A CONCEPTUAL FRAMEWORK FOR A DECISION MAKING AID IN THE DESIGN PROCESS

Abstract. The research, which is the subject of this paper, is concerned with the integration of the environmental variables in the process of architectural design. It is contended that the theory and the architectural practice are characterised by everlasting series of determinisms, which make some design variables to be eluded in the design process. Several hypotheses are put forward in order to explain the factors inhibiting a complex approach to architectural design. It is shown that the solution of such a problem requires the formulation of a theoretical paradigm possessing its own postulates, axioms and speaking the language of the architect. The notion of ‘type’, transformed in a ‘generic type’, embodying multifaceted knowledge is put forward as a concept in the way to defining a design process. The typology embodies an important applicability potential, which, associated with that of the computer, namely; expert systems and case based reasoning, may contribute to the decisive integration of the physical factors of the environment in the process of architectural design.

1. Introduction

Since the energy crisis of the seventies, the interest for an energy conscious architecture has been growing ever since. In fact, a significant shift in attitudes has taken place and has had an effect in enhancing studies and research in this field. Nevertheless, in the architectural practices and in the schools of architecture, the ‘climatic’ variables tend to be overlooked in the design process. A methodological obstacle seems to be the main argument when examining the different reasons inhibiting the integration of
environmental variables within the process of architectural design. The lack of a well-defined paradigm structuring the architectural knowledge has left the way free to a multitude of discourses that have made great ideological and conceptual influences. In most cases, the influence of ‘iconic’ models, conceptual modes and elusive pictorial movements tend to transcend the other design variables. Often the overlooked variables are those dealing with environmental problems.

A critical review of the leading works of modern and post modern architecture shows that the architects known as ‘masters’ of these movements had a rather simplistic view to the physical factors of environment. Number of critics has pointed out to the above mentioned problems by reviewing works which eluded the climatic variables. Among those come Harkness and Mehta (1978), Cowan, H, J (1980), Fitch (1972).

In the modern architectural theory, building is not always considered as a ‘climate modifier’ (Hillier, Sullivan 1984). Environmental issues are often missing in the critical discourse of the architectural magazines. This view is supported by the argument of John Marston Fitch who stipulates that modern critical history has been dominated by the ‘iconic’ aspect of buildings (Fitch, 1972).

2. Towards A Conceptual Framework

Drawing from works showing that designers design always from a stereotype or a preconceived idea, and from the hypothetico-deductive model of Popper (Popper, 1969), researchers suggest an alternative model of the design process called ‘conjecture-analysis’, by opposition to the well known ‘analysis-synthesis’ model (Hillier and O’Sullivan, 1984). Often, the conjecture, in the form of a fuzzy mental image, corresponds to a memory resident ‘case’. The retrieval of such a case makes it necessary to understand the context of the project to be studied. The context, in its conceptual, environmental dimensions enables the designer to recall the ‘appropriate’ precedent, to solve technical problems, to identify new ones and to learn how to solve them while mastering a body of knowledge otherwise out of the scope of the architect. Sun argues that memory does not reflect directly past information, but selects appropriate reconstructions to the situation in which the recollection is taking place (Sun, 1993).

The context appears therefore to be of primary importance because, according to Sun, understanding is not, as stipulated by Schank, the adaptation of past experiences to new situations, but as some authors like Heidegger, Winograd and Flores, Maher, Snodgrass and Coyne, have put it: memory presents the ability of understanding present in terms of interpreting the past (Shank, 1982; Winograd et al., 1986; Maher et al., 1994; Snodgrass et al., 1990).
In the specific case of architectural design, number of researchers, (Los, 1986; Hawkes, 2006; and Mazouz, 1988, 1998) have suggested that if an integration ‘scientific analysis tools’ is sought, it should be through a strategy of reappropriation of the architect’s language through the «setting up» of a correlation between built forms (mainly thermal): strategy in which one starts by inventorying a given building stock then by establishing for every form a list of performance specifications that are stored in a database. Hence the architect can choose, according to the performance of every form and by manipulating a language which is familiar to him.

The abstraction of complex architectural models and their translation into basic forms associated with their attributes is believed to be a way towards restoring and rehabilitating both architectural knowledge and language (Billings, 1995). We feel that such a formulation could give way to the type’s complexity to be expressed by associating to drawing and geometry (graphic), a text, performance specifications and notes (text) (Figure 1).

To Billings, form and shape describe two different things, respectively two and three-dimensional configurations. Here we use the word form as describing both and composed of a number of primitive forms. From the above definitions, we formulate the ‘type’ as the pair (form-attribute), with different reading levels. We feel that such a formulation could give way to the type’s complexity to be expressed. Hence, the reductionism which seems to have characterised the type, reducing it to a simple ‘icon’ may be overcome by this approach which associates to drawing and geometry (graphic), a text, performance specifications and notes (text).
3. The Contribution of Expert Systems

Expert systems or knowledge based systems, which were developed out of research in artificial intelligence, are interactive computer programmes that attempt to achieve expert level competence in problem solving by integrating a support of a body of knowledge (Lutton, 1995). If cybernetics (Simon, 1981), was in the mood in the fifties and sixties and has even influenced a number of researchers in architecture who drew from its principles to build up theories and models in the architectural field, artificial intelligence is becoming a potentially new research paradigm.

3.1. CASE BASED REASONING

Case based reasoning has become a common paradigm in artificial intelligence domain (Kolodner, 1993). It is a technology, which is supposed to have had a certain success in a big number of applications, among them architecture. One of the most prominent definitions is the one presenting Case based reasoning as a system based on a number of existing cases, which solves new problems by adapting used solutions in previous situations (Riesbech et Schank, 1989). This means that in this kind of systems, a database containing cases, parts of designs is supposed to exist. The conceptual task consists of finding, among the cases stored in a case base the solution which is the most suitable to the problem in hand, then of storing the new solution in the case base. This process is carried out until an optimal solution is found.

Basing their observations on the cognitive model behind C.B.R. and on designers at work in the development of their concepts, Domeshek, Kolodner and Zimring underline the fact that conceptual approaches in design are among the most overlooked in the search of methodological schemes for artificial intelligence in design. The main concern of these systems being: experience at the basis of expertise. Hunt and Miles (1995) found out, after discussions with architects that the latter had been extremely disappointed by systems that do not help them in the retrieval of cases. The majority of the systems offer, instead, methods for the adaptation of the existing cases, task, which, they feel should be devoted to architects. What architects feel as their biggest challenge, according to Hunt and Miles, is the maintenance and retrieval of important amount of information concerning a given design.

3.2. THE NATURE OF THE CONTRIBUTION OF CASE BASED REASONING

It appears after the review of some systems based on the C.B.R. paradigm that they differ in their approach to the architectural problem. The salient fact remains the observation that these systems, supposed to embrace human
expertise in domains where the problem is ill defined, tend to elude such expertise. They are most of the time based on schematic and uncertain experiences describing episodic and elusive phenomena, for example the observation and interview of a design team at work. These experiences do not reflect the complexity of architectural design.

The total lack of theoretical formulation at the outset; it is the example of some systems reproducing the architect browsing through magazines in search of a good solution. The systems in which we find an attempt to formalise the architectural knowledge by means of structured indexing systems tend to overlook important aspects of design, taking into account only a few well known and commonly handled aspects like functioning and structure (Dave et al., 1994). Others follow a relatively out of date approach overlooking the recent consciousness and knowledge in energy conscious design, leaving environmental and climatic issues in their entirety to engineering tasks. It seems therefore that the lack of a theoretical formulation of design in these systems tends to emerge as a characteristic that may inhibit their promising potential.

The choice of 'cases' does not rely, in most cases, on a rational process nor on the long tradition of typological research in the field but on the uncertain storage in memory of projects designed by 'stars' of architecture. These projects are published and well known but rarely appraised. The remaining knowledge given in other forms than drawing is made of fragmented pieces of knowledge, mostly not interconnected between them, considering the totality of the project of architecture.

Once the cases are selected and stored in memory, some systems use an indexing method, usually through conceptual needs. Others let the designer browse freely. In the case of indexing, it is the pertinent elements of design that seem to us the most crucial point which should define the nature of knowledge relevant to form generation and decision making. As we have noticed, a number of important variables are eluded in the indexing processes. The mediocre quality of the expertise can be explained by the lack of real experts involved in the design of Case based reasoning systems (C.B.R.). Nevertheless, it is clear that these systems bear a tremendous potential in contributing to integrate environmental knowledge in the process of architectural design.

4. Description of the Suggested Model

Based on the theoretical model discussed in paragraph (2), A Tool, called ABDUCT, is developed. In its experimental version, the model assists in the design of architectural schools. Since knowledge remains the catalyst of the different operations, we should ask ourselves what kind of knowledge
should we look for and how could we break into parts a complex body of ill defined knowledge and how can we proceed by fragmentation which we have criticised elsewhere.

Once again we did look back to a long tradition of research in architecture dealing with the issue of assembling into one model, broken parts of the architectural knowledge in order to be used in design and appraisal of buildings. The models developed in the seventies by the Building Performance Research Unit and by Broadbent (Broadbent, 1973) still bear a potential of utilisation. These models, drawing on the cybernetics analogy, namely the concept of structural articulation(1), divide the knowledge related to building into articulated parts.

Building on the above mentioned work, and studying their differences and similarities, we defined four families of form generation factors, articulating with each other and forming a greater entity constituted by the interaction building-man-environment

4.1. THE DEFINITION OF EXTRINSIC AND INTRINSIC ATTRIBUTES

As already stated, the suggested model is based on the typological research in architecture, namely the pair (form-attribute). Attributes associated with a given project are the intrinsic ones. The extrinsic attributes are those defining the context. The formulation of the intrinsic attributes of the project to come is achieved by means of a knowledge base and an ‘expertise’. The knowledge base enables the architect to acquire knowledge by finding answers to specified problems, such as technological and environmental problems, which the designer might come across during his process of designing. The objective is the understanding of the context in which the design is to be implemented. The context is then used in the retrieval of the cases. The fragmented architectural knowledge can be assembled in one body. The ‘expertise’ contains modules operating in a textual mode by means of a dialogue with user. The aim is the determination of intrinsic attributes (physical environment, spatial planning, conceptual), a module for the determination of the ‘generic type’s and a module for the precedent determination. Finally a conceptual research module completes the whole.

The formulation of the extrinsic attributes is achieved by means of a database. The database contains data belonging to the above mentioned four bodies of knowledge. The users browse through the existing data; enter their own data or modify the existing one.

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(1) A concept coined by Angyal meaning a subdivision that preserves natural junctions between subsystems of a given entity.
5. Structure and Functioning of the Model

The model, supposed to help the designer in the preliminary phases of the conceptual research, has to function as a support of concept search, simplification and memorisation, like these trip notebooks that architects hold always on them. It is therefore on a traditional conceptual research in architecture that the tool is based.

The model should be able to manipulate various information. No mean of representation is discarded in the beginning. The architect in search for inspiration and ideas during the initial phases of the project has recourse to various means such as text, diagrams and images. The architect nuzzles and researches diversified information that can take various forms. He can come across structured information processing a well specific subject or across a row, ill structured information, to be processed in view of an ulterior utilisation. An image can make part of a system of information associated to texts or to other images, or simply be part of a catalogue in a bank of images. In the two cases, the architect recuperates the information, stocks it in his personal file, alone or with other iconographic or textual information, then he undertakes his simplification and annotation process, in view of the ulterior exploitation of the whole material in the process of generation of the architectural form.

Hence, the database, contains especially ill structured information but usable in this precocious stage of the architectural ideation. The knowledge base contains structured information directly exploitable by the user or forming the foundation to others modules. The module Expertise forms the main component of the model. It is this last module that exploits information contained in the database and those contained in the knowledge base. The expertise, by means of an explained reasoning, shows to the user, step by step, the situation of the project and defines a series of attributes in the form of a text that the user can directly exploit. The expertise allows equally determining the generic types and precedents corresponding to the technical specifications provided by the knowledge base. It is this module that bears the better the concept of integration. Thus, to the consultation module and determination of attributes of the project (in text mode), is attached a module of determination of the generic types (graphic mode), a module of determination of the precedents (graphic mode), and a conceptual research notebook (integrating text, image, etc.), (Figure 2.)
5.1. MODULES COMPOSING THE EXPERTISE

5.1.1. The diagnosis ‘consultation’

The consultation module functions exclusively in text mode. It completes the other present graphic modules in the application. At this advanced stage of ideation, this module represents the capital analysis necessary and preliminary before the creative jump (conjecture). The module consists simply in a dialogue between the designer and the computer. The designer replies to the questions of the computer and the latter defines a certain number of intrinsic attributes to the project. The presentation of attributes is made as the consultation is made and is regrouped at the end of the consultation in a text file called ‘digest’ of attributes (physics, spatial or conceptual). As in all expert systems, an engine of inference, working in backward chaining, allows to maintain a dialogue with the user. The usefulness of the presence of such a module is supported by the following elements:

- All information entered by the user concerns known aspects of the site, the climate, conceptual and personal preferences or imposed by the program or the brief. No a-posteriori information (i.e. known only after an architectural solution is found) is necessary.
- The dialogue is in natural language, privileging to the maximum the architectural jargon and parting to the maximum too imposing numbered information.
- The gradual progression and the explanation of the Reasoning by the module would have to facilitate the apprenticeship, which remains an essential objective of this research.
• The physical attributes ‘digest’, spatial or conceptual under the form of a text file comes as the result of the consultation and can be directly used by the designer.
The module ‘consultation’ determines three attribute types; physical, spatial and conceptual (sociocultural).

5.1.2. The determination of the generic type
Spatial and physical attributes files can determine the generic type. The generic type, because of its high degree of abstraction, and in order to allow the affirmation of its generic character, does not embody concepts of the socio-cultural environment; i.e.: solutions dealing with ideologies or stylistic and formal choice. Only after having determined attributes of the physical environment and those of the spatial environment, can the designer determine ‘his’ generic type. The designer can go on to determine the precedent but only after having determined the conceptual attributes (sociocultural environment).

This choice is explained by the possibilities given to the user and in order not to bias his/her formal and plastic choice; the precedent will come far more for information and to show alternatives of solutions. The generic type remaining the vault key on which the designer leans to generate architectural solutions. Its implementation in the model has necessitated a supplementary effort of graphic representation. So as to confer it this aspect, attributes defined by the expertise are translated in graphic symbols allowing a well-off perusal, an interpretation of the type and the ulterior formulation of an architectural solution (Figure 3.)

Figure 3. The generic type window
5.1.3. The determination of the precedent
The concept of precedent has also been discussed earlier. Its implementation in the model has necessitated a particular effort searching for existent cases in the fragmented documentation. The precedent, that is the graphic translation of the three files of attributes processed in this research and defined by the expertise; physical attributes, spatial planning attributes and conceptual attributes, embodies an idea of a solution to a part (only a part) of the problems identified by the user through the expertise. Like the generic type, the precedent can be retrieved in two ways:
- By nuzzling, selecting a precedent, copy it in the user file, schematise, annotate, but especially make the link between annotations and images in an ulterior utilisation view.
- The determination of the precedent through the process of Expertise then benefit from the same functionalities as in 1. However, the determined precedent is supposed to be the 'good one' which architectural solution is the closest to our case of study (Figure 4).

![Figure 4. The precedent window](image)

5.1.4. The conceptual research notebook
So as to guarantee an effective utilisation of the tool in the initial phases of the project, the tool should be able to support the preliminary conceptual research prior to all design operation. The classic operation that consists in browsing through magazines in search of precedents bearing a potential of 'correct' solutions must be dealt with. A creativity tool, helping the designer in the preliminary phases to come across the concept that could help him/her to find acceptable formal solutions, seems necessary: it takes the form of a conceptual research notebook.
The implementation of the conceptual research notebook stems from the awareness of the importance of this type of tool in the process of architectural design. A growing number of researchers emphasise the importance of the analogical process in the design (Chupin and Leglise 1996, Girard 1986, Coyne 1994, and Tzonis 1991). These same authors insist on the role of the schematisation and the individual interpretation to insure the success of the operation (Schon 1979, 1994).

The tool should be able to support a set of cognitive operations taking part in the conceptual research process. These operations are the schematisation, the document, the image and the possibility of the analogical reasoning between images. The analogical reasoning should be as vast as possible using intangible and tangible channels of architectural creativity. Each analogical reasoning process is illustrated by the 'confrontation' of two images on the same page of the notebook. Texts figuring on the same page of the notebook allow the designer to bring his personal comments and his interpretation in view of a more rapid memorisation.

The module should therefore be able to support:

- The graphic presentation of objects in a page layout that allows comparisons.
- The interpretation and the annotation (graph and textual) of these objects
- Easy navigation in articles of the database
- The easy research of a concept

Figure 5. The conceptual research notebook window.
The conceptual research notebook can be implemented under the form of a database containing two image fields, two text fields, a mechanism of navigation between pages of the notebook and finally a conceptual research mechanism. The user will benefit from the suppleness of the conceptual research module to research a given concept in the existent database, or to load images, text, and to constitute their own personal repertory and to insert his personal interpretations in text spaces reserved to this end (Figure 5).

6. Validation of the model

The validation of such a system requires time and resources. The model is not a simple application that one can experiment in one or two hours, because it is based on the acquisition of information, knowledge and expertise and on the constitution of a designer’s personal repertory. Thereby, the application can hardly be evaluated outside this framework. However, and for evident convenience reasons and means put to our disposition, such scenario was not possible to achieve.

The evaluation that we were able to realise took two full working days among fourth and fifth year students of the school of architecture of the University of Biskra. These had been chosen on the postulate that from the fourth year on, the student is supposed to have acquired the main rudiments of architectural design and is therefore fully qualified to take part in the process of evaluation.

6.1. THE PROCESS OF EVALUATION

The experimentation took place in two halls equipped with drawing tables and adjacent to the university’s documentation centre. One of the two halls being equipped with microcomputers, this choice was not fortuitous. It was motivated by the desire to encourage some students to use the documentation centre and make sure that the other part gathers the necessary design information only from the application. In order to avoid that the two different groups vary considerably in terms of basic intelligence or in specific background, it has been decided to opt for a random distribution. The first group has to use the application beforehand, while the second one undertakes a straightforward design session without using the application. Two types of questionnaires were distributed to the two groups accordingly. The questionnaire 1 deals with issues such as, the integration of the modules, their co-ordination, the phase in which it was mostly used, the assistance with the decision-making, the quantity of the information contained in the module, the character of this information and finally the contribution of the information in the generation of the architectural form.
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The evaluation has articulated around the observation and the appraisal of projects realised by the two groups and by the analysis of the results of the questionnaires. Out of the seventy persons having taken part in the evaluation, only thirty persons gave back the required graphic and textual documents (design drawings and filled questionnaires). After a thorough examination, only 28 persons (two groups of fourteen each) have been retained for the statistical analysis.

6.2. THE ELEMENTS OF EVALUATION

6.2.1. The variables retained in the process of evaluation

It is impossible to take into consideration all variables of a given project. Several factors pleaded in favour of the evaluation of such or such variable theses were:
- The pertinence of the chosen variables and their degree of measurability
- The integration of variables other than those of the physical environment destined to be taken into account by the application’s different modules.
- The interaction of the different variables.

Finally, some indisputable variables such as location, orientation, form, grouping and zoning were selected. On the other hand the integration of these variables had to be made in harmony with the other variables of the project. This is why we added other variables such as spatial and conceptual ones. The objective was twofold; first to question the compatibility of such variables with the other variables of the physical environment and to verify in a second time the contribution of the modules processing the spatial and conceptual aspects. A meticulous observation has allowed attributing for each variable an appreciation mark ranging from 0 to 4 with values 0: bad, 1: mediocre, 2: average, 3: enough good and 4: good. Finally statistical calculations have been undertaken with the help of the specialised statistical analysis software.

6.2.2. The evaluation of the projects designed by each group

An examination of the frequencies of the different variables shows that the average of the evaluation’ marks ranges in the first group from of 1.07 to 1.50 with minimum values of 0 and maximum values of 3. It should be noticed that no project of this group has succeeded to get the maximal mark 4 (Table 1). The variables the least dealt with are the orientation (1.07) and the zoning (1.07) while the best dealt with was the location with a value of 1.50.
TABLE 1. The marks achieved by Group1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>N</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPCONC approach</td>
<td>1.71</td>
<td>.61</td>
<td>1.00</td>
<td>3.00</td>
<td>14</td>
<td>Conceptual</td>
</tr>
<tr>
<td>ORGSPATI spat. organisation</td>
<td>1.93</td>
<td>.83</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>ORIENTAT</td>
<td>2.07</td>
<td>1.07</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td>Orientation</td>
</tr>
<tr>
<td>ZONING</td>
<td>2.29</td>
<td>.91</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td>Zoning</td>
</tr>
<tr>
<td>FORM</td>
<td>2.50</td>
<td>1.02</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td>Forms</td>
</tr>
<tr>
<td>IMPLANT</td>
<td>2.50</td>
<td>1.09</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td>Location</td>
</tr>
<tr>
<td>GROUP</td>
<td>2.64</td>
<td>1.01</td>
<td>1.00</td>
<td>4.00</td>
<td>14</td>
<td>Grouping</td>
</tr>
</tbody>
</table>

The descriptive technique allows observing that the same design variables are better taken into consideration in the group having used the application. In this group, minimal values are 1 (better than the group 1) and the maximal are in the order 3 or 4 with an only one 3 and 6 * 4. The means range from 1.71 (well superior to the maximal value of the group1) to 2.64. Here, the variables the least dealt with are the conceptual approach and the spatial organisation with respective means of 1.71 and 1.93 (Table 2).

TABLE 2. The marks achieved by Group2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>N</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIENTAT</td>
<td>1.07</td>
<td>.73</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td>Orientation</td>
</tr>
<tr>
<td>ZONING</td>
<td>1.07</td>
<td>.83</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td>Zoning</td>
</tr>
<tr>
<td>APPCONC concept. Approach</td>
<td>1.21</td>
<td>.70</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>GROUP</td>
<td>1.21</td>
<td>.89</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td>Grouping</td>
</tr>
<tr>
<td>FORM</td>
<td>1.21</td>
<td>.58</td>
<td>1.00</td>
<td>3.00</td>
<td>14</td>
<td>Forms</td>
</tr>
<tr>
<td>ORGSPATI spat. Organisation</td>
<td>1.29</td>
<td>.73</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>IMPLANT</td>
<td>1.50</td>
<td>.76</td>
<td>0.00</td>
<td>3.00</td>
<td>14</td>
<td>Location</td>
</tr>
</tbody>
</table>

First conclusion: the two variables the less taken into consideration in the first group are variables of environmental type while in the second group all the variables of the environmental type are taken into consideration.
This gives an idea on the considerable contribution of the application on the process of architectural design. The T–TEST confirmed the superiority of the marks of the group having used the application first. This is well clear not only concerning the environmental variables but also concerning others variables such that the spatial organisation. The only variable not presenting a significant difference in the two groups is the conceptual approach (Figures 6).

Figure 6. The means of the marks in group1 and group2 respectively

6.3. THE CONTRIBUTION OF THE EXPERTISE MODULE BY MODULE

One of objectives appointed to this application was to test the contribution of the expertise in terms of ‘speaking the language of the architect’, in assisting the latter the crucial phases of design, in helping to take decisions and assisting in the provision of the necessary knowledge. If the application as such is conceived to be usable during the preliminary phases of the design process, the different modules are differently used. It is the conceptual research notebook that occupies the highest rank with 85.7% of utilisation during the preliminary phases of the process. This position is logic due to the type of information it contains. The climatic database comes in the second position with 85%. Modules operating in text mode only (physical attributes, conceptual and spatial) are differently used. If the physical attributes are strongly used in the preliminary phases, spatial attributes with 57% and especially conceptual attributes with only 35% occupy the lowest ranking. This seems paradoxical because the information embodied by conceptual attributes is the same embodied by the conceptual research notebook to the difference that the latter operates in both text and image modes. This is probably the difference between the two. This trend tends to be confirmed by the satisfying use of the others modules operating in text and in image (the Precedents module with 78.6% and the generic Type module with 71.4%). The lack of links between the conceptual
attribute module and the conceptual research notebook may explain this dichotomy.

Concerning the contribution of information in the generation of the architectural form, and as already stated, this aspect constitutes one the important problems of this research. Although cumulated percentages of the users’ responses (decisive - average) tend to enhance the hypothesis that the information contained in the application possesses a decisive contribution the process of design, it is interesting to note that in terms of decisive contribution alone, physical attributes and modules based on image and graphic representation (like the generic type and the precedents with 50% each) rather than on text alone, have a decisive contribution on the process of architectural design. This shows the inclination of architects to work with images rather than with text.

7. Conclusion

In conclusion, the application has aroused the adherence and the enthusiasm of the students who took part in the experimentation and the results of the statistical analysis demonstrate the contribution of the application in the integration of the physical environment variables, not as dominant entities, but simply as ordinary variables to process in the process of architectural design.

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