PROPOSITION OF AN ARCHITECTURAL DESIGN PROCESS MODEL BASED ON A CONSTRUCTIVIST DECISION SUPPORT APPROACH

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ABSTRACT

This paper presents a model of an architectural design process for multi-performances which incorporates a constructivist approach of multi-criteria decision support. This approach seeks to reconcile the value system of decision makers, as it believes that they do not have the same goals. Thus, the aim is to reach a space of consensus among decision makers (in the case of the design, among experts/designers). This space of consensus must aggregate multiple views of reality arising from each participant. We started from the hypothesis that the incorporation of such an approach helps to reconcile conflicting goals of the project and, therefore, for collaboration among experts since the early stages of design. The proposed model is result of a research based on a Design Science Research approach. This methodological approach suggests the proposition of an artifact to solve a practical problem. In this case, the practical problem is the compatibility of multiple performance dimensions in the project. The proposed artifact is the model of an architectural design process for multi-performances. The application and testing of the model occurred through a didactic experiment. It is expected, through this research, a model of design process that systematizes the participation of experts and promotes collaboration in order to reach compatible goals of different dimensions of performance in a design solution.

KEYWORDS

Lean design, decision support, design science research, design process model.

INTRODUCTION

Greater the complexity of a building and its relation to the environment, greater the need for specialized professionals to work with each of the many issues involved in building design. However, traditional ways of collaboration, based on sequentially workflows, suffer with the low levels of communication. This situation leads to a lack of understanding, which generates errors in design and construction and user dissatisfaction with the final product (Kalay, 2001).

Each design discipline has its objectives whose performances are assessed at the end of the design process. The objectives of one discipline are often conflicting with other discipline objectives and do not always consider the requirements of value to

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the building users. Thus, the multi-performance assessments consolidation passes through decision making based on interests of different stakeholders.

At the Project Definition phase of the Lean Project Delivery System, multiple conceptual designs solutions must be generated and evaluated based on needs of customers and stakeholders and on design criteria for product and process (Ballard, 2000b). In this context, how can we choose between design solutions? How stakeholders should interact in order to reconcile their interests?

Based on these issues, it is important to use a method to support decision making in situations where multiple goals of design dimensions must be met. Therefore, it is essential that this method considers subjectivity of the specialists involved in formulating the weighting of goals.

In this context, this paper presents a model of an architectural design process which aims to reconcile multi-performance objectives in a design solution. In order to achieve this, the model incorporates a constructivist approach of multi-criteria decision support to allow the participation of the stakeholders in a collaborative and systematic way focused on the conceptual design stage.

DESIGN PROCESS

As construction, design is a complex task that involves several stakeholders. Some of them are directly actors on decision making. Others have influences on decision but do not make decisions. Most of the decision makers in design process are specialists. Specialization is essential for design. However, each specialist tend to optimize the performance of one dimension, without consider others (Ballard, 2000a).

According to Koskela (2000), there are much more interaction in design than in production. The design problems are often multidimensional and interactive, as multiple dimensions influence each other. It is often necessary to develop an integrated solution for a whole set of interrelated requirements (Lawson, 2005).

Thus, solve a design problem is not about combine sub-solutions to form a general solution, but to create a solution that satisfies the whole set of interrelated requirements. One cannot think each design problem in isolation if every problem should be satisfied by the same element of the solution. A design solution is characteristically an integrated response to a complex multidimensional problem (Lawson, 2005).

The early design stage is the more critical period of the design process. It is at this stage that the designers from all disciplines need to interact to achieve optimal design solutions. This contributes to reduce the need for adjustment of design at a later and more critical period of the process (Macmillan et al., 2001). Yet, at the early design stage, decisions have great potential to improve results such as reduce costs and increase customer satisfaction.

Macmillan et al. (1999) developed a comparison between some relevant design process models and identified that they have comparable, but not identical terminology. Thus, at the present study, the early stage is what Macmillan et al. (1999) define as *conceptual design phase*. Some activities inherent of the conceptual design phase are: specify needs, assess requirements, identify essential problems, determine project characteristics, generate initial concepts, and evaluate proposals (Macmillan et al., 2001).

Despite the relevant importance of the conceptual design stage, it often fails to deliver outputs that meet the expectations of clients. These failings are the result of poor communication between stakeholders, ineffective collaboration, little understanding of the complexity of the interdisciplinary nature of design, and weak and unconsidered decision-making (Austin et al., 2002). Therefore, we argue that the solution to reconcile multi-performance analysis should incorporate a decision support process that involves the stakeholders' collaboration.

MULTI-CRITERIA DECISION SUPPORT PROCESS

In the decision support process, decision occurs over time through interaction among stakeholders (designers/specialists and others), who influence each other. This is not a sequential process, with steps beginning, middle and end, but an evolutionary process (Ensslin; Montibeller; Noronha, 2001). Decision is not the product of a pre-determined sequence of activities, but emerges during the process.

As the problem is being structured, the stakeholders interact, confront and reinterpret their values. From the interaction between the stakeholders emerge qualities that do not exist elsewhere. Additionally, this same interaction inhibits the expression of qualities relevant to the parties individually. Thus, result consensus, compromise and mutual learning.

One of the actors in the decision support process is the facilitator who operates in support of interaction between other players. In the decision support process based on the constructivist approach, the facilitator is considered an intervener. Despite a rationalist approach defend traditional neutrality of scientific models of decision making, in practice the facilitator will never be neutral (Schwarz, 1994 *apud* Ensslin; Montibeller; Noronha, 2001). From this, ascends the assumption that is the basis of differentiation between the rationalist approach and the constructivist approach adopted by the decision support process: the importance of the stakeholders' subjectivity.

The process of decision support system incorporates the values of decision makers, as it consider that not everyone has the same goals (according to the rationalist approach, this single goal would be to minimize costs and maximize tangible benefits). Thus, the role of the facilitator is to reach an area of consensus among the other decision makers. This space must incorporate multiple views of reality arising from each participant (Ensslin; Montibeller; Noronha, 2001).

As many decision makers are involved on a decision context, decisions are characterized by multiple objectives. Keeney (1992) proposed an approach to support decision making called Value-focused Thinking. According to him, one of the most important phases of decision process is to identify and to structure objectives. The objectives will not only help to make wiser decisions, but also to recognize and create new decision opportunities. Dealing with objectives leads to a better understand of decision makers' values which make it easier to clarify difficult value issues.

In the context of the design process, the decision support process presents some peculiarities. In the project activity, the decision is taken along the generation of alternatives. The decision is not a step that occurs at the end of the design process, as an activity of choice, but actions that occur during the process. Moreover, there is a parallel between the activity of structure the decision problem in decision support, and the activity of analysis in the design process. In both cases there is a need to establish goals and criteria to guide the solutions.

Thus, the decision support process should be a support to the design process and not merely a complementary activity of choice of alternatives generated. From this conclusion, we proposed to incorporate a decision support model based on a constructivist approach into the design process.

RESEARCH METHOD

This research followed a methodological design approach based on the Design Science Research (DSR). This paper presents the experimental solution proposed in the stage of suggestion.

DSR is a research approach focused on producing innovative constructions with the intention of solving real-world problems and, thereby, contribute to the discipline in which the theory is being applied (Lukka, 2003). Constructions are all the artefacts produced by man. Lukka (2003) cites as an example: models, diagrams, plans, organizational structures, commercial products and projects information systems.

The typical way to do DSR is to construct and evaluate (March and Smith, 1995). That is, design and build an artifact and check if the original problem is solved by this artifact. To do so, Vaishnavi and Kuechler (2007) propose a general methodology to be applied in DSR based on five steps with their respective products (generics). This methodology is illustrated in the diagram of Figure 1. In this diagram, it was delimited the scope of this article, highlighting the specific product of this step of research that will be discussed below.

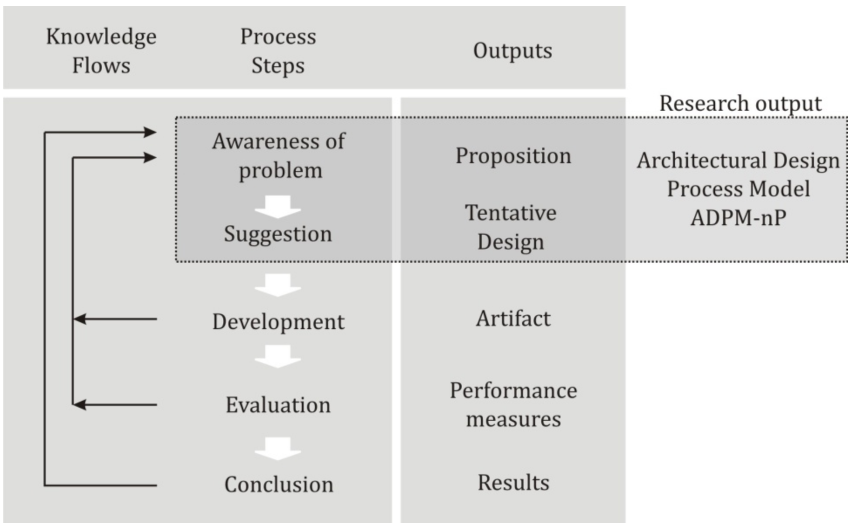

Figure 1: General methodology in Design Science Research (adapted from Figure 2.5 in Vaishnavi and Kuechler, 2007)

The awareness stage corresponded to the definition of the research problem, the construction of a theoretical conceptualization and definition of constructs and theoretical models to be followed. At this stage, it was proposed to incorporate a constructivist approach of decision support at the design process.

The suggestion stage consisted in proposing the Architectural Design Process Model for Multi-Performance Analysis - ADPM-nP. For the application of ADPM-nP, was developed a didactic experiment, which corresponded to the stage of development. The steps for evaluating the application of the ADPM-nP and conclusion will be executed. This article presents the model ADPM-nP proposed.

ARCHITECTURAL DESIGN PROCESS MODEL FOR MULTI-PERFORMANCE ANALYSIS

The ADPM-nP model is a model of design process that should be applied by the designers and other project stakeholders at the early design stage. It should be applied in order to improve interaction between stakeholders to reconcile multi-performance analysis.

The model consists of five main stages, illustrated in Figure 2. They are: identification of the decision context; structuring of the problem; structuring of the multi-criteria model, project development, and evaluation of potential solutions. These stages are described below, with emphasis on the stages of the analysis activity, in which was incorporated the constructivist decision support approach.

Importantly, despite appearing in a linear way, the process steps are not necessarily sequential and unidirectional. The process flow is recursive. At any time one can return to a previous stage and feeds it back with the knowledge generated in subsequent stages, which, in turn, will be reconfigured.

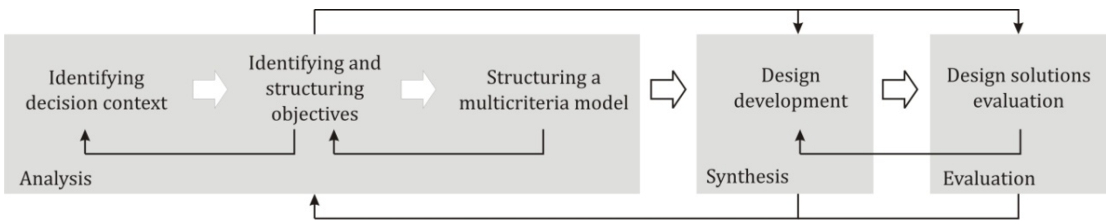

Figure 2 – Architectural Design Process Model for Multi-Performance Analysis - ADPM-nP (source: authors)

The identification of the decision context consists of identifying the dimensions of performance to be evaluated, identifying the stakeholders involved in the decision process, choosing which actors will be decision makers, and identifying the users value (needs, requirements and goals) by means of post-occupancy evaluations, satisfaction surveys, and previous analyzes of the building. This step provides the information that decision makers will use as a basis to determine the objectives to be achieved by the project.

Identifying and structuring objectives consists in determining a family of performance objectives. This is an important activity to make values explicit. The objectives are aspects considered fundamental to evaluate the alternatives according to the values of decision makers involved in a particular decision context. This stage is critical for the stakeholders (designers / experts) explicit among themselves what should be taken into account in the project for each performance dimension. Group discussions, initiated with the structuring of the problem and continuing with the structuring of the multi-criteria model, promotes an interaction between the actors that result in compromises, consensus and mutual learning. Shared understanding between team members is a key to successful collaboration.

The objectives emerge in the form of goals, characteristics and consequences of active alternative solutions. They are classified into fundamental objectives when they are essential reasons for interest in a situation, or means objectives, when they are important because of its implications for other objective.

For example, at an application[3] of the ADPM-nP model, the designers established at a first moment that "to reduce cost" was one of the fundamental objectives of the design. After some discussion between them, they decided that, for that specific context, "to add value" was more fundamental than "to reduce cost". In this case, the changing of objective changed the design focus. This was possible by mean of the interactions provided by the group discussions to identify objectives.

Structuring objectives is an important task to set the context for decision-making and provide the foundation for the use of a quantitative evaluation. This structuring occurs in two ways: an objectives hierarchy and a means-end objectives network. Each shape has a different function.

The objectives hierarchy aims to identify criteria to indicate the degree to which objectives are being met. That is, it indicates a set of objectives on which criteria should be defined. In the hierarchic structure, objectives are organized so that the level down specifies the meaning of the objectives level up. Then the hierarchy branches until it reach a level where the criteria can be defined.

Figure 3 illustrates an example of hierarchical structure of objectives.

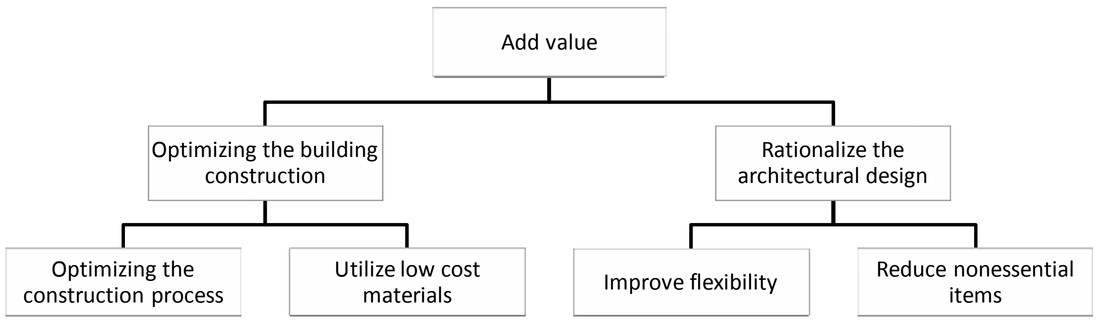

Figure 3 – Example of an objectives hierarchy (partial) (source: authors, adapted from the model application results)

The means-end objectives network is a structure of concepts related by means-end influence. It explains a causal relationship between adjacent levels. A mean-objective indicates how to achieve an end-objective. For the example above, the designers established that "utilize local materials" and "apply well-known construction techniques" are means to optimize the construction process.

Structuring a multi-criteria model starts with establishing evaluation criteria to the objectives. The criteria are used to describe quantitatively or qualitatively the performance of each objective in the context under consideration. That is, allow that goals can be measured. The criteria, also called in the literature by descriptors of impact or attributes are a set of impact levels, which represent the performance

[3] To a low-cost self-constructed house project.

(impact) of a goal in one alternative. According Ensslin, Montibeller and Noronha (2001, p.146), the criteria are used to: assist in the understanding of what the decision makers are considering; make a goal more intelligible; allow generation of improving actions on solutions; enable construction of scales of preferences; enable alternatives performance measurement on a goal; and assist in building a global model of evaluation.

In the presented case, to evaluate if the design solution optimizes the construction process, the team proposed a categorical criterion. The designers surveyed a list of possible materials and techniques to be used in the project. Then, they grouped them into levels of know-how and distance of acquisition (inside the state or outside the state). The upper level represented the group of better known construction techniques and local materials. The low level represented the opposite situation. As they collaborate to formulate all the criteria, they were having insights for design solutions.

To compare different criteria, it is necessary to construct a function that quantifies decision makers' preferences between levels of impact (Chart 1). Adopting this function enables that various criteria can be measured by the same scale of preference, and that qualitative scales can be converted into quantitative scales.

OPTIMIZING THE CONSTRUCTION PROCESS	
LEVEL	DESCRIPTION
L1	Materials found outside the state and unknown construction techniques
L2	Materials found inside the state and unknown construction techniques
L3	Materials found outside the state and well-known construction techniques
L4	Materials found inside the state and well-known construction techniques

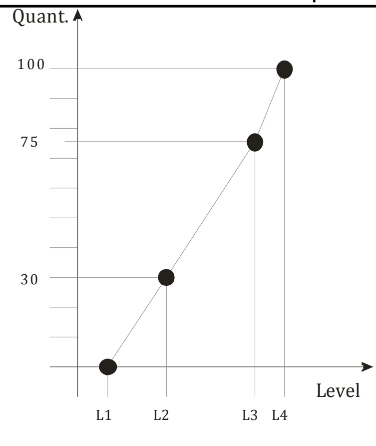

Chart 1 – Example of criteria (levels and function) (source: authors, adapted from the model application results)

The impact levels together with a function are a criterion of the multi-criteria model (Chart 1). The criteria are designed to measure the performance of each alternative on each goal. However, in situations in which the project is needed to handle with multiple dimensions of performance, the model should evaluate the multiple objectives.

To comprehensively evaluate alternatives, considering all the objectives established, it is necessary to aggregate the criteria taking into account preference relations between different goals. This is done by means of replacement rates (weights), which express tradeoffs between performance losses in a given goal and performance gain in another.

The stages identifying decision context, identifying and structuring objectives and structuring a multi-criteria model match analysis activities. These stages derive information for the development of the design itself. The development stage of the design corresponds to the synthesis of design solutions in order to meet the goals established by consensus among designers.

The evaluation stage of design solutions does not occur in isolation at the end of the process, but in parallel to the development of design solutions, such as support for design decisions. In both activities, synthesis and evaluation, information from the analysis stages are used. In addition, the results of the synthesis and evaluation may lead to revision of the analysis, which sets the recursiveness process as a whole.

At the end of the design process outlined by the presented model, the aim is not to arrive at the optimal design solution to the problem set. The purpose is to achieve the solutions that are considered valid for the stakeholders involved and the specific decision context in question.

DISCUSSION AND CONCLUSIONS

The ADPM-nP model application suggests that it reconciles the different dimensions of performance considered on a design. This is possible by considering the relevance of each performance objectives to the architectural proposal as a whole.

To that, the ADPM-nP incorporates to the analysis stage of the design process the process of structuring a multi-criteria model to support decision making. The model combines in a systematic manner different performance objectives. It also promotes collaborative work and provides the basis for a quantitative evaluation of design solutions. The collaborative work results from the space of consensus developed by the interaction between designers/specialists.

On the other hand, as the decision process is unique for each situation and each design problem and context, if there be lots of stakeholders and performance dimensions to consider, the ADPM-nP may be time consuming. To avoid this problem, later stages of this research aimed to identify how the building information model must support the design process proposed for it to be automated and flexible, in view of the large amount of data and information and the large number of variables that must be considered.

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