Abstract

Architecture is more than form. It must be more than form. It can be spectacular, it can be revolutionary, but it should also be comprehensible, reasoned and plausible and this should be reflected in its form. This very nature of architecture makes it different from other design disciplines. However, it is these central aspects that are not supported by current computer-aided planning systems. The development of digital models concentrates on the purely formal aspects.

Architecture does not just concern the external appearance; it also involves finding solutions for the organizational and technical realization of a building. The function, suitability, economic and ecological aspects, construction and implementation are important factors in the design and execution of a building. For architects at least, they should remain uppermost in the design considerations. Leaving aside the few exceptional buildings whose characteristic is defined by the building’s form, it is obvious that the majority of buildings are determined by other factors. During the concept design, fundamental decisions are made that influence the rest of the design, without the architect having objectively considered a variety of relevant planning information. A large amount of potentially influential information cannot be considered, remains neglected or simply ignored. The paper describes research in progress into the design of planning systems which provide the architect and designer with such information during the conceptual development of a building, so that the chosen solution is plausible, reasoned and understandable. The design of such a planning system is oriented around the possibilities of information technology with regard to architectural demands and constraints. In contrast to currently available systems, the proposed system will include concepts which provide the architect with relevant information during the design phase. Architectural and urban planning issues are here as important as technical, ecological or economic factors.

1 Introduction

At the outset of the project we started with the hypothesis that planning and building is dependent upon the tools the architect used. The recent wave of built blob-architecture and current developments in digital architecture demonstrate this impressively. Through the use of modeling software, a generation of architects are now able to develop a new formal language previously only mastered by a handful of exceptionally talented individuals. Form becomes the dominant criteria for a generation of buildings whose virtuosity can be traced back to the tools used in its design. The use of such tools can be learned and can therefore be used by every architect should they so wish. However, the realization of such daring forms as built, functional buildings, which have to fulfill many more criteria than aesthetics or elegance, is much more difficult and has been mastered by few architects. And although computer-assisted planning processes have long been the subject of systematic research in the field of architecture and psychology (Schmitt 1993), none of the existing modeling programs support the realization-oriented development of a design as part of the architectural planning process. Plausible design and computer-aided support for the entire planning process do not feature. Other disciplines
have developed solutions which could be applied in an architectural environment, however these have made little impact. The use of planning systems in architectural design is currently limited to individual systems which do communicate to a degree with one another (i.e. can interchange relevant data) but fall far short of supporting a continuous workflow in the development and realization of plausible designs. Seen from the viewpoint of integral planning, these systems cannot be regarded as planning systems in the true sense of the word.

2 Theoretical context and motivation

2.1 Terminology

Planning system: For the purposes of our research we define a “planning system” as a computer-aided system which supports the architect in the provision of planning services by providing contextual information and suggesting possible solutions during the planning process.

Planning process: The “planning process” encompasses all planning services provided by the architect. This includes identifying the need for and integrating services from other specialists whose services in turn contribute towards planning confidence.

Planning confidence: “Planning confidence” means that a planning system provides the architect with appropriate information during the planning process, so that the developed solution is plausible, reasoned and understandable. A solution can be seen as plausible when it considers and fulfills essential relevant demands and constraints and when its development can be understood as the result of reasoned intentions.

It is obvious that a planning tool based upon these conventions has very different design criteria to conventional CAD or modeling software. Technologies such as patches, force-fields or particles may possibly also be a part of this, but are more likely to be applied to an aspect such as a plot, a load or water currents.

3 Methodology

Our primary intention in the research project is the use of information technology to assist the development of plausible solutions in order to achieve more planning confidence for architects in the design and development of building projects. The methodological approach of establishing factors leading to increased planning confidence requires an analysis of existing planning practice and an investigation and assessment of existing tools in architecture and applied computer science. Before we begin with a detailed scientific assessment we undertake a series of tests using different test groups with the intention of describing and developing a planning system for a representative architectural issue in the planning process. The results of the test series are document in part four (results) and serve as a basis for our initial scientific investigations.

3.1 Analysis of existing architectural and planning practice

A determining factor in the development of a system for supporting the planning process is the analysis and breakdown of planning practice i.e. the approach and process of the architect when developing a design solution. Architectural and planning theories already exist which describe and break down the planning process into logical interrelationships. However, from our experience as practicing architects and researchers, it is doubtful whether these planning theories really support the planning process or can serve as a basis for developing criteria for the design of such a system. An empirical investigation using methodologically suitable groups of test persons is, in our opinion, more useful in the detailed assessment of current planning practice. The development of a questionnaire or investigation aimed at achieving representative findings is subject to a series of factors which make the structuring and later assessment exceptionally complex and time-consuming. However, it is the only real possibility of
attaining representative data about the structure of the planning process with a view to restructuring
deficient developments in planning tools for architectural planning.

Existing findings already show that the breakdown and structuring of different influencing factors and
their respective weighting must be accorded more importance in the design of planning systems. Vague
factors and research into knowledge when establishing fundamental constraints and intents at the
outset of the planning process are just as important as constructive, legislative or functional factors in
later design phases and the preparation of planning permission documentation. The initial design phase
can have a significant effect on the further economic development of a project and decisions made early
on in the planning process can have extensive consequences when it comes to amending the planning
at a later date. The amount of information available to the designer at the conceptual design stage is
therefore of fundamental importance for the further development of a project. Furthermore, as Löhnert
points out with regard to integrative planning approaches, energy and cost-efficient planning can only be
effectively achieved by considering these in the initial planning phases (Löhnert 2002). It quickly
becomes clear that such a planning system cannot be a single-workstation based system. The initial
information requirements and the need to integrate specialist input e.g. from engineers, public
authorities etc. necessitates a networked platform under the architect’s coordination that can be
accessed at any time by all participants. The architect’s coordinating role in the early phases of the
architectural design is of central importance in achieving planning confidence and reducing the need for
cost-intensive modifications in the later planning phases.

3.2 Analysis and evaluation of existing architectural planning systems

An overview of currently available digital architectural planning tools and an assessment of their
capabilities showed that a considerable number of CAD-systems are in use in architectural offices (Buss
2001). Within the last year the number of new developments coming onto the market as well as the
number of manufacturers has reduced considerably. This can be explained by fusions and/or takeovers
by larger manufacturers who are gradually clearing smaller companies from the market, though often
the products continue to be supported or are incorporated into the manufacturer’s own product ranges.
This development has more to do with strategic market positioning than with architectural factors.
However, a definite decrease can be observed in innovative solutions on the market as well as a
concurrent stagnation in progressive development. This tendency is most certainly a key factor in the
analysis of the design of current software solutions and requires further investigation.

The assessment of relevant CAD systems used in practice shows that they differ only slightly from one
another in structure and user-friendliness, but vary considerably in their functional capabilities. A few
very advanced systems such as CATIA or Pro/E are particularly difficult to operate, but have functional
capabilities far above average (Andreas 2001). A general characteristic of all of the systems assessed is
insufficient support for the requirements of the planning process and their syntax which is rarely oriented
towards the language or structure of architecture. Most systems are without doubt oriented towards
generating geometries, i.e. the generation of design or working drawings. Support for the subject matter
itself for instance the plausible development of a solution, is practically non-existent or in selected cases
covers only the detailing of standard problems such as roof eaves or wall sections.

4 Research findings

4.1 Test cases:

The implementation of an empirical investigation for producing meaningful data is a difficult and time-
consuming process. Developing hypotheses requires intensive consideration in advance of the kind of
results that may be expected. In order to better define the questionnaire and reduce the error-potential a
series of test-cases were initiated with thirteen test groups. Each test group consisted of two
architectural students with differing experience in CAD and graphics applications. The test involved developing a system for the solution for a typical design task as well as a representation of their planning approach which would help them in reaching a reasoned solution. The test candidates were given an open hand in their choice of instruments and methods for developing a solution. The solution did not necessarily have to reflect its real-life realization i.e. proposals could be developed whose realization using conventional IT-methods may be questionable. Likewise no stipulations were made regarding the IT-platform or medium to be used. The candidates were explicitly given freedom in developing their solution.

The tests were devised making use of an architectural theory and involved the design of a planning system for solving an urban, an architectonic and a construction problem (Alexander 1977). The choice of tests reflects everyday architectural problems with which an architect may be confronted with the aim of assessing whether it is possible and sensible to develop a computer-supported tool for any architectural, urban or construction-oriented problem. The test candidates each selected a task from Christopher Alexander’s set of 253 patterns as described in his Pattern Language. Each pattern in Alexander’s Pattern Language contains a description of the solution that can be used as a basis to design the planning tool. The aim was to gain more insight into the following aspects:

- Establishing a criteria catalogue of potential application areas of planning systems in architecture.
- The preparation of a questionnaire aimed at identifying and categorising deficit areas in the planning process.
- Identifying characteristic features of program and interface design of planning tools.

4.2 Assessment of the Test cases

The following describes a representative excerpt of the test-cases carried out:

4.2.1 Test case 1: Path and Goals

Task:

Only when a path actually leads in the direction one wants to go does one follow it with conviction. This process is more complicated that one might think. There are two principal approaches. The first approach involves taking the shortest route, one cuts corners and takes diagonal routes. In the second approach one uses a series of key points for orientation which lie roughly on the route to the intended destination and which are visible from one point to the next. As soon as one reaches a key point of orientation one looks for the next and can follow the route to the destination without having to know the way in one’s head as one can always use the key points for orientation.

Realization:

The test persons developed a graphic solution in the form of an urban massing model. The architect defines the area to be planned within this massing model and the principal orientation points in the surrounding area. The orientation points are categorized and given a weighting with regard to their role in the existing urban structure (Figure 1). In this way new points of orientation which lie in the area to be planned by the architect are assessed within the surrounding context. A similar approach is taken in the development of B-plans and local building regulations, which are binding for the planner. In addition rules are integrated into the system which measure the distance between individual orientation points and suggests alternative locations where distances are exceeded or routes cross. The assessment of critical or poorly articulated junctions help identify the need for modifications in their design.
The suggested solutions within the test series are oriented around the specific conditions of the urban problem. The test persons recognized, however, that the problem is in essence not dependent upon scale and can equally be applied to buildings as well as urban situations. The graphic integration of the rules devised and the definition or orientation points ensures its application in other problem areas, for example the organization of routes within complex administrative facilities or hospitals where rapid orientation play an important role. The planning system is graphically oriented towards the task at hand i.e. the plan and massing model are only detailed and designed to a degree that is necessary to solve the problem. The syntax of the system is oriented towards the subject matter. Realization was in the form of mock-ups.

4.2.2 Test case 2: Indoor Sunlight

Task:
If the main rooms of a building have a southerly orientation, the house is light, sunny and pleasant. If the less important rooms are oriented southwards, the house is dark and unfriendly.

Realization:
Although the task itself is relatively straightforward, involving arranging the important rooms with high natural light requirements on the south side of the building, the test persons developed a more complex system which took into account further constraints (Figure 2). The description of the system showed that the orientation of the building and the rooms is dependent upon a number of factors regulated by the B-plan or building regulations such as number of full stories, building massing, limits and extents, arrangement lines or boundary distances. These and other factors such as form, location and orientation of the plot and neighboring buildings were input in an initial window and used to generate a building proposal with an optimally oriented building. A next step involved applying weightings to individual rooms and proposals for organization within the building.
Figure 2: Definition of Project Parameters

Evaluation:

The proposed solution shows clearly that the arrangement of rooms within a building is dependent upon a number of factors over which the architect has little influence. Building regulations complicate the ideal-case planning and can lead to problematic solutions (Figure 3). Through the input of regulatory stipulations these are taken into consideration. As in the previous case, the program uses a very different syntax to conventional CAD systems. None of the input modes required lines, boxes or other geometric forms to be entered. The syntax employed by the test persons is an architectural syntax oriented around the planning process. If building lines are input, the program automatically generates the line in plan representation.

The system is realized in JavaScript and VRML and can therefore be used on a desktop and in immersive VR-environments (Figure 4).

Figure 3: Definition of Building Regulations
Figure 4: The Project seen from within a Virtual Environment
4.2.3 Test case 3: Warm Colors

Task:
Natural materials, sunlight and light colors produce a feeling of warmth. To a certain degree the warmth of selected colors is responsible for the comfort levels indoors. It is not the color of objects or surfaces that contribute to a feeling of warmth or coolness, it is the color of light. The color of light in a room is, however, not determined from the color of the surfaces alone. It depends upon a complex relationship between the color of the light source and how the light is reflected from different surfaces.

Realization:
The proposed system makes use of ASCII stereolithographic CAD data input from CAD-systems. The user defines the color of the surfaces and the location and strength of light sources. The program then undertakes a light-energy calculation and evaluates the voxel-colors on a scale of warm to cool (Figure 5). The interpretation of the voxel-colors informs us about comfort levels for people inside the room. The warm-cool scale is based upon empirical investigations (Alexander 1977).

Evaluation:
The solution proposed by the test persons is similar in approach and function to radiosity programs such as lightscape or radiance. The syntax employed is understandable for architects but includes terminology and methods not directly used by architects. The functional operation is exceptionally good and represents a clearly defined and structured approach to solving the problem (Figure 6). The program structure is however oriented around conventional programs and less so an architect’s way of approaching the problem. Although this is the most powerful of all the test cases it has a very different structure. It is programmed in C++ and runs on Windows operating systems.

Figure 5: First-step Radiosity-Calculation of Voxel Data
Figure 6: Finished Radiosity-Calculation with Warm-Cold-Histogram

5 Conclusions
The results of the first series of tests show that the all candidates were able to develop IT-solutions for the tasks chosen. It is interesting to observe that most test candidates did not limit their solution to that described by Alexander, but expanded their strategy to encompass further aspects related to the problem at hand which appeared to fit into the solution of the problem. Typically these included related
architectural problems with regard to legislative or economic aspects. It could also be observed that none of the test candidates limited themselves to a single strategy. All of the developed solutions were complex and none of the candidates attempted to clearly define and solve the problem with the minimum means necessary. Most of the patterns chosen were taken from the field of architectural planning with town planning or constructional problems playing a secondary role. The extension of the solution strategies demonstrates a tailoring of the problem to actual architectural application areas.

Furthermore the evaluation of the test cases shows that the structural organization of the planning systems developed is oriented exclusively around the architectonic conditions. In addition the test groups with little or no programming knowledge proposed solutions which are visually very different from conventional planning or CAD-systems. Their syntax and structure is arranged solely around solving the task at hand, in most cases including further boundary conditions. Interestingly enough the test group which first developed programming skills during the test program proposed solutions which allow the architectonic problem to be solved in immersive VR-environments. This indicates that given the flexibility of developing one’s own strategies for solving a problem very different solutions can be developed as those currently available. To summarize one can say that those test groups with the least technical skills and knowledge with regard to digital tools developed solutions that are best tailored to the architectural design and planning process. Although the number of test groups is not representative to support this hypothesis, it is clear that further investigations cannot be undertaken solely online. It is vitally important to assess test groups whose technical IT-skills are low or even non-existent.

The evaluation of the test cases produced definite recommendations for the design-development of further investigations. For instance the establishment of a catalogue of characteristic aspects of potential application areas should concentrate on the additional strategies developed by the test candidates as these can provide information about deficits in existing conventional planning systems. The variety of additional strategies developed for the chosen tasks show that the categorization of deficits in the planning process, with regard to designing a questionnaire for architects, is much more complex as the variety of factors uncovered diversify rather than concentrate the issues. With regard to characteristic aspects of program and interface design, the tendency towards an architectural syntax can be observed oriented around the terminology related to the respective task at hand.

To summarize, the test cases made clear that future planning systems must be oriented around the architect’s approach and structure in solving the architectural problem. In contrast to existing systems none of the proposed systems included traditional drawing tools. Instead, boundary conditions are defined that need to be integrated by the architect. The computer assists in the architect’s evaluation and interpretation of these boundary conditions. An approach which integrates design, planning or functional-legislative aspects into its system is a basis for the development of reasoned and plausible architectural design.

References


