ARCHITECTURAL TECHNOLOGY IN HISTORY CLASS

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'Technology' according to Webster's is "the science of the application of knowledge to practical purposes" and "the totality of the means employed by a people to provide itself with the objects of material culture".[2] In both definitions, technology share angles of a triangle in reciprocity with knowing and doing.

Vitruvius (1st century BC) finds scientific training a must for the profession of architecture: structures like machinery for festivals "require careful thought and planning by a well-trained architect"[3]. In keeping with this, he puts physics under philosophy, a branch of study that the architect should be equipped.[4] Vitruvius underscores inseparableness of manual skill and theory (scholarship):

"It follows, therefore, that architects who have aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains, while those who relied only upon theories and scholarship were obviously hunting the shadow, not the substance."[5]

Webster's above-stated concept of 'technology' recuperates Vitruvian entrenching of theory in practice, or science in doing.

In the US, since the publication of a report in 1995 by National Academy of Sciences with the title "Education of Architects and Engineers for Careers in Facility Design and Construction", integration of technology in curricula of architecture schools became a central issue. This report has a high tone of criticism targeting the existing scene:

"The committee concluded that both engineers and architects leave school with inadequate knowledge of technology. Many schools of architecture place emphasis on aesthetics, the art of architecture, and broad design concepts, and, as a matter of policy, leave the teaching of practical technology to the practitioners who hire their graduates. For architects, the problem is integrating academic design with applied technology. Architectural schools tend to separate design from the production process. Students may know how to design, but they do not know how to put things together in an efficient and practical way using the minimum amount of material... The committee believes the situation can be remedied by placing considerably more emphasis on technology -especially construction methods and materials and building systems- and that technology must be integrated into the design studios."[6]

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[1] *METU Department of Architecture*

[2] *Webster's Third New International Dictionary of the English Language* (Springfield: Merriam-Webster, 1986).

[3] Vitruvius, *The Ten Books on Architecture*. Trans. M.H. Morgan (NY: Dover Publc., 1960) 281-2.

[4] Ibid., 8.

[5] Ibid., 5.

[6] *Education of Architects and Engineers for Careers in Facility Design and Construction*, by Board on Infrastructure and the Constructed Environment, Committee on Education of Facilities Design and Construction Professionals (Washington, DC: National Academy Press, 1995) 51.

The report instigated educators of architecture to rethink technology track in the school. As a matter of fact, the report came two thousand years after the Vitruvian postulate. This article is not the place to discuss how the place of technology came to be questioned in architectural education in the end of the 20th century. It is about how inventiveness has been technological in manifestations of architectural innovation that accordingly needs to be rendered central to architectural history class in departments of architecture.

Watson in a paper on the topic notifies that "any architectural curriculum that does not integrate design and technological inquiry can be considered absolute."[7] He suggests that technological knowledge base of architecture needs to be presented through inquiry based on physics, chemistry and environmental sciences, and this knowledge is also gained through empirical experience and design.[8] This approach reminds the definition of Vitruvius, whose education model becomes clearer when we visit Graham Pont's treatment of the concept *fabrica* (practice). Pont is against the translation of the term *fabrica* as referring directly any kind of manual art. According to him "*fabrica* yields the kind of professional knowledge and experience that is derived from thoughtful study of...various constructive arts", and it is "practical know-how".[9]

Technological awareness can be efficiently instilled in architecture school earlier than professional experience teaches it in the field. We know from history that new technologies promoted innovation in architecture. Zeniths in architectural history need to be profoundly studied and thought on the way to create insight about the role of innovative technology.

Recent advance in horizontal construction through strengthened cantilever trivialized uprights, and resulted in open plans and floating configurations.[10] Given this and further high tech tools for construction, contemporary architects like Zaha Hadid (1950-) reached convoluted formal expressions and spatial dimensions by computational design.

Industrial revolution invigorated recurrence of innovation. Le Corbusier's (1887-1965) acclaim of machinery and construction methods in the beginning of the twentieth century reveals architect's thrill before technology. Manifestly discovering new design and building opportunities in new materials, Le Corbusier finds steel and concrete revolutionary: "…steel and concrete have brought new conquests, which

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[7] Donald Watson, "Architecture, Technology, and Environment," *Journal of Architectural Education*, 51/2 (Nov., 1997) 120.

[8] Ibid., 123, 125.

[9] Graham Pont, "The Education of the Classical Architect from Plato to Vitruvius," *Nexus Network Journal*, 7/1 (2005) 77-78. M.H. Morgan translated *fabrica* in the *Ten Books* as 'practice'; and '*manibus'* as manual work: "...Practice is the continuous and regular exercise of employment where manual work is done with any necessary material according to the design of a drawing. Theory, on the other hand, is the ability to demonstrate and explain the productions of dexterity on the principles of proportion" (Vitruvius, The Ten Books, 5), (orig. *...fabrica est continuata ac trita usus meditatio quae manibus perficitur e materia cuiuscumque generis opus est ad propositum deformationis. ratiocinatio autem est quae res fabricatas sollertiae ac rationis pro- portione demonstrare atque explicare potest (Frank Granger, "Vitruvius' Definition of Architecture*," The Classical Review, 39/3-4 (May - Jun., 1925) 67).

[10] Manja van de Worp, "On Technology and Architecture: In Pursuit of Floating: The Cantilever." http://nocloudinthesky.wordpress.com/tag/zaha-hadid/. 03 November 2014

are the index of a greater capacity for construction, and of architecture in which the old codes have been overturned."[11] A few decades later, a contemporary in the States, F. L. Wright (1867-1959), by the same token appraised new materials and machines in calling them "substitute for tools" in the age of steel and steam.[12] According to him "machinery, materials, and men –yes- these are the stuffs by means of which the so-called American architect will get his architecture…"[13] And he goes:

"Plasticity is of utmost importance. The word implies total absence of constructed effects as evident in the result. This important word, "plastic," means that the quality and nature of materials are seen "flowing or growing" into form instead of seen as built up out of cut and joined pieces." [14]

Surely Wright's anticipation draws a picture of the path Zaha Hadid and other moderns trek now.

We have a tendency to regard technology a subset that reigns in realms like structure and amenity systems, and associate its development with industrial revolution and ignore the fact that technology is embedded in every material property created by man today and in the past. Architectural inventiveness is closely tied to innovative technologies developed in building material and structure and the other way round. Structurally innovative buildings of the past incorporated such technologies, a number of which also developed during the design process.

Selected examples:

Roman architectural revolution arisen from the use of cast concrete for primary load-bearing structures in the 1st century. It resulted in Pantheon (A.D. 123).

[11] Le Corbusier, *Towards a New Architecture*. Trans. F. Etchells (NY: Dover Publc., 1986) 271.
[12] F.L. Wright, *The Future of Architecture* (NY: Meridian, 1970) 84.
[13] Ibid., 82.
[14] Ibid., 107.

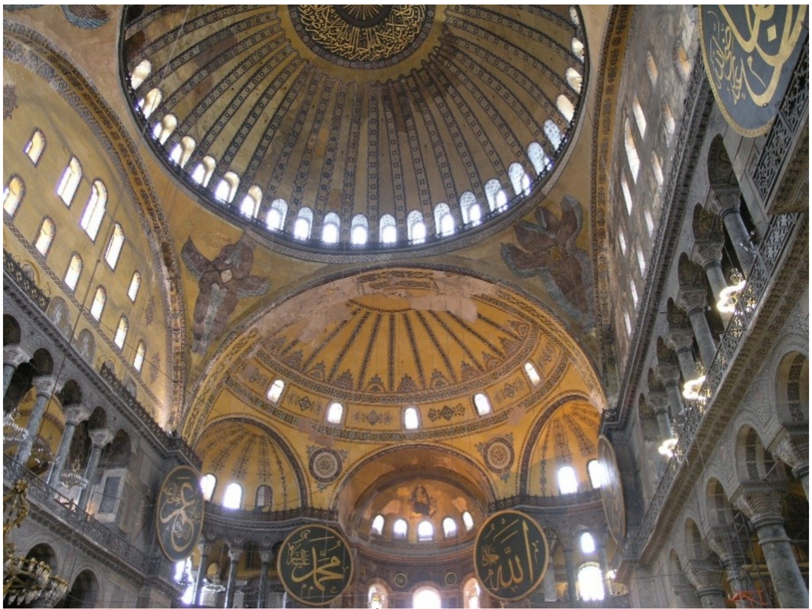
Pantheon in Rome (2^{nd} c.), interior (Painting by G.P. Panini 1691-1765)

According to Mark and Robison, innovative aspect of this building reigns in the structural form instead of structural conception, since it was unreinforced; monumental Roman buildings in concrete nourished mainly from traditional building practices.[15] Though structurally sterile, Pantheon became the largest domed space (43 m.) in the Roman world by means of supporting pozzolana concrete walls and proved to be a new technology-driven configuration of form. In Hagia Sophia (532-537), Pantheon's concrete replaced by traditional brick with mortar layer in the walls, domes and vaults and stone in piers.[16] Its interior underneath the dome and half domes is 1.5 times larger than Pantheon.

[15] R. Mark and E. C. Robison, "Vaults and Domes," in *Architectural Technology up to the Scientific Revolution*, ed. R. Mark (Cambridge, MA: The MIT Press, 1993) 141-5.

[16] R.J. Mainstone, *Hagia Sophia: Architecture, Structure and Liturgy of Justinian's Great Church* (London: Thames and Hudson, 1997) 67-70.

Hagia Sophia in İstanbul (6th c.), western facade (Photo: A.U. Peker)



Hagia Sophia in İstanbul (6th c.), interior (Photo: A.U. Peker)

Technological innovation of the Hagia Sophia rather lies in the way two conflicting structural features brought together: oblong basilica and central dome with half domes (supporting cubical/spherical covering systems). Since, this encounter was not backed with technological innovation but Justinian’s great aspiration and its scientist-designers’ vigor, the dome collapsed a number of times and massive external buttresses later added impeding integration of the building. Anyhow Hagia Sophia with its great dome of 32.5 m. wide and 56 m. high is still above a colossal rectangular naos verifying its makers' command of existing agglomerate building technology that they resolutely challenged through an innovative design concept. They did their best to manufacture an elaborate supporting structural system of arches, half domes, pillars and buttresses at the same time perforated massive walls to obtain transparency underneath the dome. If we disregard safeguards introduced later to keep the building on its feet, Hagia Sophia in its pristine state was truly an innovative design.

In Anatolia, a less known architectural tradition was created by builders under a Turkic dynasty named Seljuk (1037-1307). Traditional building technologies ruled their architecture. Their role as innovators reveals when we inspect the way they collated two grand building technologies: brick and stone, Iranian and Anatolian.

Yazd Friday Mosque in Iran (12^{th} c.), entrance portal (Photo A.U. Peker)

Divriği Great Mosque and Darüşşifa in Turkey (13th c.), western façade with portals (Photo: A.U. Peker)

Seljuks of Iran penetrated Anatolia after 11th century where their builders encountered a deep-rooted ashlar masonry building technology. They adapted kilned brick construction of Iran to Anatolia.[17] Local aisled basilica in stone covered with uniform vaults transformed in their hands to domed and exquisitely vaulted halls with bare walls, typical features of the brick building tradition in Iran.[18]

[17] For a study of this transformation see Ö. Bakırer, "From Brick to Stone: Continuity and Change in Anatolian Seljuk Architecture," in H.C. Güzel et al., eds., *The Turks*, 2 (Ankara, 2002) 729-36
[18] For the local basilica architecture in Anatolia and its impact on Seljuk mosque architecture see A. U. Peker, "Anadolu Bazilika Geleneği ve Anıtsal Mimariye Etkisi," in A.U. Peker and K. Bilici, eds., *Selçuklu Uygarlığı: Sanat ve Mimarlık*, 2 (Ankara: 2006) 55-65.

Isfahan Friday Mosque in Iran (11th c.), star-vault in southeastern hall (Photo: A.U. Peker)

Divriği Great Mosque in Turkey (13th c.), vaults over piers and unadorned walls (Photo: A. U. Peker)

This “technological adaptation” is innovative since led to unique structural solutions and formal inventions in the Ottoman age later.

In Europe, Gothic architectural design owes its creativity to a series of technological innovation achieved by pointed arch, ribbed cross-vaulting, flying buttress and increased fenestration.

St.Vitus Cathedral in Prag (14th c.), eastern façade (Photo: A. U. Peker)

St.Vitus Cathedral in Prag (14th c.), nave (Photo: A. U. Peker)

Ashlar stone integrated in an innovative construction technology, which manifested higher, lighter and more profusely illuminated surfaces. This provided builders prospects for improvement, as a result the evolutionary path from Early to High Gothic exhibits how innovations in technology progressed leading fulfillment.
Our last but not least example is Süleymaniye Mosque (1551-57) in İstanbul built by Architect Sinan (1490-1588). Scholarship on the building sufficiently demonstrated contributions of Sinan in this mosque in terms of organizational innovativeness.[19]

Süleymaniye in İstanbul (16th c.), western façade (Photo: A. U. Peker)

[19] For a description of the Süleymaniye Mosque in the lineage of other Sinan buildings see Aptullah Kuran, *Sinan : The Grand Old Master of Ottoman Archıtecture* (İstanbul:ITS, 1987)


Süleymaniye in İstanbul (16th c.), interior (Photo: A. U. Peker)

In our opinion most prominent contribution of Sinan's architectural design is his use of proportions in relation to human scale. This is the reason his grandiose buildings look less colossal than they are. Sinan at all times avoided to create dominating interiors with gigantic dimensions. Sinan's main occupation in the Süleymaniye was integration of the Hagia Sophia's structural system of domed-basilica to Seljuk/Early Ottoman iwan-court configuration in a robust building of pure stone. The Süleymaniye's well-thought load bearing system facilitated a stabile lower structure. Furthermore, transfer of the galleries of the Hagia Sophia to the facade conduced the inner structural system join the surrounding walls reproducing the carrying system on planar facades.

İhsan Mungan finds the success of Sinan in his *baumeister* role, who balanced partial rigidities in the load-bearing system and created a fine buttressing system around dome and walls beneath it.[20] It is evident that structural inventiveness of the Süleymeniye also stems from the use of new ashlar stone construction technologies, which can be observed in masonry details.

Creativity in man-made matter (or material) has always been technological. From Pantheon to Hadid's contemporary designs history teaches us that architectural inventiveness thrived when new technologies developed and/or embraced by the builders. Knowledge of new technologies needs to be promptly and appropriately assimilated to architectural education. Architectural history course is more effective when past architecture is thought in reference to the technological triumphs of grand

[20] İhsan Mungan, "Strüktür Çözümü," in Selçuk Mülayim, ed., *Süleymaniye Külliyesi: Bir Şaheser* (Ankara: KT Bakanlığı, 2007) 91, 94-7.

works and traditions. But, one might still ask: If innovative technology is so decisive what would be the purpose of such a course focusing on outdated technologies of the past? Straightly speaking, its function is to teach new generations the formula often failed to be noticed that architectural inventiveness is contingent upon new technologies (and vice versa).