

TECHNOLOGY AND ARCHITECTURAL EDUCATION: A CONCEPTUAL FRAMEWORK

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ABSTRACT

The development of materials and technologies available for construction always had affected architecture and architectural education either directly or indirectly. Furthermore, these new developments cannot be thought apart from the changes in the socio cultural and economic structure of the societies. It was both the availability of the pozzolana during the Roman period that lead to construction of imposing structures but also it was the Roman culture that created a need for the construction of these structures. During the modern era it took some time for the architects of the time to accept and use the new technologies and materials available as representatives of the new age. It required not only the availability of these new materials and technologies but also acceptance of them by the society.

During the contemporary period, the development of material and construction technologies coupled with developments in software engineering are providing the means to create the language of new architecture, while at the same time altering the experiential dimension of architecture. Today, architecture and more significantly architectural education are facing a new challenge that needs to be solved: the emphasis on the surreal over the real experience of spaces. In this paper, the interrelations of material and technological developments and architecture is examined in a historical perspective hoping to bring forth some of the critical dimensions related to the discipline of architecture and architectural education. The aim is to highlight the positive and negative opportunities that are presented with contemporary material and technological developments for architecture in general and architectural education in particular.

Keywords: Technological developments, new materials, architectural education

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1. INTRODUCTION

Architecture is a profession that defines spaces to suit certain required functions. As available means are used to define spaces, architecture is directly affected by the materials and technologies available at the time. Architectural education cannot be thought apart from this relationship between architecture and technology. During the long human history the interplay of development of materials and technologies and architectural education had different characteristics, sometimes one lead to another at other times there is a conflict that needs to be solved before they can start working together. During the Roman period for example, the use of pozzolana in Roman cement gave way to unprecedented successes in the construction of imposing structures for public use. Another example is after the industrial revolution when architects were resisting to the use of steel and glass and it took some time for them to reconcile with the use of these materials and to consider technology as the “cultural manifestation of modern man”.

The contemporary period is facing a similar challenge since the development of material and construction technologies coupled with developments in software engineering. On the one hand these developments are providing the means to create the language of contemporary architecture, while at the same time altering the experiential dimension of architecture both in real life as in architectural education because of the emphasis on the surreal over the real experience of spaces.

In this paper, the interrelations of material and technological development and architecture in general and architectural education in particular is examined in a historical perspective in four distinct periods: Before the Modern era including Ancient period and Middle Ages where practice was the key to architecture while architectural education at first involved trial and error problem solving out of which the apprenticeship and guild system was born; Modern period starting with Renaissance well into twentieth century when the academies and universities emphasized theory over practice even though there were some efforts towards the end to unite the two as in Bauhaus example; and lastly, contemporary Post Modern period where the information age and globalization has a toll on everything and where the separation between architectural education and technological developments is at the highest. In doing so, the paper hopes to bring forth some of the critical dimensions related to the discipline of architecture in general and architectural education in particular in relation to technology and materials available over the course of the history. The aim is to evaluate and highlight the positive and negative opportunities that are presented with contemporary material and technological developments for architecture in general and architectural education in particular.

2. HISTORICAL EVALUATION

2.1. Before the Modern Era

One can easily assume that the first design education began during the prehistoric times right after there were skills to learn. The first step in learning involves trial and

error problem solving even among animals. It can be assumed that the first humans also used trial and error to built their shelters. After much experimenting with the materials available to them, they were able to develop a mechanism that hold the pieces together to form their houses. The ones that succeeded were imitated later by others to avoid the failures inherent in trial and error approach. As the complexity of the processes increased the learners needed to be thought with more explicit directions. This can be considered as the start of the apprenticeship system in craft teaching. In this system, a novice who wishes to learn the craft becomes a helping hand for the experienced master in creation of the work. The student first observes the master at work learning the details of the craft and when he tries to conduct the skill he gets corrected by his master to do the work right. In this pragmatic education the theory is not a major component, only the practice needs to be in accordance with the rules of the craft. (Kostof 1977)

During the Ancient period though, when the architects aimed for the timeless forms of the buildings then they had to use precise methods to achieve these true forms. Thus the students of architecture should had to be educated to learn these essential rules of design. As a result, these essential knowledge of the design, the theory of architecture had to be thought as well. The design education now involved not only the teachings of the practice of construction but also this theoretical part as well, which later became the trade secret for the guilds to be handed down from master to disciple. By the time Vitruvius wrote his book on architecture, he emphasized the importance of being educated both on the knowledge of universal principles as well as on practical training. He warned architects, “the child of practice and theory,” to have a thorough knowledge of both to “sooner attain their object and carry authority with them.” (Morgan 1914) It was also during the Roman period that the workers came together as informal and voluntary organizations for the first time and called themselves as guilds or collegia (Gertner, p.85). They not only thought the young designers the theoretical part of design, the objectively true divinely inspired forms, but also the practice of how to construct the buildings.

The apprenticeship system that emphasized crafts continued all throughout the medieval period. The guilds uniting the workers in the same trade started to become more organized especially towards the eleventh century to pursue common interests such as securing raw materials, combating foreign trade, and controlling and regulating the craft itself via educating the young workers. The guild members also socially became more connected to each other as they started to work and even worship together. Their social ties were reflected with their rule to provide financial security for their widows (Gertner, p. 85). A student of architecture, first learned a building craft such as carpentry or masonry or both, and worked alongside the builders on actual projects. The trade secrets such as how to generate plans and elevations through geometrical manipulations or important construction details were thought to apprentice architect by his master and through his membership to the guild. After seven years of education with a master, both on the practice as well as on the theory of architecture, the student became a journeyman for three years travelling across Europe observing and sketching notable buildings while also working at different sites to gain experience. After settling down, the student presents a masterpiece of work to the guild to prove his competence. Only after he is

found qualified by the guild that the student became a master on his right and started to get commissions as well as apprentices of his own. (Kruft 1994)

It was also towards the end of the medieval period that the first universities emerged. With the rise of the city life, revival of trade and renewed interest in learning in the eleventh and twelfth centuries, the schools that were attached to monasteries for education in arts and sciences were not able to meet the new need for trained lawyers, doctors, secretaries and logicians. (Gelernter 1995) The first universities that were established by the end of the twelfth century took their formal curriculum from the cathedral schools and their institutional structure from the guilds. These universities aim was not to develop new knowledge or students creativity, they were to transmit to students the pre-established divine truths by carefully studying authoritative texts. The student in a university similar to one in a guild studied with a master for four years to hone his ability to reason through argument learning standard texts. After passing an examination he received a Bachelor's certificate similar to journeyman's certificate in the craft guilds. After further study, he took exams for Master's and Doctor's certificate. Only those with Doctor's certificate were then hired in universities as a fellow master entitling him to teach. Until further development of the universities, the design education in the guilds were able unite the theory and practice of architecture and both was considered as necessary for an architect to be. (Kostof 1977)

2.2. Modern Era

Modern period starting with Renaissance well into twentieth century can be summarized as a time when theory is emphasized over practice especially for the discipline of architecture. The most rudimentary element of the modern era is its attention to the individual stressing the development of his personality and character in such a way that he would be able to understand the world and reason for himself. It was the Renaissance men who for the first time in human history would develop an awareness of consciousness. It was also during the Renaissance period that the first time we see an increasing interest in personal fame. (Kruft 1994)

The emphasis on personality and character also had an effect on design education during the Renaissance. The old guilds that thought the young students the pre-established secrets of the trade, both existing bodies of knowledge and skills necessary, were not suitable in this era where the individual was to reason why certain things are done and in what other possible ways it could be done. The individual could no longer rely upon the established knowledge of the world, he needed to question to find the common structure behind all human knowledge. In the pre-modern era, the guilds explained how to do a particular task, while the new educational system needed to explain why they were done in that specific way. Moreover, in the guilds the masters had to be exceptional in their practice while in the new system the teacher was to understand the underlying principles of the craft even if he had little practical skill. The distinction between the practical craftsman and theoretical scholar was increasingly felt. (Gelernter 1995)

With more value given to theory over practice, the architects of the period were always theorists as well searching for the true knowledge of art and architecture. One of the earliest architectural theorists, Leon Battista Alberti for example, aimed

to explain the source of artistic and architectural ideas in such a way that it would be as objective as possible. According to Alberti, the source of all true forms lie in the underlying structure of the nature itself, which is to be found in a set of proportional ratios. Alberti wrote treatises on painting as well as architecture to set out these rules. Similarly, other theorists of the period also stressed the importance of the absolute rules for design and many wrote treatises such as Serlio's, "Works on Architecture" and Palladio's "Four Book on Architecture".

Since Renaissance what is important is that, as Leonardo Da Vinci suggested, practice ought always to be built on sound theory. As he argued, a painter should be guided by the "science of painting which included the principles of perspective and proportions as well as the most accurate ways of portraying light, shadow, human gestures and even human emotions" (Gelernter 1995 p. 114) In his workshop Leonardo would have the young painter first learn these principles of art before he could step into the workshop. His idea was the first step in the academic art education.

Academies were invention by Renaissance humanists who admired Plato's Academy, informal school, consisting of a community of scholars committed to the pursuit of knowledge. Soon after their establishment these academies challenged and ultimately won from the guilds the right to educate the young in art and architecture. The first of these academies, Accademia Platonica established by Marsilio Ficino around 1470s, were similarly little more than informal social gatherings (Gelernter 1995). In 1563, the first official art academy, the Academia del Disegno, were established in Florence by Cosimo de' Medici with Vasari's influence. The students continued to work in the shops of their masters but in addition three visiting scholar from the Academy visited them regularly and criticized their work according to the academy's principles. They also got supplementary courses on theoretical subject such as geometry, anatomy and perspective. In other words, they got their practical training in the workshops and theoretical training in the lectures given in the academia. Later academies tried to bring the theory and practice even more closer to each other by bringing the masters and students in the workshops of the academy itself. This is the academic method of design education that continues even today, even though challenged at times. (Kostof 1977)

By 1670s, following the epistemological shift from Rationalism to Empiricism in sciences, a debate began in French Academies questioning the rationality versus subjectivity in art and architecture. By the first half of the eighteenth century, artistic theory emphasized the priority of sensory appearance over rationality creating the well known "Quarrelle des Anciens et des Modernes". Similarly in architecture, Claude Perrault liberated the true sources of form either from God or nature that were always rational and put it on the custom and culture, which was subjective to the rules of the societies. After Perrault, the creation of the rules to follow was up to human agency thus instead of reason a definitive authority should be agreed upon. This new perspective put the academies in a difficult position questioning their very existence that was based on the teachings of the timeless universal principles of art and architecture. In the following decades many such principles were to be discussed including the importance of function as well as materials and technology available. (Gelernter 1995)

During the Enlightenment, for example, although on the one hand we see academies were trying to continue the neoclassical tradition insisting on the universal timeless principles of art and architecture, there are now other perspectives that equally voice their concerns for the source of true form for designers. Carlo Lodoli for example, who himself was not an architect but a monk, suggested for the first time that function and nature of materials to provide the guiding principles for architects (Gelernter, 1995). It was also during the Enlightenment period that a new conception of history was born as well; one that rejects the continuous and progressive understanding of western history but rather sees history as a series of separate compartments where each compartment is as valuable and valid as the other. This new conception of history led to the creation of the idea of style for the first time that architects would be able to then choose freely as they deemed appropriate for their creation. For example, Piranesi argues for the superior quality of Roman forms, while Winckelmann championed the Greeks and Kent the Palladian Classicism, yet others who value the emotional over rational the Gothic style. (Kruft 1994)

While these new ideas of Enlightenment were spreading among architectural theorists, new technological developments and new materials were due on their way after the Industrial Revolution. The way of life was changing in every way for everybody starting with the everyday objects changing from hand-made to mass produced standardized ones. The architects were reluctant to recognize these changes. They were busy with the discussions of which style was more appropriate for new functional buildings. In terms of the architectural education, the academies that were constantly increasing in number continued their predecessors with students working as apprentices in their master's workshops while attending the academy to learn the general principles behind practice. It was during the nineteenth century that the Ecole des Beaux-Arts in Paris would alter for the first time the traditional arrangement of academies. Ecole des Beaux-Arts, founded after the French Revolution as part of a general movement to establish and reorganize academies, combined the schools of Painting and Sculpture, Ecole Speciale de la Peinture et de la Sculpture, and Architecture, Ecole Speciale de l'Architecture, under one heading (Kruft 1994). This joint school treated architecture as one of the fine arts stressing the aesthetic aspects of architecture over practical matters of construction. At first, the Beaux-Arts continued the tradition of student working in the workshops of their masters in addition to taking lectures at the academy. Soon, this arrangement was changed and atelier system was initiated. The students no longer had to work in the workshops as masters now separated their workshops and instead worked with students in the ateliers on make-believe design projects. For the first time in western history, students could complete their professional education without ever stepping into a real architectural office. Still, the masters in these ateliers should have to be practicing architects, the weak link left between theory and practice for architectural education. The Beaux-Arts become the model for the following school of architecture around the world, such as for MIT that offered the first formal architectural education in 1865 in North America. (Kostof 1977)

Even though Ecole des Beaux-Art, emphasized the aesthetic aspects of architecture, it was also towards the end of the nineteenth century, that the style with which the buildings were clothed was dismissed and instead convenience and economy were

emphasized as the two essential requirements that good architecture should satisfy. It was Jean-Nicholas Durand, the professor of architecture at Ecole Polytechnique in Paris, who suggested that objective principles of architecture should be considered as general abstract concepts which lie behind all good style, which are the qualities of symmetry, regularity and simplicity. In other words, as Ecole des Beaux-Arts focused on the aesthetic principles of Classical architecture Ecole Polytechnique focused on the economical and functional requirements defining Classicism broadly as rational, geometric planning. (Kruft 1994)

Towards the end of the nineteenth century, there were also some romantic rebellions against these developments after industrial revolution. Following Ruskin and Pugin's ideas and headed by William Morris, the Arts and Crafts movement argued for a return to medieval craft practices where the form of the products were derived from the inherent qualities of the materials used from a clear expression of constructional realities. The designers also saw design as a matter of personal artistic expression deriving from inner sense of taste free from universal principles. The Arts and Crafts artists even established informal versions of medieval craft guilds as they believed a complete return to the way of medieval life needed to moral goodness that the industrial society lost. (Gelernter 1995)

Since it was not possible to compete with the demands of the industrial society, the romantic rebellion of Arts and Crafts movement was not able to continue for long though its ideas were influential for Art-Nouveau approach and later on for Bauhaus educational systems. Founded by Walter Gropius in 1919, Bauhaus was considered as a watershed offering a modern vision of design and education appropriate for the new century. It called for a searching for the source of art and architecture in considering material and function in a crafty way. To reunite art and craft, Bauhaus educational system took the model of medieval craft guilds where students were trained to design and execute in one continuous system where master and apprentice were united in the workshops. Soon though he needed to add the instructional education in the classrooms for training in conceptual design, the abstract characteristics of form defined as "language of vision" by Moholy-Nagy, or well known as basic design principles of point, line, plane, rhythm, balance, proportion etc. Bauhaus method that includes avoiding preconceptions, teaching basic design principles, and emphasizing creativity that seeks new expression for a new age still provides the foundation for design education in today's architectural schools. (Gelernter 1995)

2.3. Post Modern Era

At the end of the Modern Era, it was clear that something was not quite right in architecture as there were major social problems arising because of the way we have designed the built environment. There were some reactions to these problems in the form of new styles from expressionism to post modern eclecticism to post modern classicism, post modern structuralism and deconstructivism. Yet, what distinguishes this era from the Modern is not these different styles, but it is the insistence on considering the discipline of architecture not only as a profession but also as a rigorous empirical science. The new architectural research agenda established with the aim to create a body of scientific knowledge about how people use and are

affected by buildings, and also to create a rigorous method to apply this knowledge produced into design problems. The scientific approach to architecture also affected architectural education as some schools soon started to reorganize their curriculum to incorporate this new approach to architecture. In 1960s, the Bartlett School of Architecture at the University College London replaced the Beaux-Arts method with a rigorous education in the basic sciences related to architecture, including courses such as anatomy, physiology, psychology of the senses and some physics. The school was to teach the theory alone and the architectural offices would later show students how to apply those theories into practice. Soon University of California at Berkeley followed the same steps, which later on continued to spread across US and Europe. (Kruft 1994)

Another major distinguishing aspect of Post Modern Era is related to its being the information age; a period that is characterized by the ability of individuals to transfer information freely, and to have instant access to information that would have been difficult or impossible to find previously. The idea is linked to the concept of a digital age or digital revolution, and carries the ramifications of a shift from traditional industry that the industrial revolution brought through industrialization, to an economy based on the manipulation of information, i.e., an information society. The Information Age developed with computer advances, with the advent of the personal computer in the late 1970s to the internet's reaching a critical mass in the early 1990s. The following decades the public adopted this technology in their daily life. Fast evolution of technology in daily life and in educational system allowed rapid global communications and networking to shape modern society.

The digital age also affected architecture with the introduction of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) technologies. A CAD program produces at first a digital file consisting of a sequence of numbers which later on could be converted to print outs or even three-dimensional printouts via other machines, applications and interfaces which might be digitally controlled as well. Early in history of CAD, it was realized that although the computer screen is two-dimensional, all three-dimensional forms visualized using CAD programs may exist in a computational 3D space right from the start. Thus, a coherent object designed on a computer screen could be automatically measured and built informationally and even computer can fabricate the same object using CAM via a suitable 3D printer (Carpo 2011). A continuous design and production process is made possible with 3D printing, 3D scanning and reverse modeling. Furthermore, one or more designers could interact with the 2D visualizations and 3d representations even printouts of the same object and all the revisions could be incorporated into the same master file of the project. Carpo (2011) considers this process as similar to artisanal hand-making with the only exception that in digital production chain the primary object of design being an informational model. Furthermore, by bridging the gap between design and production reduces the inherent limits of notational regimes of 2D architectural project drawings such as straight lines, right angles, squares and circles and some limited variations on similar elementary Euclidean themes (Carpo 2011).

CAD CAM applications are not just recording tools for scripting final set of design instructions; they are responsive tools for designing as well as making at the same time. Designers using the potentials of digital technologies, though a handful for now, working on informational models or even interactive avatars of the objects themselves using these technologies as mechanical utensils like hammers and chisels (Carpo 2011). Prior to introduction of these digital technologies it would have been exceedingly difficult to represent and produce objects that are possible to design and manufacture today. Thus, to consider these digital technologies similar to traditional notational vectors such as blueprints of construction drawings is being ignorant of the potentials that are presented to designers today. It is important to recognize the changes in digital technologies and incorporate them in architectural education as well. In the fall of 1992, Columbia University's Graduate School of Architecture, Planning and Preservation inaugurated its seminal "paperless studio". However, this is not a common thread in architectural education yet.

3. DISCUSSION

In the earlier section, the interrelations of material and technological developments and architecture is examined in a historical perspective hoping to bring forth some of the critical dimensions related to the discipline of architecture and architectural education. It was mentioned that during the Middle Ages the language of design was based to a greater extent on the essential qualities of materials and technology available, thus the student of architecture was to be thought both the universal guiding principles as well as the materials and technology that is used. The Middle Ages joined the designer and builder in the same person, while Renaissance had set design apart from construction and the designer apart from the builder. The Renaissance architect who was separated from the builders intellectually produced project documents hand-drafted as precisely as needed before they were shipped to the distant sites where they would be used.

The common thread in the Modern Era was that, the first priority in architectural creation had never been the materials and technology available. The topic of discussion was always based on what principles to follow to reach the true forms. During the Renaissance, it was the universal principles that was agreed upon for centuries and architectural education was based on teaching of these rules in academies. During the Enlightenment period, with the new understanding of history as separate compartments, the idea of style was born for the first time only to focus the discussion on which period's style to be considered for the true forms. It was only towards the end of the Modern Era that the importance of new materials and technologies for the creation of forms was recognized to be important. It was also for the first time that technology and materials available was considered the most significant aspect of architectural creation as it was the "cultural manifestation of modern man".

The distinct characteristics of Post Modern Era is a the importance of considering architectural discipline as a rigorous science on the one hand and the introduction of digital technologies, CAD CAM possibilities on the other. The new developments in

digital technologies are enabling collaborative, information-based decision making a possibility in design process. It is important and yet not fully understood yet that the new digital design tools could serve to make something that was not possible before because of many geometrical notational limitations deeply ingrained in the history of architectural design.

4. CONCLUSION

Built architecture depends on the production of material objects such as bricks, nails, iron beams, etc. Therefore history of architecture cannot be thought separate from the production process. Architectural design on the other hand can be considered as an informational operation specifying how the pieces of the built architecture need to come together. The processes of design uses a range of cultural and media technologies available at any given time. At first the architectural models were used for centuries to record, transmit and imitate architectural design ideas. The architect was not only the designer but also the builder before the Modern era and thus always his existence were required on the construction site. During the Renaissance period, Alberti's new geometrical definition of architectural project drawings consisting of a set of notational tools to be materially executed by builders, supported the intellectual separation of designers and builders. Alberti's claim that architects should be designers not makers and Brunelleschi's legendary struggle for recognition as the sole designer and master of a major building programme also reflects this separation between designer and builder.

Architects were so involved with the problem of style that architecture was not developing hand in hand with the developments during the industrial revolution. Throughout the nineteenth century, most architects were either ignorant or reacted against the new technological developments of industrial mass production. It was the pioneers of modern architecture that for the first time recognized that mechanical production was changing the world and they had to come to terms with it. They recognized that they should invent new forms that would measure for the new tools available.

Similarly, one can argue that today most architects are also ignoring or denying that today's machines are no longer same as the mechanical production which modern architects celebrated a century ago. It is important to recognize the possibilities presented with the advent of new digital technologies both for architecture as well as for architectural education. While CAD CAM technologies are rising up in challenge, most of the architectural schools do require the students hand-draw their projects until the end of their second year of education. Most of these new digital technologies are not existing in many of the architectural schools and there is constant discussions among the professors about the necessity of digitally producing architectural projects for the students. The problem needs to be recognized together with its underpinnings: The sooner the acceptance of this new technologies the sooner the language of today's architecture could flourish.

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