UNDERSTANDING DIGITAL DESIGN TECHNIQUES IN SAUDI ARCHITECTURAL EDUCATION

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Abstract. To understand the current architectural digital design techniques, architects and architecture educators and students need to know that these techniques are the new tool set. These techniques offer architects a new way of thinking and designing and enhance complexity. They will link architecture design with mathematics and computation, and they will generate and improve ideas. Giving that Saudi architectural education is still using traditional manual techniques and using technology only for drawing and montaging, this evokes the fact that there is a need to know and understand these techniques and their importance.

1. Introduction

With recent technological developments, digital design techniques are becoming more complex, which radically affects architectural design and architectural education. In architecture, computers have become more available and affordable than ever before, which enables the production of curvilinear and complex surfaces. This has triggered the need to understand these techniques, especially at the architectural education level in Saudi.

Architecture has witnessed a transformation movement from the manual tool-based design to a global computer-based design. But, due to a lack of architectural computational education or increased confusion on digital design ,this transformation has not reached its full potential (Terzidis, 2006: p. 40). The use of this technology is still at an unstable phase, especially in Arab countries. Some architects develop their designs in the traditional manual way, whereas others in the West are using computers to explore new possibilities and expand beyond the limitations of the human mind.

Now, computers have become an intelligent system that help designers to maximise the decision-making options. Computers have become an intrinsic aspect of architectural teaching to the extent that architects may not be able

to design or build without them. For instance, Carpo (2013: p. 8) states that a building in the digital age is not one that is being designed and built using digital technology; in fact it is one that could not be designed or built without it.

This paper will discuss five main aspects as an introductory platform to inform architecture educators and students in Saudi Arabia. The first part will describe how these techniques became a new way of thinking and designing. The second section will talk about the role of digital technologies in increasing complexity in architecture design. Then the relationship between architecture and mathematics will be discussed. Coupled with that is the relationship between architecture and computation. The last part will study the debates on considering computers as a drawing tool or as a generative system.

The recent Saudi architectural education appears to be removed from these techniques. According to some Saudi educators and students interviewed by the first author, Saudi architectural education still uses the old school way of delivering architecture design knowledge and skills. They also agree that computers are used at Saudi architectural schools, but only for drafting and montaging. For example, Alkharoubi (interviewed 2014) described the current process in their school: using manual techniques such as 2D, 3D, shade, shadow and others. Then they move to draw in 2D using AutoCAD, then to 3D modelling. While other interviewees such as Al Jabali, Gadi and Alsamhan (interviewed 2014) agreed that, in terms of technologies used at Saudi universities, computers are used in traditional "2D and 3D" ways, the new digital design techniques, their software and programming languages are not used yet.

2. A new way of thinking and designing

Digital design techniques have been introduced as a new way of thinking and designing. These new technologies have the ability to go beyond the limitations of the human mind, which cannot perform such sophisticated processes and cannot run for a very long time in the way that technology can. According to Jakob (2011: p. 142), the digital and technological revolution has expanded the limitations of imagination and possibility.

Using computers in architectural design should be an extension of the human mind, enhancing the ability to produce, generate and evaluate. Terzidis (2006: p. 22) claims that architects have been using computers as a device to generate, discuss, and critique new forms in an attempt to introduce a new way of thinking and designing.

The generation of digital computational forms is contrasted with the traditional way of designing. It uses logical steps and/or calculations,

whereas the latter depends on intuition and decisions of the human designer. Today, architects are using a collection of digital techniques, such as algorithms, scripting and simulation, to generate complex forms (Tang, 2014: p. 19). Architects can now conceive and construct geometries that were very difficult to achieve using traditional methods; as such, the popularity of these technologies has increased (Dunn, 2012: p. 6). This is evidence that technology is a driving trigger that has opened up endless opportunities (Barkow & Leibinger, 2012, p. 94).

From an architectural perspective the exploitation of digital technologies is the ideal way to explore the new and/or future architecture. By introducing digital technologies to architectural design, the designer can achieve a coherent integration of concept, investigate form-finding and generative approaches, and add intelligence and performative aspects to the outcome (Tang, 2014: p. 8).

Computers can extend the capacity of our imagination and allow us to communicate as never before (Cook, 2004: p. 41). It is a relationship where both designer and computer take advantage of each other. Computers provide enormous calculation power but with no intelligence, meanwhile humans have limited calculation power but with enormous intelligence (Williams, 2004: p. 79).

3. Complexity like never before

Recently, complexity issues have been raised which relate to the architects' concerns and interests. With the available technological techniques, architects can maximise the exploration of the unknown world of complexity.

Before the intervention of computation in architectural design, forms which are difficult to draw and measure used to be difficult or impossible to build or, in other words, there was no complexity. Carpo (2011: p. 32) states that you cannot build what is in your mind if you cannot draw it in order to have others make it for you. But when you cannot make what you cannot draw, what then? In this case, the role of computers is emphasised, as architects need technology to help them draw and make what is in their minds, even if it is extremely complex.

One of the key ideas behind complexity is manifested in the replication, combination and changing of small, simple parts that follow simple rules to generate a series of unpredictable iterations and new information (Burry & Burry, 2010: p. 53). Often these ideas are discerned from some process in nature such as self-organisation. Frazer (1995: pp. 19–20, 102) claims that in nature the developmental processes led inevitably to complexity. This

complexity could be the result of mimicking the natural behaviour of flocks, swarms, crowds and schools.

Kolarevic (2004: p. 7) is certain that using digital technology opens up new possibilities to generate and construct complex forms in novel ways. This strengthens the connection between complexity and computation in architecture. With the aid of computers, designers have the ability to handle greater complexity that could not be handled in the conventional way "by hand" (Schroder 2008: p. 154).

4. Architecture and mathematics

Architects have been able to link algorithms, computation and design in one logic to derive "algorithmic design". The term "algorithmic design" brings together computational complexity and the creative way of using computers to allow architects to move towards programming architecture (Terzidis, 2006: p. xii). Therefore, digital algorithms are mathematical models that tie together all contemporary architectural intentions.

An algorithm is actually a set of information and instructions given by users and performed by either humans or computers, and is based on the way that the problem is addressed and understood. Where the instruction is performed by humans, it will be direct, precise, definite and logical, but where it is performed by computers, it is a linguistic expression – code or script – written by humans to be run by computers to produce the same quality as the human outcome but in a shorter time and with huge iterations.

When architects code an algorithm to help solve a design problem, they can explore more options by modifying the program or sketching it by algorithms. It is crucial to know that using algorithms is conditioned upon fully understanding the rules from the very beginning to the end. Williams (2004: p. 79) argues that an algorithm is only complete when every rule it contains is fully described.

Algorithms could be assigned to handle more than one particular design problem that they were never designed to address. For example, if an algorithm is being designed to help find the ultimate curvature of a building cladding, the same algorithm can be developed to address completely different problems. Terzidis (2006: p. 23) indicates that the same algorithms can be used with different parameters to produce completely unexpected behaviour. However, the designers can keep changing and tweaking the algorithmic variables until they are satisfied.

Recently, the relationship between algorithms and computers has become very intimate, but the human aspect still plays a vital role in the process. Some scholars such as Terzidis, Carpo and Burry and Burry, agree that the relationship between algorithms and computers is not necessarily associated

with computer science. Most of the algorithmic preparatory steps are predetermined by the designer according to the design problem. Then the designer interprets these steps to allow the computer to understand them and calculate them in an algorithmic format. But overall, the designer has the responsibility of creating and understanding these algorithms.

5. Architecture and computation

Terzidis (2006: pp. vii–viii) points out that usually the computer's involvement in architectural design takes two trends. First, some designers consider computers as an advanced drawing tool. Second, other designers decided to enter the world of scripting and programming to take advantage of what computers can do. Indeed, computers are a complementary tool to humans that helps them to think outside the box.

Architecture has moved from hand drawings to computerisation and, more recently, to computation. Computation means calculating, or using a mathematical or logical method to determine something. It is less popular as it requires extra knowledge in programming and scripting fields, and is "the hard way".

Compared to the conventional tool set, architectural computation has a notion of the exceptional and unprecedented. Traditionally, designers use the available manual tools. As a result, the outcome will be something predictable, doable and usual. The digital way, however, depends on the available techniques or sometimes requires developing new techniques, and the resultant outcome is most likely something unexpected. Terzidis (2006: p. 55) stresses that concepts such as randomness, complexity, emergence or recession are incomprehensible by the human mind because they depend on intellectual means that are external and foreign to the human mind.

Architects categorise computer use into tool makers and tool users. Tool makers refer to computation aspects that provide design exploration tools by using computers and they are usually software developers, computer scientists and mathematicians. In contrast, tool users seek to connect their design ideas with the digital phenomena (Terzidis, 2006: p. 56).

Architectural programmers could be architects who want to describe the design process using algorithms that use the computer's capacity to produce a desirable outcome. Understanding algorithms is not enough; architects need to grasp computation as an operator who can run algorithms faster and with more accuracy. According to Dunn (2012: p. 60), algorithms and their use in architecture may generate and develop design ideas, but architects need to understand that this requires a shift in the way they use computers.

Computer-aided design applications offer a collection of algorithmic commands which deal with a specific graphical design issue. The user of

these applications may not understand the algorithmic logic running behind them, nor do they have enough knowledge of how they work, and therefore the user is not able to grasp the application's ultimate power.

6. Drawing tool or generative system

Throughout history, architects' work has been linked to drawing as representational and designing tools, but today's computerisation and computation still do the same job but in a more advanced manner. Peters (2013: p. 15) argues that as pen and pencil are used to draw conceptual sketches and building details, computation tools can be used to provide better communication, increased efficiency and conceptual sketching of algorithmic concepts. Architecture is now experiencing a shift from drawing to generative algorithms.

In architecture, the term 'tool' refers to the cooperation between designers and computers, but digital technology may be viewed as a drawing tool or as a generative system. Some scholars look at it as just a drawing tool, some as a generative system, some as a collaborative partner, and others see it as both drawing and generative at the same time.

Ramona Albert, in a conversation with Terzidis (2006: p. 149), argues that computers are just tools that fulfil the designers' needs because they do not have a mind of their own. Albert says that we even use algorithms because we need to be in control, "imagine if computers have their own mind and control, we will be living in a nightmare".

On the other hand, Christopher Shusta (Terzidis, 2006: p. 150) emphasises the role of computers in decision-making. He argues that "computers are not the equivalent of pencil", as a pencil never acts to generate forms, it only represents the designers' ideas while computers can help in the decision-making.

Marble (2012: p. 9) and Frazer (1995: p. 10) claim that the use of computers in architectural design is varied, for they could be used as representational tools, and they could also be used as generative systems that receive coded algorithms to produce architectural outputs, hence can be used to increase the designer's imaginative capability.

The design process has changed from drawing surfaces to setting up rules through programming. The new generative and parametric design systems use a collection of constrained rules and relationships between objects (Vanucci, 2008: p. 118). It is an exploratory shift towards programming in architecture in order to get the most benefit from computation. Programming is a method where we can experiment using rules and principles, for it questions the way people think and the way the mental process develops through the use of computers, which is the only way to benefit from the full

capacity of computers, and is also the vehicle for obtaining knowledge and seeing hidden things. For example, instead of changing a whole set of drawings using the computer mouse by clicking and dragging, it is easier to use algorithms by changing some of their variables.

7. Conclusion

Computers are not fully automated machines which have the ability to run, process and produce without human intervention. Some architects think that they are great users or fans of digital design, but what they are doing is manual transaction "mouse manipulation" which allows them to move, drag, bend and stretch what they see on their screens. Digital design is a process, not a tool or a product; it is about using algorithms to make patterns to be run by computers, to explore the imaginary and unpredictable concepts which are impossible to be explored by the human mind.

With digital design techniques, Saudi educators and students need to (re)think and design differently. They need to know that technology has been used to generate, discuss and critique new architecture in an attempt to introduce a new way of thinking and designing. Architects are now able to understand and produce geometries that were previously very difficult to achieve using traditional methods. This will also allow architects to explore far more complex shapes, in addition to breaking the barriers of physical constraints. They need to understand that using technologies in architectural design will promote complexity, novelty and better opportunities, more than ever, to the extent that complexity itself is not complex to achieve.

They also need to grasp that they are now able to link mathematics, computation and design as 'one logic' aimed at algorithmic design and programming architecture. Finally, they need to comprehend that using computer-aided design packages to manipulate architectural geometries is not ideal for this exploration. This exploration needs a new generation who are willing to channel their efforts through computation, algorithms and architectural logics towards new digital architectural designs.

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References

BARKOW, F. & LEIBINGER, R., 2012. Designing assembly: how tools shape materials that constitute space. *In:* S. MARBLE, ed. *Digital workflows in architecture: designing design, Designing assembly, designing industry*. Basel, Birkhäuser: Page, 49-99.

BURRY, J. & BURRY, M., 2010. *The new mathematics of architecture*. London: Thames & Hudson.

CARPO, M., 2011. *The alphabet and the algorithm*. London: MIT Press.

CARPO, M., 2013. *The Digital Turn in Architecture 1992-2012*. AD Reader, John Wiley & Sons.

COOK, M., 2004. Digital tectonics historical perspective future prospect. *In:* N. LEACH, D. TURNBULL & C.J. WILLIAMS, eds. *Digital tectonics*, Britain, Wiley-Academy: Page, 41-49.

DUNN, N., 2012. *Digital fabrication in architecture*. Laurence King.

FRAZER, J., 1995. *An evolutionary architecture*. London: Architectural Association.

JAKOB, A., 2011. Digital media and architecture: an observation. In: Rieser, Martin, ed. *The Mobile Audience: Media Art and Mobile Technologies*. 5, Rodopi: Page,141-154.

KOLAREVIC, B., 2004. Architecture in the digital age: design and manufacturing. London: Spon Press.

MARBLE, S., 2012. Digital workflows in architecture: designing design, designing assembly, designing industry. Basel: Birkhäuser.

PETERS, B., 2013. *Computation works: the building of algorithmic thought*. Architectural Design, John Wiley & Sons.

SCHRODER, P., 2008. Digital geomtry. *In:* M. RAPPOLT, ed. *Greg Lynn form*. Rizzoli: Page 146-155.

TANG, M., 2014. *Parametric building design using Autodesk Maya*. Routledge.

TERZIDIS, K., 2006. *Algorithmic architecture*. Routledge.

VANUCCI, M., 2008. Open systems: approaching novel parametric domains. *In:* T. SAKAMOTO & A. FERRÉ, eds. *From control to design : parametric/algorithmic architecture*. New York: Page, 118-121.