A Digital Design Coach for Young Designers

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Abstract
The present use of digital media in architectural practice and education is primarily focused on representation, communication of ideas and production. Designers, however, still use pencil and paper to assist the early conception of ideas. Recently, research into providing digital tools for designers to use in conceptual designing has focused on enhancing or assisting the designer. Rarely has the computer been regarded as a potential teaching tool for design skills.

Based on previous work by the author about visual thinking and the justification for a digital design assistant, the intention of this paper is to illustrate to the reader the feasibility of a digital design coach. Reference is made to recent advances in research about design computability. In particular, research by Mark Gross and Ellen Do with respect to their Electronic Cocktail Napkin project is used as a basis on which to determine what such a digital coach may look and feel like.

Keywords
Design Education, Protocol Analysis, CADD, Sketching

1 Introduction

In 1991, when commenting on the use of computers in practice, Garry Stevens wrote, "Computer-aided drafting is uncommon … and computer-aided design is almost nonexistent..." (Stevens 1991). In 2001, ten years later, despite far reaching advances in the production and use of digital tools in the field of Architecture, designers to a large extent, still prefer to use handdrawn sketches in the early conceptual stages of the design process. The current digital tools available while being excellent at the communication of ideas and concepts have not been able to facilitate the kinds of design thinking enhanced by the sketch (Tang and Gero 2001). The importance of the handsketch as a means of communication and thinking makes the act of sketching (in whatever form) an essential ingredient in any attempt to use the computer in design.

Efforts in the field of design research have sought earnestly to amend this problem and most postulated solutions have concentrated on providing tools of support for the designer. For instance structural analysis software, energy analysis software etc. In conjunction with these research efforts, design education has been finding imaginative ways of better integrating digital media into the design process. No longer is a school's digital prowess marketed by how many computers are in their computing lab or whether they are teaching the latest available software but rather, how well digital media is integrated within design studios and other parts of the curriculum (Cramer and Guiney, 2000).

By finding new and innovative ways in teaching digitally mediated design, educators are giving students of architecture the ability to easily manipulate and use this new media as part of their design process as well as to convey their ideas in a visually convincing manner.

Despite all this progress, the impact of computers on practice has not affected the way architects think and design. In other words, the design process has remained structurally the same. Likewise, the presence of digital media in design studios does not necessarily mean that it has changed in any immense way students' understanding of the design process. For while there has been tremendous effort to integrate digital media into the studio, there is no evidence that these tools are being used to directly inform and educate young designers about much of what must be considered during the design process.

This paper seeks to define an alternate approach to design education in which the computer acts as the linchpin for this change. This approach is a combination of the processes and ideas involved in visual thinking (Goldschmidt 1999; Herbert 1993) and design methodology as imagined by such authors as Christopher Alexander and John Chris Jones. It supports this alternative approach to design education with evidence from empirical studies (conducted by the author) and consequently, proposes a digital design coach. Succeeding this is a description of what such a tool might look like utilising research by Mark Gross and Ellen Do (with their electronic cocktail napkin project) as a basis on which to derive the "engine" for the tool. We conclude with the argument that not only is it prudent to provide the computer to students as alternate media to physical models and pen based systems but also as tools used in the direct learning of design ability which is the primary purpose of design education.

2 Arriving at a suitable model

2.1 Sketching

The hand sketch is one of the most important tools that the Architect uses in the design process. Rather than simply being a method to record ideas, the designer uses the sketch as a means to reason with. Researchers have likened the act of sketching to conversations (Schön and Wiggins 1992) and have given value to the idea of backtalk (Goldschmidt 1999) in which the drawing itself acts as a catalyst to propel the design process forward. It can be suggested that the designer in actuality explores the drawing for *clues* as to the way forward. In this way, the sketch fundamentally directs and aids the architect's decision making.

Sound and imaginative decisions are based on the designer's ability to take advantage of sketching. In other words, the more experienced the designer is, the easier it is for the sketch to inform and clue him or her in on the vital aspects of the problem.

2.2 Double H

Based on the presupposition that sketching can be seen as the meeting of the "hand" and "head" to achieve a design solution, a unique protocol analysis experiment (termed Double H) that put human subjects in both these roles was developed by the author. One person was the "head"; this person did the designing by telling the *hand* what to do. The other person was the "hand"; this person had the responsibility of sketching images to assist the *head* in grasping the problem and progressing towards a satisfactory design outcome (Bailey 2000).

When it became clear (based on preliminary analysis of the protocol) that this technique could also be used as a teaching tool, the experiment was expanded for design studio with the aim of illustrating to students the generative role of drawing in designing.

The two-week project was introduced into a second year architectural design course at Victoria University of Wellington, where each student acted as either *head* or *hand* in the design of small building.

The exercise was repeated later at the Caribbean School of Architecture in Kingston, Jamaica. One difference between the two studios was the fact that students from year 3 (equivalent to the studio in Wellington) were paired with students from year 6.

In these experiences, the medium for communication between *head* and *hand* was the sketch. At all times, when the *head* came up with design ideas, the *hand* attempted to interpret and represent explicitly the issues embedded in the decisions the *head* was taking. It soon became obvious upon analysis that the level of expertise in the *hand* contributed to a relatively smoother process for the *head*. This is illustrated in the following protocol extract where a practitioner (expert), in the role of "hand", attempts to "clue" the student (novice) in on the implications of various design decisions about a stair:

Expert: Do you want me to leave that much for your landing? (indicates distance on drawing)

Novice: Yep, Yep. We could go that way

Expert: Or we could wind up further. (Makes circular motions)

Novice: Wind up further, yeah

Expert: And then just come back a little way this side, which means people, could walk… (starts to draw outline of stair)

Novice: I think… yeah we will go like that. Keep the walkway though because I want to be able to get around the other side.

It can be extrapolated from the anecdotal evidence presented that the expert as hand in the arrangement broke down the task under investigation into smaller issues or clues for further exploration and in this way acted as a 'clue machine'. It can also be seen that the clues offered by the hand made it easier for the head to comprehend the "make-up" of the problem.

2.3 Design Education

One of the chief purposes of design school is the learning of design ability. The main pedagogical tool used is the *design studio.* Here teaching is done by confronting the student with a series of problems (or projects) increasing in complexity. These are diverse situations with different approaches, themes, focuses, and contexts and unless the project is technically oriented, the student is usually expected to self learn from reference books the technical and social paradigms that have implications for the users of the solutions proposed. Although this information is readily available, a beginning designer sometimes has no idea such issues exist or even where to look. More often than not, in the opinion of the student, these are the very issues that seem to "get in the way" of the solution.

Students often miss the evasive fact that design is a deliberate and conscious act. Due to implicit messages transmitted by design teachers, it is not communicated directly to students that learning design not only involves creation but also largely involves the recognition and analysis of problems and the contexts within which they exist (Ledewitz 1985; Dutton 1987). One way of enlightening students would be to break down or decompose the problems into smaller inter-related issues or problem states. This creates a "map" of the problem

that the student can use to navigate his or her way through the task. The solution then, is finding a suitable method or approach that gives students the ability to "see" design issues connected to design situations whilst learning about them. The student then gains an appreciation of the problem and handle related issues better.

This requires having "someone" who rationally deduces the design problem/situation make-up, asks the right questions or provides the right clues that enable the student to tackle the problem. Since it would be expensive and time consuming to provide such a person for every student while they were engaged (at all times) with a design problem, the computer could easily fill this role. The computer then serves as an important component when teaching young designers essential design skills.

3 Digital Tools

3.1 Electronic Cocktail Napkin

Digital tools for architectural design have reached the point today where "pen based interaction will allow architects to use the pencil again" (Gross, Do & Johnson 2000). Demonstration applications have been built that recognise sketches and provide analytical tools to the user (Do 1998) and prototypes now explore the direct generation of three-dimensional form from freehand drawing input (Gross, Do & Johnson 2000). Of all these tools the one that shows tremendous potential in relation to the approach advocated in previous sections is the Electronic Cocktail Napkin developed in the mid-nineties by Mark Gross, then of the University of Colorado. This project was designed to be a prototype diagramming environment that targeted early design activity (Gross 1996). The aim of the project was to support designers in the incremental formalization of the design idea, from conceptual designing to schematic designing. In this environment, a pen-based interface supported ambiguity and non-commitment, parsing and recognition systems analysed the sketches created by the designer and their spatial relationships, and constraint management routines kept the high-level relationship between designer's diagrams. (Tang and Gero 2001)

3.2 Right Tool Right Time

Using this project as a foundation, Ellen Do (who worked as assistant on the aforementioned project) examined through her Ph.D. thesis the viability of an intelligent sketch environment that provides designers with the right tools at the right time (Do 1998). Rather than asking the designer to find and select tools for specific design tasks, she explored the notion of automatically invoking various computational tools based on the designer's drawing. Dubbed RT^2 (Right Tool Right Time) the environment used the drawings of the designer as a reflection of the task being worked on. It then used this understanding as an indicator of intention and provided the designer with knowledge-based support appropriate to the task at hand.

For example, using Do's own words;

> *"… in Organization activities, architects often draw a bubble diagram to explore functional arrangement of spaces; they draw sight lines and viewsheds when working on visual analyses. Therefore, when the designer draws a bubble diagram, RT^2 will retrieve a design case with a similar spatial configuration. When the designer draws view lines in a floor plan, RT^2 will bring up a spatial analysis program. When the designer is engaged in Ideation activities, RT^2 will find visual references from building slides or natural artifacts based on similar shapes or concepts." (Do 1996)*

3.3 The Digital Coach

Taking Gross and Do's project one step further we propose a digital coach (Fig. 1) that uses the sketch as the method of learning and interface. The pedagogical basis of this coach will involve the idea that by breaking the problem down and presenting it as smaller "problem states" we are giving the student an appreciation of the issues involved in the design situation.

When using the *coach* the designer makes a mark or series of marks on the screen or drawing tablet. With the electronic cocktail napkin as an "engine" the program stores and attempts to recognise the hand drawn figure. Once interpreted the tool presents the designer with a list/mapping of issues influenced by that mark or series of marks.

For example (Figure 1), the designer draws a box on the screen, the tool sees this and provides information through a menu or map about typical room sizes, window sizes, door sizes, or as in the figure asks questions about the nature of the box – is it a room, or a building or just a rectangle? These questions then raises in the mind of the student/designer questions about scale and size and the implications thereof. The designer responds verbally (using speech recognition), 'clicks' on the issue or continues to draw hereby defining the context; the "map" changes accordingly. If the designer defines the context by writing the room name, the list then asks questions about orientation, nature of adjoining room, egress, etc.

The information or knowledge base remains constant whilst the configuration or map changes as the context is developed and determined by the designer. This information is presented within the visual field of the designer's drawing or overlaid on top of the sketch (much like an "Heads-up Display") changing with every stroke and mark. A map of the issues (and decisions) is made (Figure 2) both in the memory of the computer and designer. As an added benefit this enables the designer to revisit the "moves" and reflect on decisions made. The information provided would range from Christopher Alexander's pattern language to ergonomic data, climatic data or rules of thumb (Figure 3).

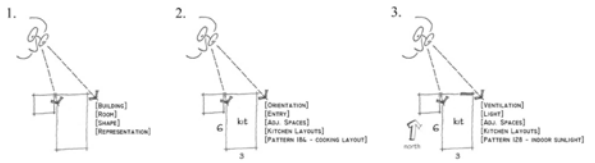

Figure 1. Conceptual representation of the design coach

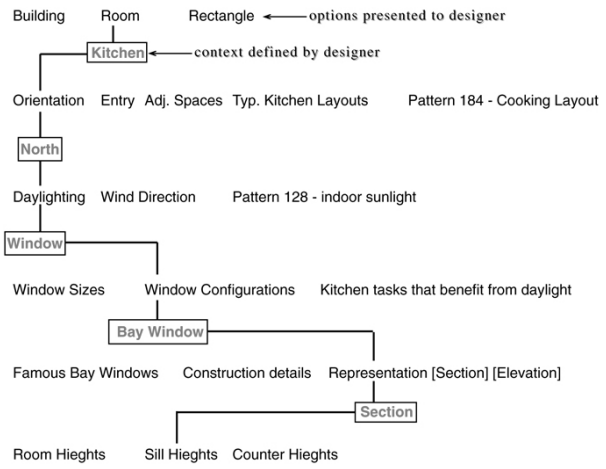

Figure 2. Decomposing and revealing issues

4 Discussion

The most important premise in teaching design is to let the student understand that design is a conscious activity (Uluoglu 2000). Being deliberate during the process makes for a more skilled designer. The key to achieving this is not the provision of a tool that tests, analyses and provides answers but one that makes the issues known by constructing a map of *clues*, facilitating a deeper understanding of the problem. A tool of this kind demonstrates to the student that the changing nature of the problem is dependent on decisions taken hence encouraging more conscious "moves" in the design activity. 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. Teaching design to students by providing them with an "expert" digital partner is an innovative way of doing this

As pointed out by Gero and Tang in their article on cognition based CADD, the electronic cocktail napkin fits well in this role (Tang and Gero 2001). With the Electronic Cocktail Napkin and similar projects we can now consider using drawing in the digital realm as a direct means of *think-*

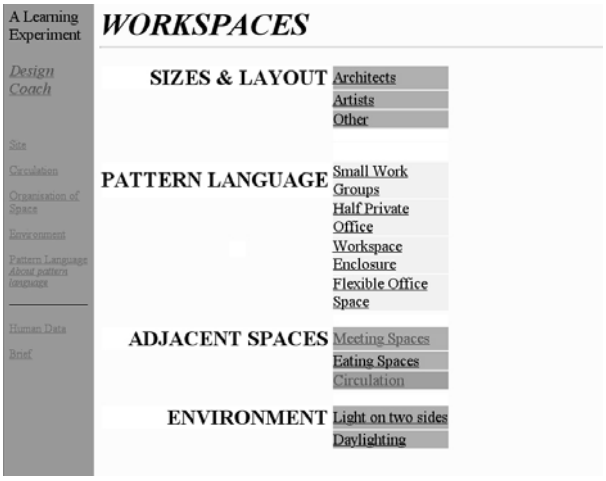

Figure 3. Preliminary screenshot of Design Coach

ing rather than as a means to automatically generate forms and shapes for consideration.

Taking the idea of a cognition based digital tool further and linking it with ideas in design methodology and systematic designing we propose the development of a digital teaching tool that can be used by young designers to acquire design skills. This teaching tool for young designers (students) would use the sketch as the method of learning and interface. This would be an excellent way of exposing student to the benefits of visual thinking as well informing them of some of the oft-neglected fundamentals of Architectural design.

The sketch, for the student, becomes a conscious tool that supports and informs exploration. In turn it allows the student to make more intelligent, well-informed and confident decisions.

Thus, the computer is no longer perceived as alternate media to physical models and pen based systems but rather as a tool to be used in the learning of design ability which is the primary purpose of design education.

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