic reference table ». The system of contextual weighting then

directs this basic reference table according to the context of the project defining a « reference table project ».

This reference table project is adapted to the specific situation of each project (table 2), while having a common base with the other projects (basic reference table).

IMPACT ON THE SITE	Weighting case 1	Weighting case 2
Shadow on the neighborhood	1	0
Right to sight in the neighborhood	1	0
To limit and manage cut-and-fill.	1	1
Limit the effect of urban heat island	1	0
Compactness and economy of land	1	1

Table 2

Importance of criteria depending on the context. (Case 1: residential buildings, dense urban, new construction type, Nancy climate in Nancy, France; case 2: residential buildings, isolated environment, new construction type, Nancy climate in Nancy)

Progressivity

This approach aims to adapt the design process, that is to say that the assessment must fit the project's progress. All criteria can not be assessed comprehensively in the early stages of the project. Some criteria can only be assessed partially, some not all.

We have therefore established a limitation of the notation, called "maximum rating". Maximum rating limits the evaluation according to the available data during the assessment (from 0 for no data available to 4 for all data available). The evaluation will be progressive with the design process.

To determine the available data to evaluate the project, we characterized the project progress. This characterization involves identifying the various missions undertaken during architecture design. For each criterion we determin what tasks are necessary for its evaluation and then we define if we are in the presence of partial or complete data (figure 1).

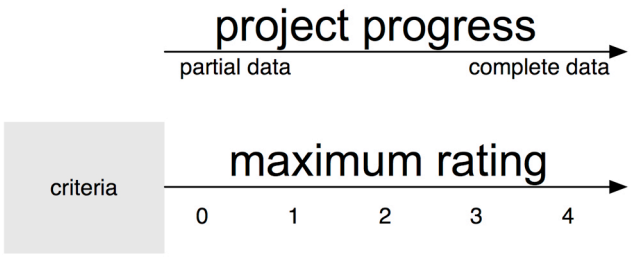

Figure 1

Project progress and maximum rating.

For example, for the evaluation criteria for "materials selection", in early design, all materials are not yet determined. At first the designer focuses on structural and envelope materials. Evaluation will not be complete at this time. As the design progresses, data are completed until we have knowledge of all materials.

Visualization

Visualization adopted since the first version is the radar. It provides a global view of all the environmental targets. However, the addition of new elements such as contexts and project progress led us to rethink the diagram.

Two elements have been implemented. First, the concept of the importance of environmental targets, determined by the notion of context, must be represented. A single radar is not adapted to provide this information because all the objectives are represented in the same way. This information will be illustrated by the possibility of varying sections of the radar and thus highlight the most important elements (figure 2).

Secondly, the model should provide information on the project's progress. We have therefore set up a second profile called "ideal profile of progress ". This profile is the maximum rating obtainable according to architecture missions carried out.

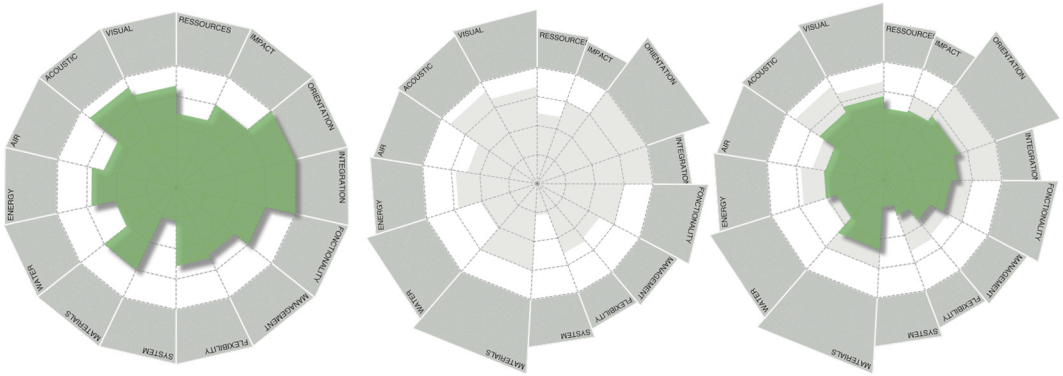

Figure 2
Example of environmental radar (left: old radar, middle: new radar with ideal profile of progress, right: new radar with ideal profile of progress and environmental profile)

Validation and experimentation

The assessment criteria, the coefficients of context and the maximum ratings that we proposed in our research have been validated several times. Surveys of architects have confirmed the need for and assumption of contextualization and progressivity.

Experiments were conducted to test and confront the proposed method. Successive evaluations were conducted as part of educational environmental projects. These assessments demonstrate the relevance of the assumptions proposed; and the results confirm the pertinence of the method when it comes to reporting the environmental quality of a project for a given context and project progress.

Tool

The proposed method has been implemented in a tool called « eco-profile ». This tool is a computer application developed in an object-oriented language.

The tool consists of two parts (figure 3); One for project information (left), context and project progress; a second part for the reference table (right).

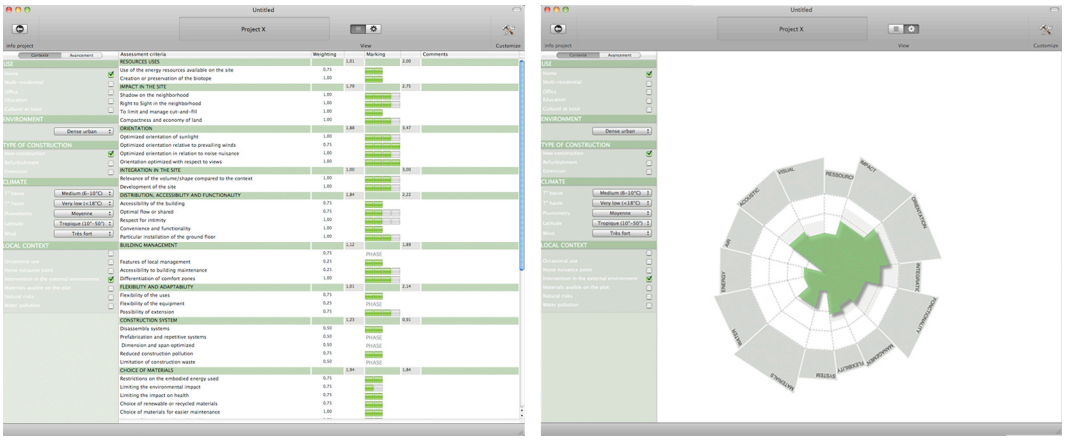

Figure 3
Screenshots of tool (left: view with reference table, right: view with radar).

Transcribing coefficients of context into logic gates allows the designer to obtain his own « reference table project » by simple selection of elements characterizing the context.

Visualization of the reference table using the radar facilitates the reading of targets and their importance; a table provides more detailed visual criteria and their weighting.

The combination of the two visualizations can serve as a pre-design guide, indicating the issues to highlight in a given situation.

This reference table can then serve as base for an evaluation, after completing project progress. First, usable by the designer, the tool can also be used by the customer possibility in consultation with an outside expert. The assessor indicates a score for each criterion (between 0 and the maximum rating), accompanied by commentary.

The evaluation presents the contextual environmental quality of a project by radar chart and a table. This chart gives a global reading of the notations obtained by environmental targets while showing the contextual importance of the latter.

The evaluation also presents the environmental quality of a project at any stage of design, allowing the designer to be informed about the progress of the environmental state of this project. The tool also indicates the remaining work required for each target and criterion (figure 4).

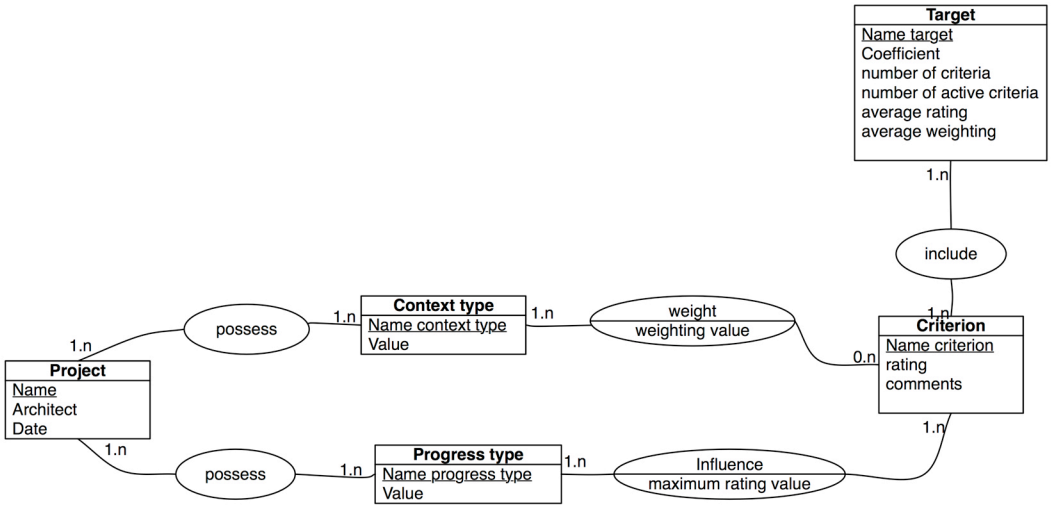

Figure 4
The current tool entity/association diagram.

The tool has several limitations that need to be overcome.

First, it does not currently permit the consideration of several evaluators / evaluations, which would reduce the subjectivity of quality evaluation.

Secondly, the application supports only one project progress. Current developments should allow the integration of several states of progress for one project, and thus follow the evolution of the latter within the same application (figure 5).

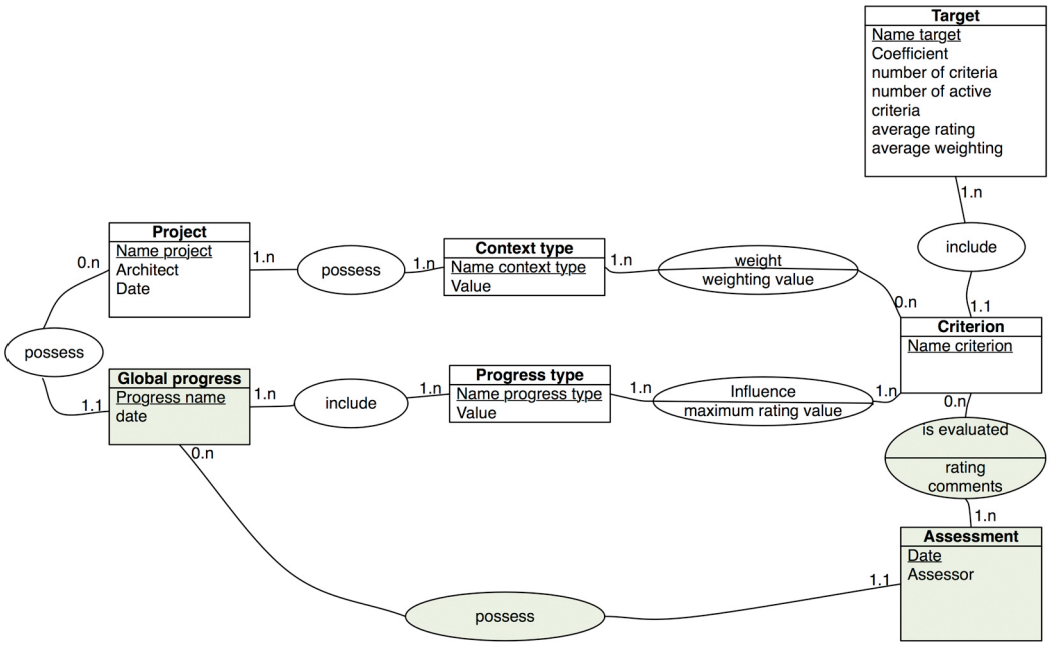

Figure 5
The tool development entity/association diagram.

However, the tool already permits us in its current form to make assessments based on project progress, and thus allows the designer to anticipate and , if necessary, to rectify any unsatisfactory points, and that, before the realization of the final documents. Furthermore, the contextualization of the evaluation brings an additional indication to the designer. When budgets are often limited, it points out the most relevant environmental issues in a given context.

References

Biswas, T and Tsung-Hsien,W and Ramesh, K 2008 'Integrating sustainable building rating systems with building information models', *Proceedings of CAADRIA 2008*. Chiang Mai Thailand, pp. 193-200.

Cole, RJ and howard, N and Ikaga, T and Nibel, S 2005 'Building Environmental Assessment Tools: current and future roles', *Issue paper of the Sessions*, vol. 4.

Ding, GKC 2008 'Sustainable construction-The role of environmental assessment tools', *Journal of Environmental Management*, vol.86, no.3, pp.451-464.

Gérard, C and Chatagnon, N and Archard, G and Nibel, S 2000 'ESCALE, a method for assessing the environmental quality of buildings at the design stage', *Proceedings of DMinUCE international conference,* Lyon*,* France.

Kern, M 2004 '*Analyse du cycle conception environnementale'*, *Proceedings of Classe 4*, Nancy, France.

Mahoney, C and Koenigsberger, OH and Evans, M (ed.) 1971, *Climate and house design*, United Nations.

Peuportier, B (ed.) 2003, *Eco-conception des bâtiments, bâtir en préservant l'environnement,* écoles des mines de paris les presses, Paris.

Soebarto, VI and Williamson, TJ 2001 'Multi-criteria assessment of building performance: theory and implementation', *Building and Environment*, vol. 36, no. 6, pp.681-690.

[1] http://ecocitoyens.ademe.fr.

[2] http://www.idae.es.