Towards a Digital Design Teaching Tool

A look at the ideas that should define a digital design primer

Rohan Bailey
Caribbean School of Architecture, University of Technology, Jamaica

Keywords: Design & decision support systems, Architectural education, Computer assisted learning, Design thinking

Abstract: Architecture in the 21st century has become an increasingly complex affair. In addition to new social and cultural norms, architects are inundated with constantly changing information regarding new materials, sustainable processes, and complex building types. This state of affairs has also affected the expectations placed on architectural education. Critics (in diverse spheres) have expressed concerns about the lack of requisite skills of graduates that characterise good design thinking strategies as well as promote responsible design. It has been proposed by this author in other forums that by using digital technology to empower design learning, we can allow students to confidently use (through reading and analysis) their sketches to develop conceptual ideas that reconcile disparate elements into a habitable, environmentally friendly and architecturally responsible whole that is fit for purpose, cost effective, sustainable and a delight to clients and users.

This paper will seek to discuss one of the concepts that govern such a tool. It will start by delineating the problem (discussed earlier in the abstract) before outlining the concepts or principles that a design teaching tool should adhere to. These concepts acknowledge the importance for the tool to reflect the nature of design tasks, facilitate learning and be accessible to all learning types. The paper will then focus on one concept – the nature of design tasks. The subsequent sections will describe an information structure borne from this idea and make mention of a current prototype of the tool. The paper will conclude with a discussion of the strengths of considering this concept.

Jos P. van Leeuwen and Harry J.P. Timmermans (eds.) Progress in Design & Decision Support Systems in Architecture and Urban Planning, 373-386.
8th International DDSS Conference, 4-7 July 2006, Eindhoven University of Technology.

1. THE PROBLEM

Today, more than any other period in history, the task of conceiving and creating architecture has become increasingly complex. New social, technological and cultural norms coupled with the growing need to protect the well-being of the planet has increased the architect's "social responsibility" to provide safe, sustainable and environmentally friendly places. This responsibility however, requires more than a passing understanding of the issues involved in the creation of these environments. This makes the preparation of students in architecture for the twenty-first century a particularly daunting task. This challenge has been amplified by claims from professional bodies, critics and architectural educators that due to a "disconnection…between the two separate worlds of architecture education and practice" (Boyer and Mitgang, 1996) graduates lack sensibility to the "real world" of architectural practice and are consequently a burden to train. Schools of architecture (and their teaching mechanisms) are hereby placed under severe pressure to provide graduates of architecture with an awareness of the issues that contribute to an architecture that is fit for purpose, cost effective, sustainable and a delight to clients and users.

2. RESEARCH

This situation has acted as a catalyst for the research being conducted by this writer. The research seeks to find an innovative and effective way to facilitate the transfer of practical, appropriate knowledge needed by students to create safe, purposeful and environmentally responsible architecture. As a result, work over the past few years have centered on issues of design sketching, the interaction between teacher and student, the role of digital technology in architectural education. Relating these disparate issues is key to the search for a medium or tool that can enrich the conversations students have with their teachers, facilitating a renewal in the architectural education process. Findings so far have suggested that the sketch becomes digitally empowered to provide an interactive medium (rather than passive) that actively prompts and cues the novice designer about aspects of the design situation. This moves digital technology (the computer) beyond functioning as an instrumental tool (in visualization, representation and fabrication) to becoming a "Socratic machine" that provides an appropriate environment for design learning.

3. A TEACHING TOOL

The long term proposal of this research points to the creation of a system, tool, or aid comprised of two main components (figure 1). The first (a sketch recognition component) involves recognising the sketch and inferring an intention or issue under investigation and the second (an information component) involves relating specific information to the inference and the communication of such information as clues about the design situation. The main thrust of current research as regards to the teaching tool, is primarily about the content of the tool. The nature of the tool's content is significant because while it is crucial for the tool to recognise architectural intent from a personal sketch, the information communicated determines the tool's value. It ascertains how far students will be exposed to the kinds of issues that are involved in the design of real buildings. It is also this information that determines the extent to which the tool can respond to the challenges of architectural education and be valuable to schools of architecture.

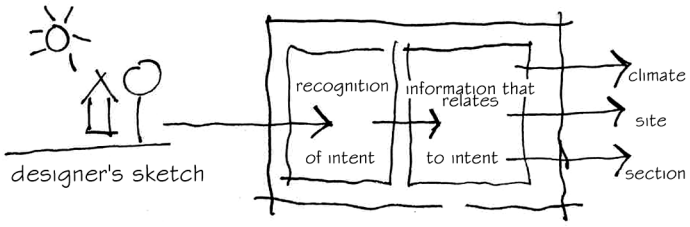

Figure 1. Conceptual diagram of a design primer.

The prototype currently being developed is targeted at beginning architectural students in the Caribbean. The tool, in fact, has been tested in design studio and has received good reviews from students. Titled, the Caribbean Design Primer, the tool is intended to inform the student about a design situation by presenting the student with issues related to a particular situation. Through the primer, the student is made aware of the implications and consequences of his/her decisions. The student is also more aware of the interconnectedness of design issues, eliciting more balanced responses to design situations. When meeting with the studio tutor, this awareness allows a higher level of student-tutor dialogue. It must be noted that, by establishing the basis on which the tutor can communicate with students the design primer primarily supports and enhances the traditional face-to-face desk based interaction between student and teacher, and does not seek to replace such contact.

There are several issues that govern the development of a digital teaching tool for design studio. Foremost, is the notion that using the computer as a teaching tool must be consistent with relevant learning theories related to computer assisted teaching and learning. Second is the students' experience of the tool through an interface that is graphic, intuitive, simple, consistent, predictable and logical leading to continued use of the tool and the ability to design effectively and efficiently. Thirdly, the primer must allow expandability and cross-fertilisation of knowledge by being flexible enough to accommodate individual evolving needs, preferences and insights. Next, the personal and idiosyncratic nature of design learning must be well considered and accommodated by employing a universal approach to reduce the exclusion of a significant portion of the intended learners. Finally, to easily facilitate design learning, the information content and structure of the design primer must reflect the realities of learning design and aid in the cultivation of an understanding of the issues that affect architecture. The content must include the kinds of information that serve as clues to ground the student in the realities of design and the structure must reflect the nature of design problems and the intricacies of the design process. It is to this final issue that we will direct our attention.

4. DESIGN PROBLEMS

In architecture school, design studio is seldom comparable to other subjects or courses offered to students. In other courses, when a problem is given, the students know that a solution or set of solutions already exists for that problem. This solution is usually found by applying (in accordance with a learned method) acquired knowledge to the problem. The problems encountered in design studio, on the other hand, have no known results. Unlike structural equations and mathematical problems, they cannot be solved by a process of logical reasoning or by applying a series of learned formula. They often lack sufficient information to enable the designer to arrive at a solution by simply manipulating the given information alone. Additional information may have to be discovered through luck, searching or experiment and some may even remain unknown. While some technical aspects of the design problem may be predictable, the context, nature and emphasis of the problem (which sometimes is not clearly defined) determine the emergence of the solution.

For students to fully appreciate the diversity, complexity and multivalency of design problems, the design primer must reflect the inherent nature of design problems and architectural ideas. It should not simply be a tool that provides the "correct" answer. It should be clear to students that

problem and solution are dynamically related. It should also be clear that design problems have variables and influences that change as the situation, context and events change. The primer should be flexible enough to allow or accommodate different approaches to design. It should provide multiple directions to the same problem implying a tool with no boundaries or stopping points, and perceived as "endless".

5. STRUCTURE

The multidimensional and interactive nature of design is embodied in the organisation of the design problem. The design primer therefore has to reflect the uniqueness of design problems, have no boundaries, cannot be fixed, have no stopping rules and accommodate the uniqueness of the designer. This, however, demands a structure.

The design of a building is a kind of multivariable problem. Along with technical issues, there are issues of human occupancy and human use to be addressed as well as a level of responsibility to a larger context (client, users, physical setting, or socio-cultural condition). These issues are themselves "mini-problems" that the designer needs to be aware of. A good illustration of this is the multidimensional qualities of windows (figure 2).

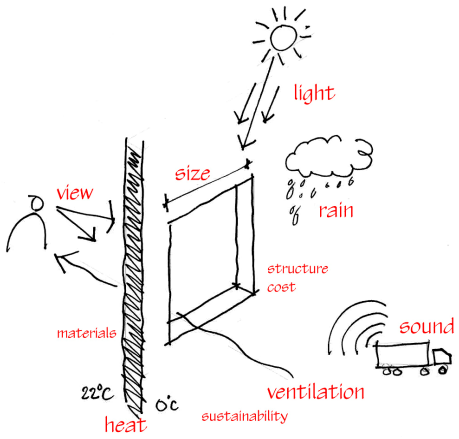

Figure 2. Some of the complex array of issues concerning windows.

When examined closely, it is obvious that there is more to the lowly window than that which meets the eye. The issues that confront the designer with respect to windows can be divided into pragmatic issues, social (or psychological) issues and a mixture of both. Pragmatic issues relate to, among other things, the orientation of the window and the amount of sun

that particular window will be exposed to. This affects light and heat, in turn determining the size of the windows, which also establishes the amount of ventilation allowed. Poetic or social issues involve such issues as view, connection to outside, privacy and the symbolism attached to windows in a particular culture. Both types of issues simultaneously have ramifications on the size of the window, its orientation, its position in the wall (centre, one side, whether it is a window wall or not), and the activities that surround it. All this is indirectly related to the size of the room, the activities that take place in it, the height of the space and where you enter the space. This further affects the position of the room involved, its relationships to other rooms in the house, the orientation of the house and so on making the myriad of issues involved in one window more than what the beginning designer can adequately visualize during design.

Emulating the structure of design problems has as its primary goal the illustration of connections. For any teaching tool to be of value to the education of the architect it must reveal the connections or relations between design issues. This can be done by breaking the design problem down and presenting or revealing its' smaller "problem states" to the student. Demonstrating clear connections between pieces of information and showing the big picture where possible will illustrate to the student or provide the means of understanding how the pieces come together. This would give the student a stronger grasp of the various issues involved in the design situation, allowing him/her the opportunity to see the design process as a means of combining and reconciling (connecting) disparate design considerations.

6. PATTERN LANGUAGES

The idea for breaking design problems into malleable pieces is by no means original. During the heady days of the Design Methods Movement, Christopher Alexander in his seminal essay – *The Determination of components of an Indian Village* (Alexander, 1963) – first suggested breaking down or decomposing problems into smaller inter-related issues or problem states as a means of solving design problems. It was his intention to list the requirements of a design, state which pairs of requirements interacted positively or negatively and feed this information into a computer that would determine which requirements were heavily interrelated but relatively unconnected to other requirements. This resulted in breaking down the problem into independent sub-problems, simple enough for the designer to understand and solve (Lawson, 1997).

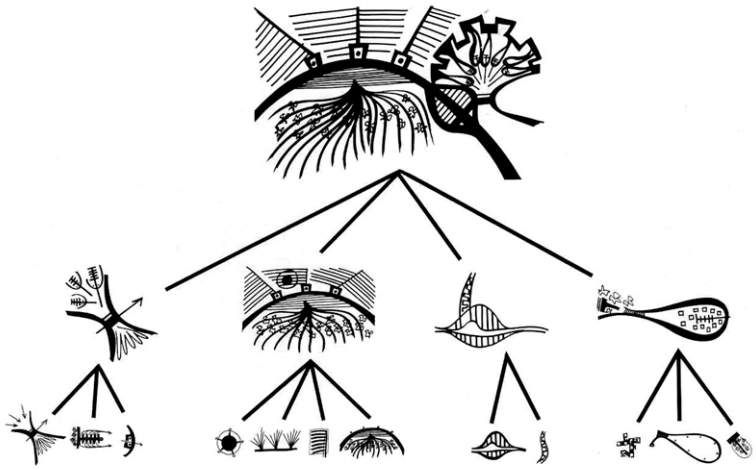

Figure 3. Decomposition of issues related to the design of an indian village. (Source: Alexander 1964).

While Alexander's method was rational and reasonable in the early years of the design methods movement, this approach (and indeed the whole movement) has since been heavily criticized for increasing the rigidity of the design process and a worsening of the quality of design (Mitchell, 1993). It is argued that contrary to the actual nature of design problems, it would be difficult to create complete, defined clusters from inadequate information (that changes as the solution is formulated). The task, therefore, had to be well defined for us to determine all the components and their relations.

While these criticisms are valid, they however do not discount the notion that design consists of several interconnected problems or issues. Both Rittel and Lawson agree that design problems are symptoms of another 'higher level', problem (Buchanan, 1995; Lawson, 1997). This particular quality relates mostly to the structure of design problems and so presents the best opportunity for a corresponding structure for the design primer.

In the early 1970s Alexander altered his position somewhat and addressed the more qualitative aspects of architecture resulting in the publication in 1977 of *A Pattern Language*, "a rich, huge, and instructive set of guidelines" (Saunders, 2002). This work, formulated a "pattern language" which consisted of 253 patterns ranging from the largest scale - towns - through buildings and down to construction details. Each pattern had a name, a diagram of its spatial layout, the rationale for its inclusion, and a specification of the links between the given pattern and those related to it at a larger and smaller scale (Mitchell, 1993). The information was presented in

such a way that readers could judge it for themselves and modify it "without losing the essence that is central to it" (Alexander, 1977).

A Pattern Language illustrates the hierarchal interconnectedness of design problems by becoming (perhaps unintentionally) a "smorgasbord for selective consumption" (Saunders, 2002). Treated as a system of interlocking parts, users of the patterns can pick and choose ideas, connect them like Lego™ blocks, and end up with idiosyncratic compositions of odds and ends that work together. The designer, in addition, gains an appreciation of the relative position of the "favourite" patterns within the whole composition.

With reference to Alexander's method of decomposing the problem, design issues in the design primer must therefore be connected to other issues that reveal more about the problem as you explore them. As determined earlier, every variable in design is linked in one way or another to every other design issue. Therefore, each piece must be connected to one other (or two other pieces) and revealed as you trace the connections, for example, the problem of ventilation is related to opening, which is connected to light and view; light is connected to orientation, size, and height. The solution then, is finding a suitable method or approach to create a "map" of the problem that the student can use to navigate his or her way through the task. Accruing a high value for the tool therefore requires breaking down design ideas (or issues) into independent "sub-ideas" or simply employing the idea of chunking.

7. CHUNKING

Let us assume that expert designers visualise information or design knowledge as segments of relevant and coherent units (or what we will call *chunks*) to be retrieved for manipulation (Casakin and Goldschmidt, 1999). These chunks are the designer's own syntactic and semantic network or framework of knowledge based on personal biases and experiences. This network, hence, becomes a hierarchical tree with nodes and connections to nodes that represents in its construction an architectural knowledge personal to the designer only. The network is given form through the designer's conjectures and its physical manifestations (sketches, models) allowing didactic criticism from a more capable peer or tutor. The aim of the primer, therefore, would be to provide the relevant pieces and connections (knowledge) for the students to assemble or construct chunks. The student would then "present" these chunks (or their construction) to the tutor.

The building blocks of the primer that contributes to the construction of chunks would be knowledge units (KU), nodes and information units (figure

4). In the primer, each unit of information would represent a part in the hierarchical tree of an entire design idea or what we will call a *Knowledge unit* (KU). At one level, a KU can represent a combination of any number of issues. At another, that same KU can be a basic unit in a larger structure (KU or chunk). For instance, if a single design idea (or KU) is about allowing light in a space for reading. This could comprise issues that deal with windows (opening size, opening shape), artificial lighting, ambient lighting, task lighting, orientation, etc. At another level, this design idea would be a part of a wider idea - designing a reading room - which would also include in combination with our first KU, issues for making a room quiet for reading, and comfortable furniture for reading. This chunk, a space for reading, would then become a part of the designer's knowledge about the much wider issue of designing a library.

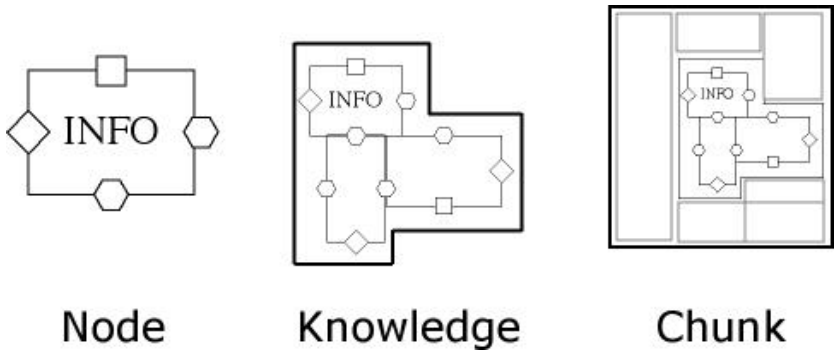

Figure 4. Nodes, Knowledge Units and Chunks.

Chunks are therefore a combination of knowledge units (e.g. allowing light for reading). Knowledge units (KU) are a combination of nodes (windows), which in turn consists of information units (opening size to light ratio) and connections. A chunk can be thought of as a network of connected KUs and nodes (each node being a piece of information and its connections) creating a complex tree of knowledge. Chunks would be user-composed and occur outside of the tool (in the head of the designer). What characterises the chunk and opens it to criticism is how the KUs are combined and the determined path or map of connections that defines the chunk and the manifestation of that chunk as a design proposal. The analysis and synthesis of the relevant chunks or simply, the proposal would be presented to the tutor. The proposal – the chunk, its connections and relations – will then become a qualitative unit for analysis and criticism by the teacher. Optionally, however, some chunks could be predetermined or "channeled" by the tutor, for instance, to determine a special focus or lesson for the design studio.

8. ELEMENTS AND STRUCTURE

Information contained in the knowledge units of the primer ranges from *Precedent knowledge* – examples of buildings and other architectural artefacts to *Conceptual knowledge* – ideas that are more abstract and less specific to a particular building or example. Conceptual Knowledge could be universal and include such notions like ordering principles while it could be unique or user-determined to field particular viewpoints or theories, such as sustainability.

Knowledge Units (regardless of type) would comprise of related nodes which in turn are comprised of connections and information units. Information units are single pieces of information (more often analogous to a leaf in the tree) that could include rules of thumb, ergonomic data, climatic data, typical room sizes, design and reference data as found in selected texts. While the information described is quantitative, the unit could also contain such conceptual ideas as found in Christopher Alexander's Pattern Language. Information units would take the form of diagrams, text, photos, references, and video/animation. In addition to statements, the information unit could also include information on further reading and reference sources.

In order to allow the construction of a chunk or KU, the design primer defines connections and relationships between pieces of information. Connections act as doors or gateways between related information units. They control how the information units, both conceptual and concrete, come together, affect each other, create nodes and the resultant knowledge units. Connections could be universal (pre-determined by the tutor) and/or idiosyncratic (defined by the student).

9. CARIBBEAN DESIGN PRIMER

The Caribbean Design Primer (figure 5), at present, uses a combination of web and interactive multimedia technologies as the primary method of delivery, allowing the combination of traditional media, such as text and images, with 3D-models, animation, video and sound. The content of the tool is based on the premise that architecture is made of qualities or issues that are determined by need and external forces. These issues can be divided into several categories depending on the theme or thrust of the studio. In the case of the Caribbean School of Architecture (CSA) the categories are form (structure, massing), space (requirements, ergonomics, layout), and climate (sun, light, temperature). The information is also considered in terms of 4 scales: elements, rooms, building, and site. Information included ranges from theoretical and cultural concerns to ergonomic and bio-climatic data or rules

of thumb. These are presented as items/ideas for the student to assemble, consider and comment on in subsequent conversations with the teacher.

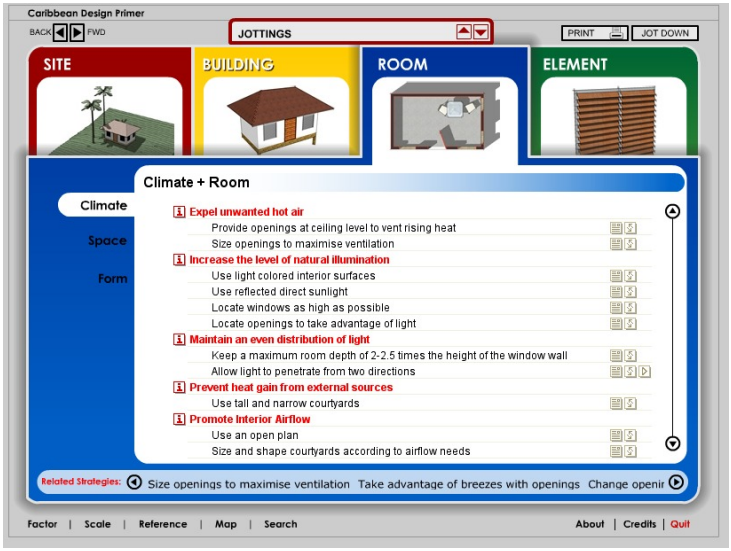

Figure 5. Screenshot of the Caribbean Design Primer.

The tool embodies the concept of chunking and extends it through the use of "design language". In it, content is divided into a hierarchy consisting of three levels of information – Design Issues, Design Strategies and Design Moves. These levels are related to chunking in that design issues become chunks of information to deal with a particular design problem e.g. daylighting. There are several *design strategies* for dealing with *design issues* (e.g. orientation, window size, surface texture), the use of each being determined by a particular design situation or the bias of the designer. These strategies are smaller chunks with significant nodes of information. Embedded within *design strategies* are *design moves*, actual action to be taken by the designer to address the design issue. Design moves are then populated by information units.

The primer uses a series of windows to present information. Each window displays either an issue or a strategy. A typical issue window would include a list of options or strategies from which to choose. The designer would then be taken to a strategy window (figure 6) that outlines the strategy under consideration, offers a set of design moves, highlights connections and recommends further literature.

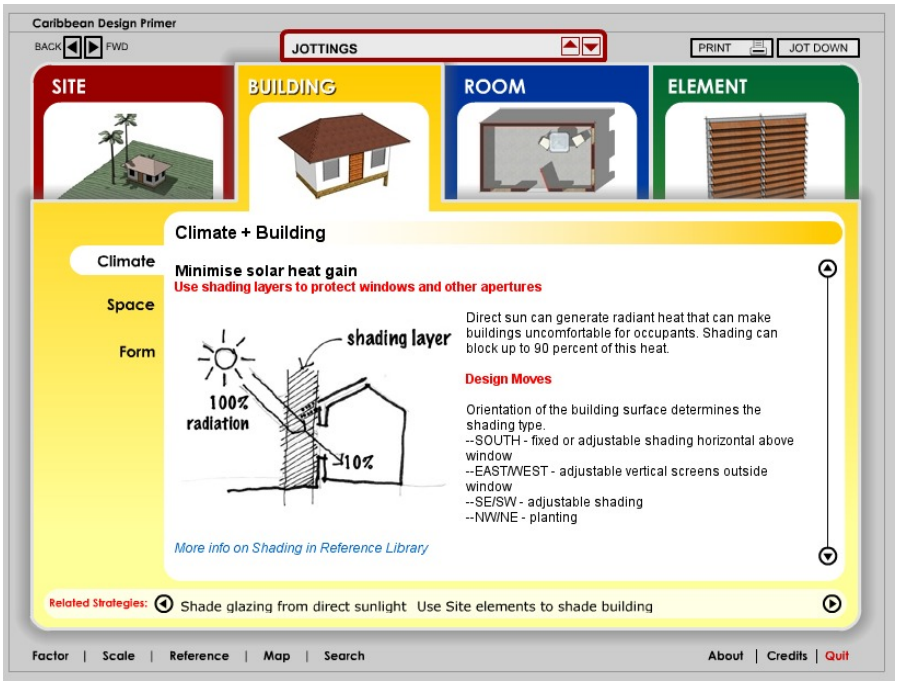

Figure 6. Example of a Design Strategy screen.

10. CONCLUSION

The information needed to produce architecture today is overwhelming for seasoned practitioners much less students of architecture. Despite this, schools of architecture are expected to provide beginning students with a practical knowledge base that is adequate to deal with the rapid changes in technology and society in the 21st century. This paper has identified this challenge as significant to the success of architectural education.

This paper proposes that meeting this challenge by using digital technology and the sketch to enrich and support students (who have limited design vocabularies) with practical and poetic design ideas, will enable a more intelligent, well-informed, richer and more productive conversation with the tutor. Achieving this is the creation of a digital aid, tool or system that will develop students' awareness of the practical issues of design while thinking critically and abstractly.

Using a digital tool to teach students of architecture about design issues should be established on selected (often unrelated) principles and use the sketch as a means of interface. For the tool to be inclusive and accessible to

a variety of users with different learning and design styles it must attempt (at least) to be universal. It must consider learning theories regarding of Computer Assisted Teaching/Learning. It must encourage student directed learning, and allow the transfer of ideas by clearly connecting issues through different information formats (verbally (written form) and visually (images)). It should be compatible with the problems the students learn from whilst allowing the student to have an opportunity to review and reflect on the information acquired. These selected tenets govern the effectiveness of the tool. If we pool the requirements from each tenet we can arrive at a more comprehensive prescription for the basis of the teaching tool.

Of primary importance is the relation of the tool to the subject that is being taught: design. We have noted that the pedagogical basis of the design primer should entail breaking the design problem down and presenting or revealing its smaller "problem states" (or its position in higher level context) to the student. The information structure of such tool should use a hierarchical system of chunks, knowledge units, nodes and bits of design data. These would range from Christopher Alexander's pattern language to ergonomic data, climatic data or rules of thumb. This system of issues, strategies and moves aims to be more than definitions and ways of breaking down architectural information into manageable units but also seeing the relationships and connections between the units prior to and during composition. This facilitates a good understanding of the object being "assembled" because of the intimate knowledge of the parts and how they fit together.

Information in this digital teaching tool is offered as a decomposition of issues that the student can "assemble" according to his or her personal creativity. Structuring the information in this way has several advantages:

1. Students understand that the changing nature of the problem is dependent on decisions taken, hence encouraging more conscious "moves" in the design activity.
2. By understanding or gaining an appreciation of the "pattern" of issues involved in certain aspects of the design problem, the student is best equipped to recognise similar patterns, even in remotely related projects.
3. Student gain a greater appreciation of the issues involved in the design situation, allowing him/her the opportunity to comprehend the design process as an accumulation of problems that need to be considered individually and collectively.
4. Students gain the ability to "read" design issues connected to design situations whilst learning about them. This reinforces the issues in the mind of the student permitting an appreciation of related problems.

5. The student has the opportunity to construct knowledge based on his/her own experiences and biases.

In the end, the student gains adequate critical thinking and problem-solving skills while using appropriate and innovative technology to learn about the things that make architecture affordable, sustainable and livable.

11. REFERENCES

Alexander, C., 1963, "The Determination of components of an Indian Village", in: Jones and Thornley (eds.) *Conference on Design Methods*, Pergamon, Oxford:.

Alexander, C., 1964, *Notes on the Synthesis of Form*, Harvard University Press, Cambridge.

Archer, L. B., 1979, "Whatever Became of Design Methodology?" *Design Studies* **1**(1): 17–18.

Boyer, E., and L. Mitgang, 1996, *Building Community: A new future for Architecture Education and Practice: A Special Report*, The Carnegie Foundation for the Advancement of Teaching, Princeton.

Buchanan, R., 1995, "Wicked Problems in Design Thinking. In The Idea of Design", in: Margolin and Buchanan (eds.) *A Design Issues Reader*, MIT Press, Cambridge.

Casakin, H and G. Goldschmidt, 1999, "Expertise and the use of visual analogy: implications for design education", *Design Studies*, **20**(2): 153-75.

Lawson, B., 1997, *How Designers Think: The Design Process Demystified*, Architectural Press, Oxford.

Lawson, B., 2004, *What Designers Know*, Architectural Press, Oxford.

Mitchell, C. T., 1993, *Redefining Designing: From form to experience*, Van Nostrand Reinhold, New York.

Saunders, W., 2002, "Ever more popular, ever more dogmatic: The sad sequel to Christopher Alexander's work", *Architectural Record,* May 2002, p. 93–96.