Critical points for change

A vital mechanism for enhancing the conceptual design process

Panagiotis Parthenios
Harvard Graduate School of Design, USA
http://www.parthenios.com

The Conceptual design is not a linear process; it consists of sub-processes, levels of refinement, which are individual but interact with each other. Each level of refinement corresponds to the types of media and tools used during conceptual design. Architects take advantage of a broad palette of tools and media for design, because each tool has its own strengths and weaknesses and provides an additional value—an added level of vision—to the architect. This closely relates to the notion of Critical Points for Change (CPC) a contribution this study makes towards a better understanding of the uniqueness of the conceptual design process. CPC are crucial moments when the architect suddenly becomes able to "see" something which drives him to go back and either alter his idea and refine it or reject it and pursue a new one. They are crucial parts of the design process because they are a vital mechanism for enhancing design. This characteristic of the nature of the conceptual design process is independent of the tools. Nevertheless, the right tools play an extremely important role. The distinctive capabilities of each tool allow the architect to deal successfully with CPC and overcome the points in the design process where he or she feels "stuck."

Keywords: *Conceptual design; design process; tool; design ability; computational support.*

Introduction

A massive volume of research has focused on trying to understand how designers perform design. Researchers have approached the exploration of design activity through different research methods, including protocol studies, interviews, and simulation trials. They all agree on the importance of the sketch as the primary tool for developing design concepts, stimulating thinking, performing design reasoning activities, and facilitating the architect's conversations with himself and others.

This paper seeks to shed light on how designers perform conceptual design, by explaining the mechanism of the Critical Points for Change. The following two short cases are part of a series of case studies conducted as part of the doctoral study *Conceptual Design Tools for Architects* (Parthenios, 2005) at Harvard Graduate School of Design. They are included in this paper not with the intention to propose a model of the design process but in order to illustrate some of the findings.

Case Study A

In the first case study we can observe what tools the architect and her team used to perform conceptual design and why the design process is not linear.

Audrey, a senior architect in Stubbins Associates, worked with two junior architects on a 6,000 m^2 research lab. She began with small sketches on her sketchbook which analyzed and filtered the information that the client had given. The first sketches were very simple and represented the basic requirements of the project. They included thoughts, questions, solutions, forms and ideas. Gradually these sketches became geometric attempts to capture the main concept and in the next stage they adopted a bigger, common scale on tracing paper. The beauty of this initial step of conceptual design lies in the freedom and ambiguity that allow the architect to address anything she wants in no particular order or hierarchy (Figure 1).

When Audrey reached a concept that she believed had good potential, she asked her two team members to take the space requirements that the client had given them in Excel spreadsheets, analyze them and translate them into geometry. This was done in AutoCAD 2D with simple rectangles that represented each module and led into some primitive plan layouts (Figure 2).

After accomplishing a satisfying layout of the plans which matched the main idea in sketches, Audrey wanted to see how that would look in 3D. She let the two team members play individually in

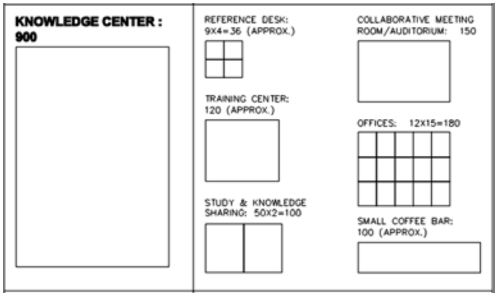


Figure 2
Translation of space requirements into geometry in AutoCAD.

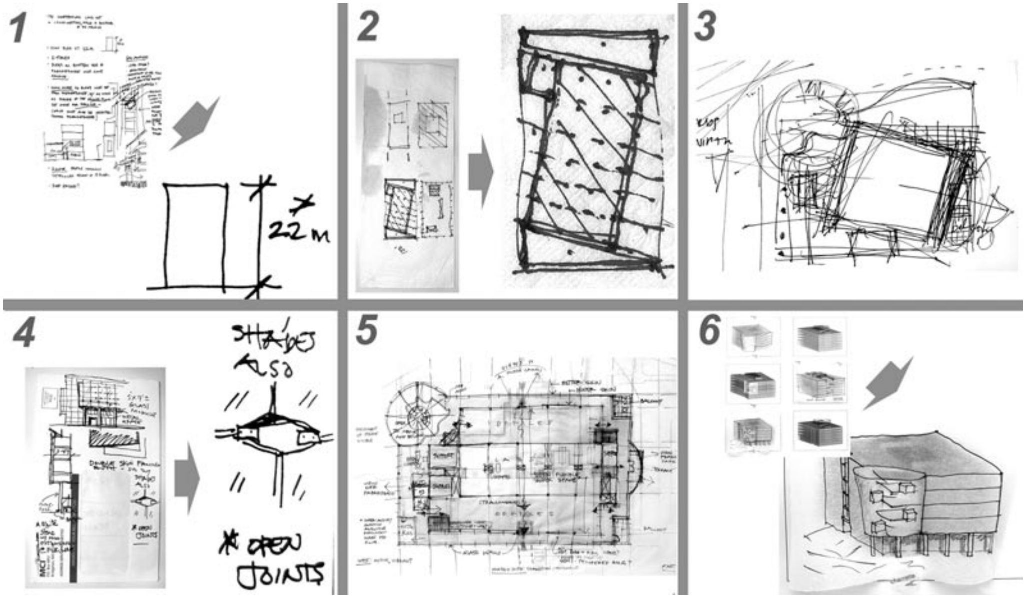


Figure 1
Sketches at different stages.

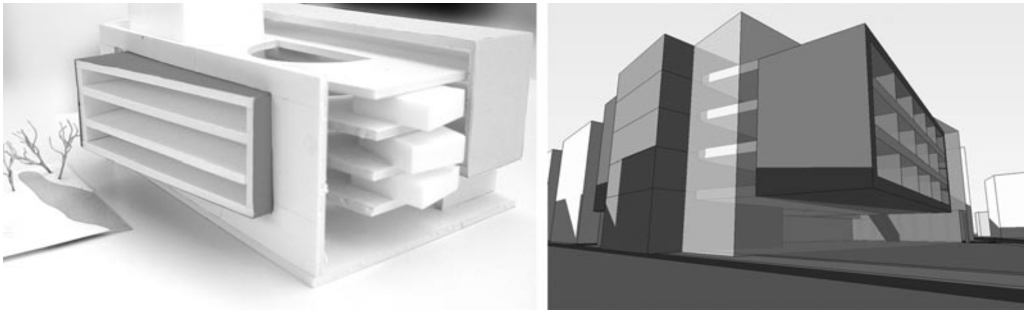


Figure 3
Physical 3D model (left) and digital 3D model in SketchUp (right).

3D and explore a number of variations. They used SketchUp to create simple digital 3D models. They would print screenshots of the models, hang them on the wall so that everyone on the team could look at them without necessarily having to meet, and Audrey would often stop by, overlay a piece of tracing paper and sketch on them.

At some point, and while presenting the digital 3D model to the board of her firm, Audrey realized that "I knew what I wanted the building to do but

Figure 4
Comparative method.

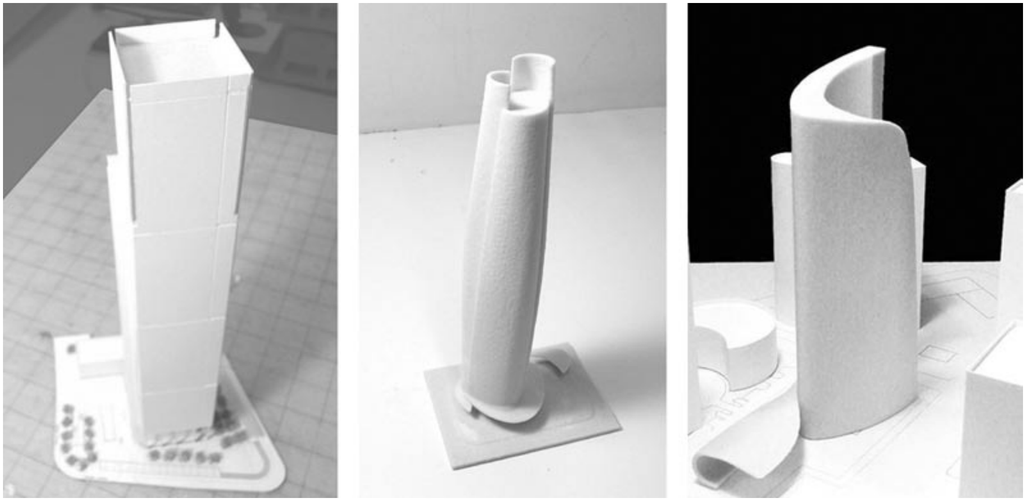


Figure 5
Tower A out of paper (left) and towers B and C out of resin (ZCorp) (center and right).

it was not really doing it". While trying to discover where the dissonance was, one of the team members reminded Audrey of a sketch she had made a few days ago and had left aside. It turned out to be a more suitable solution which they developed further and based their design on. Altering the main idea meant that they had to go back and do the layout in AutoCAD again, along with new sketches and new digital 3D models. The satisfactory result of this process progressed to the next level, which was building a physical 3D model (Figure 3).

The physical model gave Audrey an additional level of vision and allowed her to understand more aspects of the design. "It is not the same as having a piece there that you can break, stick things on, or take them off; its not a tangible thing". The new media triggered alterations which meant the architects had to go back again and update the AutoCAD drawings, the sketches and the digital 3D model.

Case Study B

In the second case study we can compare how the same architect used different tools and media in three projects and what the effect of that was on each design.

Robert, a senior associate principal at KPF, designed three office towers in Asia. His office works on a comparative method during the conceptual design stage (Figure 4).

They usually generate a lot of alternatives that investigate formal characteristics, relationships of the program components with one another, plan layouts, space efficiency and they come up with a few favorable schemes that they present to the client. Lately, the office has started to use the computer more as a generative tool than just a deploying tool. For all three of the projects in this case study, the goals and the starting point were quite similar. Robert would start with some sketches in order to explore an idea about the tower and its relationship to the site and the program. Because the towers are three-dimensional forms the goal is to get from that sketch to a model where the tower can be seen in three dimensions in relationship to its context. In tower A no computer tools were used for conceptual design; in the next two towers B and C, computer modeling in Rhino played a crucial role in helping Robert and his team to explore a number of design schemes (Figure 5).

When Robert designed tower A in 2000, he was not using computers during conceptual design so all the exploration was done through sketches and physical models. He started with a few sketches, which were followed by hand drawings, pencil on straight edge. These led to physical 3D models made out of paper which were placed on the context model in order to determine how the tower related to the site and the surrounding buildings. During the exploration the initial square plan view of the tower was slightly deformed to get some directionality and later the sharp corners where chamfered in order to comply with the city regulations.

Tower B was the result of combination of the contextual response to the site and the mayor's interest in having an iconic building that would resemble a magnolia, the city flower of Shanghai. Robert started with the idea of having the plant form at the ground level, which would rotate as it rose and this rotational aspect could give it some organic feel. After a few sketches he used Rhino to make a 3D model of the tower and capture the form he liked. Moreover, he had just learned how to use Rhino, and one of the first commands he had learned was how to twist and also how to loft a curve. "*This initial scheme was very much a result of playing with new software*." For this project his team used many small physical 3D models, initially out of paper and later out of resin (ZCorp directly from Rhino).

In tower C we can see a wider variety of tools and means deployed during conceptual design and a more mature use of digital tools (Rhino). Robert and his team used sketches, small physical 3D models out of clay and paper, Rhino for digital modelling and subsequently ZCorp printed 3D models. They explored a large number of alternatives using all of the above means at the same time, moving back and forth between the tools and producing three different complete scenarios which they presented to the client.

Conceptual design process

The design process is open-ended and problems and solutions cannot be clearly identified and separated. This set of problems and solutions cannot be broken into parts that can be solved separately; it has to be treated as a whole. Moreover, there is no perfect, "right," solution, only preferred, better ones. This means that the architect needs to be able to decide when to stop exploring different ideas and select one to carry on into development as the main concept. As we saw in Case Study A, during this hunt for a better solution there are often back and forths, switches between different media and tools, and constant questioning of ideas through comparisons, tests, and rejections. The conceptual design process is not linear.

Since there is no one "right" solution, but only better ones, there is also no panacea or set of methodologies for approaching conceptual design. Bernard Tschumi, in another case study not included in this paper, believes that an architect can use different strategies in every project and cannot prescribe which the right one is. On some projects he would explore all the possible permutations and then select the most appropriate; on some others he would look at the site and the restrictions of the project and simply conceive the main idea. On some projects he believes that computer tools are crucial in helping develop the concept (Museum of Sao Paolo) and on some others not at all (New Acropolis Museum).

Furthermore, according to the data gathered from 242 architects who participated in the Survey for Tools for Conceptual Design[1] (Parthenios, 2005), most of the architects tend to explore two to three ideas before they choose the "one" and move on to design development. What is interesting is that, contrary to what one would expect, the more expe-

[1] The survey was conducted online between 01/21/04 and 02/18/04. It was open to anyone who wanted to participate and was advertised through web forums and email messages. The 241 participants were architects who are computer users.

rienced someone is, the fewer ideas he/she tends to explore. In fact, the Survey reveals that senior architects tend to explore fewer ideas than the drafters or interns in offices. Also, contrary to common logic, exploring more ideas does not necessarily mean that conceptual design takes a larger proportion of the total design time: architects who explore four to five ideas spend less time on conceptual design than those who explore two to three ideas. However, no matter how many ideas the architects explore, they do often feel the need to go back and revise their design (as Audrey did in Case Study A). In addition, switching between different media and tools creates loss and duplication of information and forces them to re-enter information; nevertheless, they choose to do it even if that causes delays.

Comparative method

One of the most common practices in conceptual design is the comparative method. As we saw in Case Study B, the architect creates many alternatives in order to be able to compare, reject, and select. It is easier for the human mind to select one solution among others than to conceive of it originally and directly. This preference is similar to the following problem: when given a straight line and asked to mark an eighth of its length, it is easier to divide it in half, then divide the remaining length in half and the remainder in half again. The mind works better when comparing than when calculating.

Marples argues that the nature of a design problem can only be discovered through examining proposed solutions (Marples, 1961). He argues that if we examine only one proposal we end up with a very biased view. We need at least two radically different solutions in order to compare them and get a clear picture of the "real nature" of the problem. Nigel Cross agrees that even a conjectured solution is critical because it helps the architect understand the design problem. Generating a variety of solutions is a method of problem analysis (Cross, 1990). Hand drawn sketches have traditionally been the primary tool for design exploration and experimentation. Sketches not only allow the architect to visualise his or her thoughts; they also provide valuable feedback and facilitate a constructive dialogue between the architect and his or her ideas. John Gero stresses the importance of hand drawn sketches as a means of review: architects generate more meanings when revising their sketches than when drawing them (Gero et al., 2001). Architects have recently discovered the potential that certain computational tools have in helping them "talk" with their designs, in order to explore, play, be surprised, get inspired, meet the unexpected, judge, compare, refine, reject and select.

A tool for conceptual design must facilitate the need for comparisons, as an essential element of design thinking, design reasoning, and problem solving.

Sub Processes - Levels of Refinement

Conceptual design is not a linear process. It consists of sub-processes which are individual but interact with each other. Each sub-process has its own unique value and grants the architect an additional level of vision. The sub-processes correspond to the types of media and tools used during conceptual design.

For example, in Case Study A we can distinguish four separate sub-processes, which play a valuable role during decision making: a) sketching; b) 2D CAD; c) 3D digital modeling; and d) 3D physical modeling (Figure 6).

In this example, only when Audrey used a digital 3D model was she able to see an aspect of the design –which sketches and 2D CAD could not reveal- and decide that she had to go back and change the main idea. Going back entails a manual update of the design with new sketches and new CAD drawings. Similarly, only when the architects built a physical 3D model were they able to see another aspect of their design that needed to be altered; they decided to go back again and make the appropriate changes. Then again they had to re-input information in new CAD drawings, a new digital 3D model, and new sketches

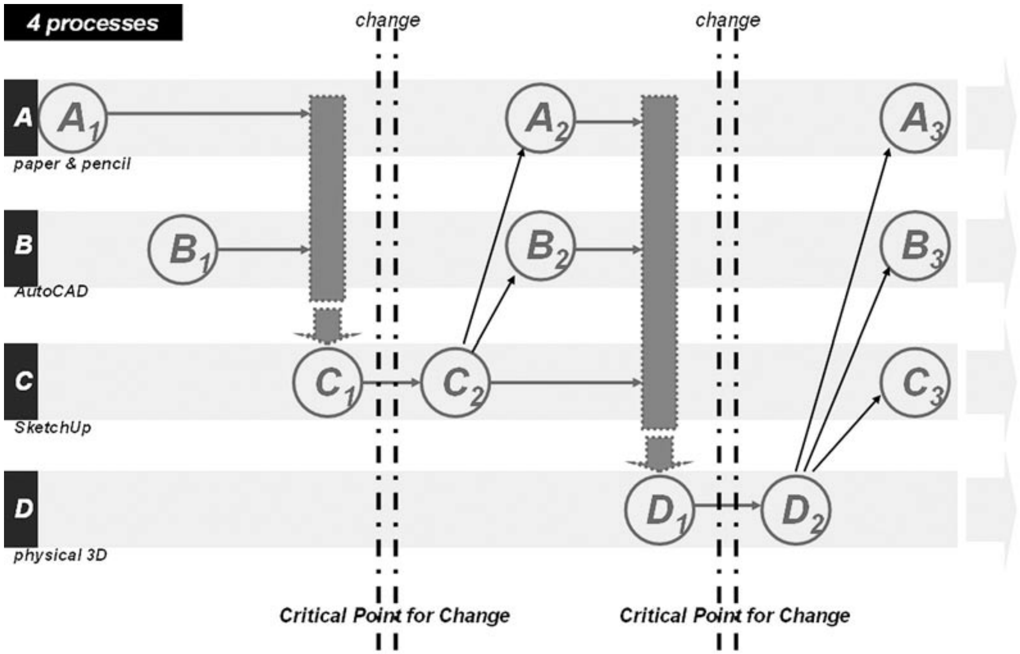


Figure 6
Sub Processes and Critical Points for Change (CPC).

(Figure 1).

These sub-processes operate as levels of refinement for the conceptual design process. Each level functions as a filter for narrowing down the number of explored alternatives. The tools used in Case Study B define four levels of refinement: a) simple sketches; b) rough small paper 3D models; c) digital 3D models in Rhino; and d) printed 3D models (ZCorp) (Figure 7).

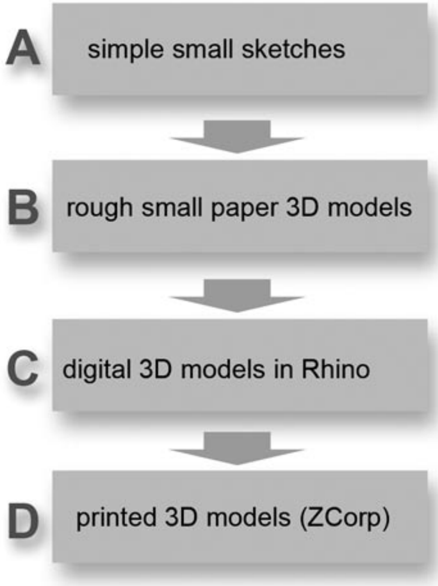
Robert utilized only the first two levels in Tower A since he was not using computers at that time. The result was a simpler design based on an extrusion of a skewed square. No one can claim that the designs of Towers B and C, which exploited four levels of refinement, are better, because what is better design? What we can observe though is that the added levels provided the platform for more exploration and allowed the architect to investigate forms which he could not have done –and he did not do- by hand.

Additionally, in Case Study B we encountered an example of how the selection of tools affects the design outcome. Robert arrived at the design of Tower B because of the particular command of the software he was using. Software tools are not innocent anymore. Undoubtedly proficiency with software reduces the effect on design solutions.

Critical Points for Change

The levels of refinement are closely interrelated to the notion of *Critical Points for Change*. These are moments when the architect "sees" something that drives him to go back and either alter his idea or start with a new one (as it was clearly illustrated in Case Study A). They are crucial parts of the design process because they are a vital mechanism for enhancing design. They either trigger alterations that refine the design solution or provoke the architect to reject the

Figure 7
Levels of Refinement.



idea and pursue a better one.

Often a new level of refinement would provoke a CPC. Through the help of a new tool, the architect becomes able to "see" something that was not visible before and can decide to go back and a) alter the design idea, b) abandon it and begin from scratch, or c) abandon it and pick an idea that had been discarded or left "inactive". Moreover half of the architects who participated in the Survey on Tools for Conceptual Design (Parthenios, 2005) reported that several times they had changed their minds and that they went back even if they had proceeded to the design development stage.

Even though CPC might look like irregularities that make the conceptual design process inefficient, the truth is that they are absolutely necessary for a creative, genuine course of design exploration. Besides, the desired outcome does not emerge on the first try. Architects need to explore a number of ideas until they can choose the optimal one.

Tools for conceptual design should not attempt to disguise or underestimate the Critical Points for Change. To the contrary, the tools should assist the architect during CPC cases in six ways:

a) Reveal CPC cases earlier in the process.

b) Provoke the emergence of more CPC cases.

c) Encourage deeper exploration of each alternative by offering additional levels of vision and understanding.

d) Support the architect in the dilemma of whether to alter an idea or abandon it and start again from scratch.

e) Organize all the different ideas and present a broad palette of them.

f) Integrate the different media and tools in order to reduce the inefficiencies that CPC causes.

References

Cross, N.: 1990, Design Studies, 11, pp. 127-140.

Gero, J.S., Chase, S., Rosenman, M.: 2001, Association for Computer Aided Architectural Research in, A., Conference, University of, S., Key Centre of Design, C. and Cognition CAADRIA2001 : preprints of the 6th Conference of the Association for Computer Aided Architectural Design Research in Asia ; [held at the] University of Sydney, NSW, Australia 19-21 April 2001, Key of Design Computing and Cognition, University of Sydney NSW, Australia.

Marples, DL.: 1961, IEEE Transactions of Engineering Management, 8.

Parthenios, P.: 2005, Conceptual Design Tools for Architects, Harvard Design School, Cambridge, MA