Frontiers of Architectural Research (2015) 4, 1–11

HOSTED BY

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/foar

Frontiers of Architectural Research

RESEARCH ARTICLE

Design support tools to sustain climate change adaptation at the local level: A review and reflection on their suitability

Catherine Dubois[a,*], Geneviève Cloutier[b], André Potvin[a], Luc Adolphe[c], Florent Joerin[b]

[a]*School of Architecture, Laval University, 1 côte de la Fabrique, Québec City, G1R 3V6, Canada*
[b]*CRAD, Laval University, 2325, rue des Bibliothèques, Québec City, G1V 0A6, Canada*
[c]*INSA of Toulouse, LMDC, 136, avenue de Rangueil, 31077, Toulouse Cedex 4, France*

Received 9 June 2014; received in revised form 9 December 2014; accepted 11 December 2014

KEYWORDS
Climate change adaptation;
Mid-latitude cities;
Architects;
Urban designers;
Design support tool;
Architecture design studio

Abstract
For mid-latitude cities, higher summer temperatures due to climate change are a cause for concern because they aggravate the urban heat island phenomenon and reduce thermal comfort inside buildings. By acquiring the appropriate knowledge and skills, architects and urban designers can become key actors in adaptation to climate change. Two workshops bringing together architects and urban designers provided evidence of deficiencies in this area. We hypothesize that a design support tool (DST) focused on the issue of adaptation of mid-latitude cities to rising summer temperatures could help improve knowledge and skills of professionals in the field. The first section presents the results taken from a review and classification of DSTs, which highlight the tools' features that are likely to reach this goal. Tools of the "hybrid" category seem most appropriate. To verify this, seven DSTs were selected and tested by fourteen students enrolled in a graduate-level architecture design studio. The second section presents the results from this test, including an analysis of the final projects, a web-based questionnaire and two focus groups. The relevance of hybrid approaches is established, but the results bring into question the capacity of a single DST to meet the individual and multiple needs of professionals in the field.

*Corresponding author. Tel.: +1 418 656 2131x6477; fax: +1 418 656 2785.
E-mail addresses: Catherine.dubois.1@ulaval.ca (C. Dubois), Genevieve.cloutier@esad.ulaval.ca (G. Cloutier), andre.potvin@arc.ulaval.ca (A. Potvin), Luc.adolphe@insa-toulouse.fr (L. Adolphe), florent.joerin@heig-vd.ch (F. Joerin).
Peer review under responsibility of Southeast University.

http://dx.doi.org/10.1016/j.foar.2014.12.002

1. Introduction

Global warming is undoubtedly real and the very likely increase in the frequency of heat waves (GIEC, 2007) is one of the chief concerns facing mid-latitude cities. The principal effects of summer temperature increases are to heighten the urban heat island phenomenon and to reduce interior thermal comfort in buildings. Assuming a significant rise in summer temperatures, the populations of mid-latitude cities would be more greatly affected as they are not acclimatized to extreme heat (Braga et al., 2001),

Architects and urban designers represent pivotal actors in climate change adaptation. At the urban scale, their decisions can create comfortable microclimates or, on the contrary, can contribute to urban heat island (UHI) formation. Moreover, architectural elements can determine whether a building offers passively comfortable internal spaces. However, these professionals continue to perceive adaptation as an element to be taken into account "later", in the future (Wheeler, 2008). We argue that these professionals have the following "four catalysts for action" at their disposal to strengthen the capacity of adapting the built environment of mid-latitude cities to higher summer temperatures: urban form, natural cover, architecture, and coating materials.

International students and Canadian architecture and urban design professionals working in the Québec City metropolitan context (province of Québec, Canada) participated in two workshops where it was found that they actually have only partial knowledge of the UHI phenomenon and of the passive cooling principles (Dubois et al., 2012). This appears paradoxical considering the substantial and rapidly developing body of scientific literature available today. The issue lies with its transfer to professionals and not with the production of scientific literature per se. First, the profusion of specialized knowledge can be overwhelming for these lay professionals. Second, the methods, tools and terminology used by researchers are alien to them. Third, the problem-solving procedure is fundamentally different from the traditional scientific approach. As architects and urban designers, they must be prepared to deal with "wicked" problems (Rittel and Webber, 1973). These problems require a prospective approach: in order to develop a further understanding of the problem and search for potential solutions, decisions must be taken, experiments must be conducted, pilot studies must be carried-out, and prototypes must be tested (Conklin, 2005). Thus, "wicked" problems foster new knowledge and creativity.

We hypothesize that a design support tool (DST) focused on the issue of adaptation of mid-latitude cities to rising summer temperatures could help improve knowledge and skills of professionals in the field. DSTs can facilitate designers' understanding by transferring appropriate multi-disciplinary knowledge that is derived from the popularization of technical or scientific insight. Such tools apply mainly during the upstream phases of any project, when decisions on the various urban, architectural and technical options are taken and when the information available to the designer is limited (Adolphe, 1995). They can also suggest orientations, indicate trends or compare solutions according to their performance (Fernandez, 2010).

The first section of this article presents a review and classification of DSTs to describe the intrinsic qualities that can likely help improve knowledge and skills of architects and urban designers regarding climate change adaptation measures. A series of DSTs are identified at the end of this first step. They were tested during a Laval University (Québec, Canada) architecture design workshop. The second section presents the results from a field survey. The purpose of the survey was to get students to experiment with various tools used for the design of an architectural project, and ask them afterwards to validate the identified positive elements in order to better define their needs.

2. Methodology

2.1. Review

The review seeks to highlight the main features of DSTs to establish which ones are likely to improve the climate change adaptation knowledge and skills of architects and urban designers working in cold mid-latitude cities. With this intention, we propose the following two sub-hypotheses:

(1) Improving the knowledge of designers depends on tools that allow them to better grasp an issue and identify potential solutions.
(2) Improving the skills of designers depends on tools that allow them to assess the performance of the selected solutions.

The features of various DSTs that were identified are highlighted by grouping them according to the classification proposed by Chaabouni et al. (2009). Five categories are considered: the tools based on (1) "intentions", (2) "references", (3) "knowledge", (4) "performance" and (5) "hybrids". Finally, given the purpose of the research, most of the tools that were reviewed and classified (Table 1*)* examine one of the following issues: climate change adaptation, urban heat Island (UHI) mitigation or passive design strategies.

2.1.1. Tools based on "intentions"

The first category combines the tools based on "intentions". The intention is to express, in its conceptual form, a constraint that is imposed or not, but influencing the geometry of a project (Faucher and Nivet, 2000). These numerical simulation tools use inverse simulation to identify solutions able to satisfy the designer's desired effect (or intention). The intention type tools include the SVR (Houpert, 2003), SOLIMAC (Siret, 1997) and DE VISU (Nivet, 1999) software prototypes along with the inverse simulation model of daylighting (Tourre, 2007). None of them have been applied beyond the experimental prototype, since they were developed in the context of doctoral research.

Tools based on "intentions" such as the inverse simulation model of daylighting (Tourre, 2007) are very specialized. It has the ability to predict how daylight is distributed within a given space and to compare it with the intention of creating a particular ambience. More specifically, the model estimates the geometrical and photometric properties of the openings needed to achieve the intended lighting effect. The inverse simulation model is very precise, but is strictly limited to daylighting effects. It is incapable of taking several criteria simultaneously into account, because