

An Insightful Resemblance between Ancient Egyptian Miniatures and Current Digital Information Models

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Architects always search for new means of describing and communicating their design ideas, and 3-D models found to be from the most informative means for this purpose. In ancient Egypt, the beliefs of death, resurrection, and eternity shaped the ancient religious structures and their construction. The design and construction processes of ancient Egyptian buildings and artefacts were collaborative between designers and workers who used stones for cult structures and clay for traditional dwellings. These dwellings as well as the daily life activities were represented by 3-D miniatures and buried with the body as those found in Meketre tomb. For example, the model of a slaughtering house described a slaughtering scene with all objects represented proportionally with colors, while the model of a porch and garden embodied an exterior porch and its surrounding landscape elements. In the current era, building information modeling (BIM) describes the creation of 3-D information models in the virtual digital environment. This technology allowed the architects to collaborate in a common data environment (CDE) on the cloud with other design disciplines through a centralized 3-D digital model to make appropriate design decisions. Fondation Louis Vuitton Museum and Shanghai Tower are notable examples that used BIM models to boost their design and construction processes. The 3-D model of the museum combined all design disciplines for real-time collaboration, while the unique shape of the tower utilized parametric modeling and digital simulation for efficient construction.

Introduction

As humans frequently invent new tools and utilize novel technologies, the visual expression of the surroundings evolved throughout history to describe the spatial compositions of the environment in the most informative mean. On one hand, the beliefs of ancient Egyptians for resurrection and eternity paved the way for creating 3-D models that described their daily life activities and the places they used to live in. These models were placed with the buried body to aid him/her in the recognition of the details of the lifestyle in the afterlife by visual expressions that would be very hard to be informative with other means other than colored 3-D models. On the other hand, the current digital design era utilizes the same concept through describing architectural elements by creating digital 3-D information models that provide the full information for each design element to easily describe

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it to the client and design team and prevent any excessive costs or errors in the construction process. Building information modeling (BIM) adopts this concept and enriches each design element with full specifications, costs, performance, visual appearance, construction details, and maintenance options in a common data environment (CDE). The research hypothetically investigates the roots of building information modeling as a radical concept adopted by the ancient Egyptians; and on that basis, states the similarities between the current BIM models and the ancient 3-D miniatures.

Literature

Architects always search for new methods and tools to clearly represent, simulate, and communicate their ideas, such as 2-D drawing and 3-D modeling.¹ The essential function of design tools is to make design ideas perceptible for the design team members and the clients. They influence the design by reducing a complex state of design problem and information into few recognizable elements that can be easily visualized and manipulated.²

Digital tools facilitate the perception of design ideas by introducing the illusion of space through animations and renderings,³ however, many designers complain about trapping their ideas inside the box through using computers. On one hand, the development of information technology (IT) and 3-D digital models proved a radical evolution in the creative design thinking as representational tools of the preconceived design idea which embrace the integration of digital technology and design process.⁴

On the other hand, BIM redefines the way design ideas are developed in the early design process; by bridging creativity with design principles and technological innovations through parametric generative processes and an intelligent database of information-rich objects.⁵

1. J. Anderson, *Basics Architecture 03: Architectural Design* (Switzerland: AVA Publishing SA, 2010), 39.

2. C. Gänshirt, *Tools for Ideas: An Introduction to Architectural Design* (Germany: Birkhäuser Verlag AG, 2007), 60.

3. S. C. Piedmont-Palladino, *Tools of the Imagination: Drawing Tools and Technologies from the Eighteenth Century to the Present* (SA: Princeton Architectural Press, 2007).

4. A. Ali, and C. A. Brebbia. *Digital Architecture and Construction* (UK: WIT Press, 2006), 42.

5. K. Kensek, and D. J. Noble, *Building Information Modeling: BIM in Current and Future Practice* (USA: John Wiley & Sons, 2014), 4.

Aim of the Study

The study aims to explore the potentials of 3-D models in describing the character of spatial architectural compositions. It investigates these potentials through two main objectives:

- Exploring the ancient Egyptian miniatures that embodied the spatial compositions of the daily life of ancient Egyptians.
- Describing the potentials of 3-D information models in the current digital design era that boosts the design and construction processes.

Research Methodology

The study adopts a comparative approach through which it targets exploring the potentials of 3-D models in describing the character of spatial architectural compositions now and then. On that basis, it investigates the roots of ancient Egyptian miniatures represented by the 3-D models found in Meketre tomb in Thebes, Egypt. After that, it describes the digital information 3-D models offered by building information modeling (BIM) technology represented by two notable examples, Fondation Louis Vuitton Museum and Shanghai Tower. The selection of the two examples is derived from the diversity between their forms and functions and the challenges and constraints they encountered. For example, the museum has a unique form that needed comprehensive digital manipulation, while the design of the tower had to respect the impact of the frequent seismic loads. Thus, the concepts of describing the architectural forms precisely and preserving a detailed mockup of the building, originated within the creation of the ancient 3-D models, and implemented within the current digital era of BIM. The study concludes with a comparative investigation about the resemblance between the ancient Egyptian miniatures and the current digital information models as shown in Figure 1.

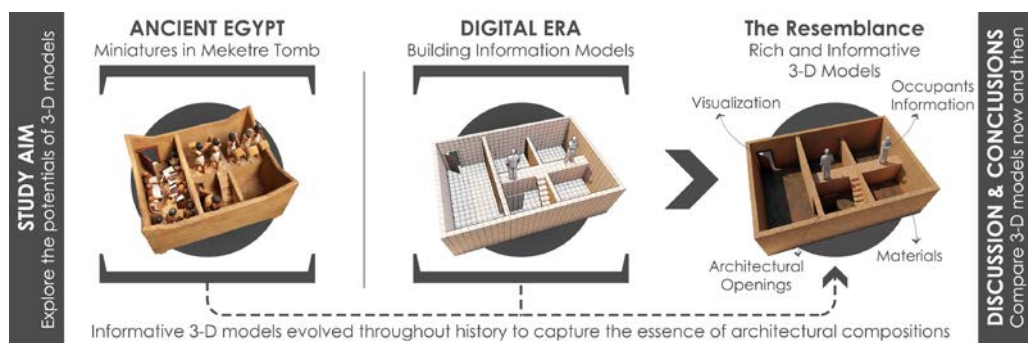


Figure 1. *The Study Workflow*

Source: The researchers.

Ancient Egyptian Architecture – Inherited Beliefs Embedded the Ancient Structures

The architecture of ancient Egypt was shaped by the beliefs of death, resurrection, eternity, cult of the dead, and afterlife; believed by the ancient Egyptians and represented by the burial rituals and the huge monumental religious structures such as the pyramids of Giza. These massive structures built in large scales and with materials far more permanent than that of the private dwellings to survive until the afterlife.⁶

Collaborative Design Environment

Ancient Egyptian buildings and artefacts were created collaboratively by a team of designers and craftsmen. On one hand, the construction process of structures such as temples, irrigation facilities, dams, and water channels needed organized participation of a large number of people to accomplish it.⁷ On the other hand, artefacts such as coffins required two or three workers to make the carpentry of the wooden case which had specific dimensions and design considerations, while other workers were responsible for the painting works and the final appearance of the cases⁸ as shown in Figure 2.



Figure 2. *Hathor Temple, One of the Most Well-Preserved Temples of Ancient Egypt (Left), and Preserved Coffin of the Mummy of Nesmutaatneru (Right)*

Source: Left top picture from (Wikimedia Commons 2014), left bottom picture from (Wikimedia Commons 2008), and right picture from (Museum of Fine Arts Boston n.d.).

6. A. L. Palmer, *Historical Dictionary of Architecture* (UK: Scarecrow Press, 2008), 12.

7. T. Fedulova, *Architecture of Ancient Egypt: Chapter 1 of Brief Guide to the History of Architectural Styles* (Progress Builders, 2014).

8. C. Riggs, *Ancient Egyptian Art and Architecture: A Very Short Introduction*. (UK: Oxford University Press, 2014), 41.

The building materials were mainly clay and stone. Non-durable adobe bricks were made of clay that dried in the sun and used for building houses and primitive huts for the noblemen. While cult structures such as pyramids were built for the pharos from stones to ensure their durability in the favor of Gods and sustain till the afterlife.⁹

Miniatures Inside Meketre Tomb

Meketre was one of the most successful seniors and royal officials of the early 12th dynasty in the Middle Kingdom of ancient Egypt. His tomb located in Thebes in Egypt was excavated by the American Egyptologist Herbert Eustis Winlock in 1920. The tomb consists of a wide portico carved through the cliffs, a passageway that cuts through the cliffs after the portico, an offering chapel, and the burial chamber. Meketre's tomb contained in its *serdab*, i.e., a narrow chamber inside the tomb, a set of 24 well-preserved wooden 3-D models that embody the daily life activities of the ancient Egyptians as shown in Figure 3. These models were affordable means of describing the daily activities to aid the Ka, i.e., soul, in the afterlife, instead of the huge structures that still exist till now such as the pyramids of Giza that were owned by the upper-class Egyptians.¹⁰ They simulated real things that belonged to the tomb's owner and eternalized the ancient Egyptian daily life.¹¹ The tomb also included carved and painted scenes on its walls which were integrated with offering texts that described the spirit's needs.¹²

The 3-D models were mainly made from wood, plaster, and linen, and finished with colored paint.¹³ They created an insightful description of how the ancient Egyptian structures laid out and functioned.¹⁴ Half of the 3-D models found in the tomb were sent for display to the Egyptian Museum in Cairo, Egypt, while the other half sent to the Metropolitan Museum in New York, United States of America.¹⁵

The miniature of a slaughtering house shown in Figure 4 described an interior space where ancient Egyptians performed meat processing. The 3-D model showed a scene where two oxen are trussed and being slaughtered by two men in the main hall. The scene also showed other two men holding bowls to catch the blood resulted from the slaughtering, two men preparing kettles, an observer who supervised the slaughtering, and a writer who recorded and documented the meat

9. Fedulova, *Architecture of Ancient Egypt: Chapter 1 of Brief Guide to the History of Architectural Styles*, 2014.

10. P. Lacovara, *The World of Ancient Egypt: A Daily Life Encyclopedia* (USA: ABC-CLIO, 2017), 211; S. Snape, *Ancient Egyptian Tombs: The Culture of Life and Death* (UK: John Wiley & Sons, 2011), 169.

11. J. Kee, and E. Lugli. *To Scale* (UK: John Wiley & Sons, 2015), 39.

12. Oppenheim, Adela, Dorothea Arnold, Dieter Arnold, and Kei Yamamoto. 2015. *Ancient Egypt Transformed: The Middle Kingdom*. United Kingdom: The Metropolitan Museum of Art.

13. A. Oppenheim, D. Arnold, D. Arnold, and K. Yamamoto, *Ancient Egypt Transformed: The Middle Kingdom*. (UK: The Metropolitan Museum of Art, 2015).

14. Lacovara, *The World of Ancient Egypt: A Daily Life Encyclopedia*. 2017, 211.

15. The Metropolitan Museum of Art, *Model of a Slaughter House* (The Metropolitan Museum of Art, n.d.).

processing process. In the upper balcony, the details of the hanging pieces of meat were well-represented. All figures have been represented as colored miniatures. The model measured 76.8 cm in length, 58.5 cm in width, and 58.5 cm in height and was made from wood, paint, and plaster.¹⁶

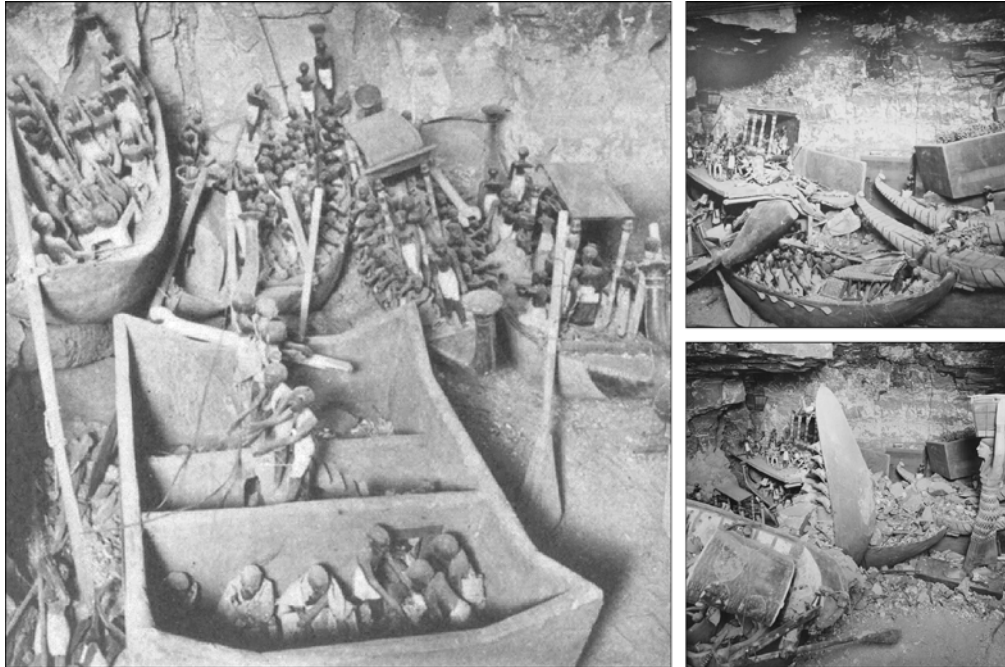


Figure 3. *The Excavation of Meketre Tomb Led to Discovering a Set of 3-D Models that Described the Daily Life Activities of Ancient Egyptians*

Source: Left picture from (Winlock 1920), top right picture from (Lilbitbrit 2014), and top bottom picture from (Lansberry n.d.).



Figure 4. *The Model of a Slaughtering House Described the Process of Meat Processing Through Colored Miniatures of Architectural Elements and Figures*

Source: The Metropolitan Museum of Art n.d.a.

The miniature of a porch and garden shown in Figure 5 described an exterior space of a house porch facing a pond surrounded by trees. The 3-D model showed an architectural composition of a garden where a framed water pond was positioned at the center and surrounded by trees with red fruits. It sculpted a house porch that

16. Ibid.

designed as two rows of beautifully colored ancient Egyptian columns holding the roof. The back of the porch had two doors and a latticed window. The details of columns' sculpting and coloring, as well as the fine placement of fruits on the branches of the trees, added a dramatic sense of space to the model. The model measured 84.4 cm in length, 42.5 cm in width, and 39.5 cm in height and was made from wood, paint, and copper.¹⁷



Figure 5. *The Model of a Porch and Garden Embodied an Exterior Scene through Colored Miniatures of Architectural and Landscape Elements*

Source: The Metropolitan Museum of Art n.d.b.

Current Digital Design Era – The Paradigm Shift of Building Information Modeling

Building Information Modeling (BIM) as a term has first appeared in print in 1992, however, its concept emerged in the 1970s in an article by Charles M. Eastman, a professor specialized in BIM, entitled “The use of computer instead of drawings in building design.”¹⁸ In 2002, the industry analyst Jerry Laiserin mentioned the term to describe virtual design, construction, and facilities management.¹⁹ The emergence of BIM acted as a paradigm shift which evolved the 2-D drawings to 3-D information models that describe each component of the building.²⁰

Common Data Environment

The digital workflow of BIM allows multiple design disciplines to work simultaneously on the same project with precise collaboration for each design

17. The Metropolitan Museum of Art, *Model of a Porch and Garden* (The Metropolitan Museum of Art, n.d.).

18. Landscape Institute, *BIM for Landscape* (UK: Routledge, 2016), 15.

19. T.-H. Chuang, B.-C. Lee, and I.-C. Wu, “Applying Cloud Computing Technology to BIM Visualization and Manipulation,” in *The 28th International Symposium on Automation and Robotics in Construction 2011*, 144-149. Korea.

20. K. M. Gairbheith, “The BIM Design Paradigm,” *Architectural Technology Magazine* 111 (2014): 8-11.

element through a centralized virtual 3-D model as shown in Figure 6. The collaboration reduces construction errors and unnecessary costs.²¹

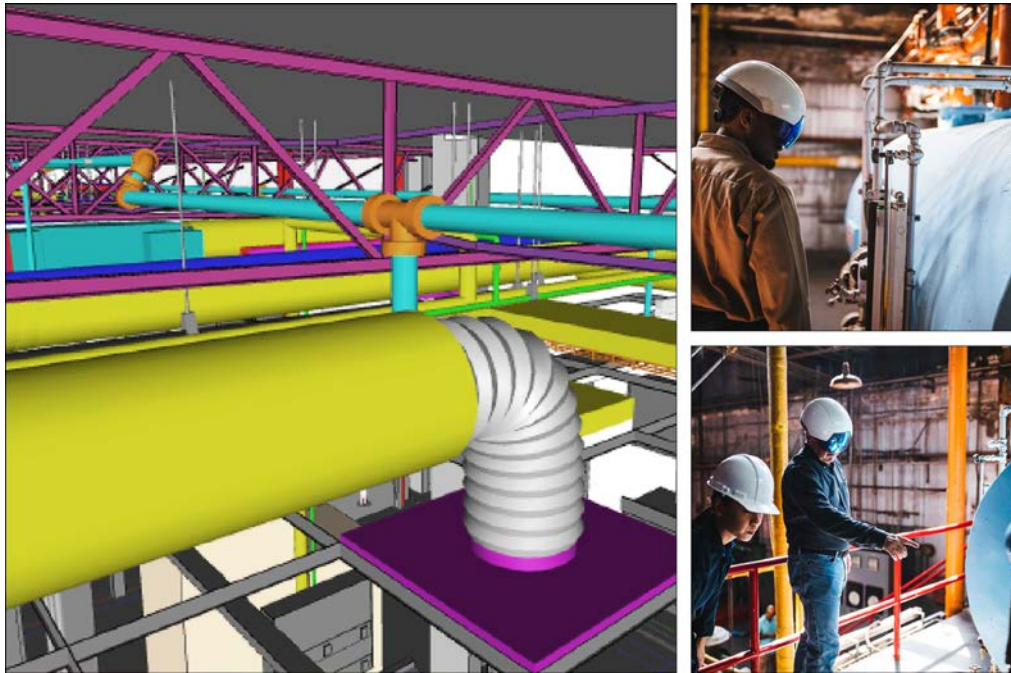


Figure 6. *BIM Models Boost Multidisciplinary Design (Left) and On-Site (Right) Coordination when Used Through Augmented Reality Helmets*
 Source: Left picture from (Sanchez n.d.), right pictures from (Mortice 2017).

In the current digital design era, designers and project parties collaborate on a cloud-based common data environment (CDE) where they manage digital information and exchange project data according to predefined protocols.²² Architects integrate the CDE with BIM to boost the collaboration between design and construction teams in the early design stage, which facilitates and reduces costs and errors of the construction process.²³

Notable Examples of BIM Models

This part presents two projects shown in Figure 7 in which BIM played a significant role in describing the buildings during the early design process. The first one is Fondation Louis Vuitton Museum located in Paris, France, and designed by

21. C. M. Eastman, P. Teicholz, R. Sacks, and K. Liston, *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors* (USA: John Wiley & Sons, 2008), 17-18.

22. A. X. Sanchez, K. D. Hampson, and S. Vaux. *Delivering Value with BIM: A Whole-of-Life Approach* (USA: Routledge, 2016), 215.

23. R. Sacks, C. M. Eastman, G. Lee, and P. Teicholz. 2018. *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers* (USA: John Wiley & Sons, 2018), 366.

Frank Owen Gehry. While the second one is the mixed-use Shanghai Tower, located in Shanghai, China, and designed by Gensler.



Figure 7. *Fondation Louis Vuitton Museum Designed by Frank Owen Gehry (Left) and Shanghai Tower Designed by Gensler (Right)*

Source: Left picture from (Vogue n.d.), right picture from (Wikimedia Commons 2015).

Fondation Louis Vuitton is an art museum of contemporary artistic creations.²⁴ It is located in the historical *Bois de Boulogne* public park in Paris, France. Its complex artistic entity made possible using design and construction technical innovations; through BIM approaches that provided collaboration between different design disciplines by using a centralized information-rich 3-D model.²⁵ The BIM model provided one source of information for design computation and optimization that were necessary to realize complex geometries and structure elements of the building.²⁶

Shanghai Tower is a super high-rise mixed-use skyscraper that rises as the world's second-tallest building. It is located in the heart of Shanghai's financial district in China. The massive size, complex design, and construction challenges of the tower were calling for non-traditional project delivery methods;²⁷ that paved the way for BIM to be the solution for achieving the project's aspirations by integrating a set of digital processes and tools. The building information model combined

24. Fondation Louis Vuitton, *Fondation Louis Vuitton Building in Paris* by Frank Gehry (Fondation Louis Vuitton, 2016).

25. Fondation Louis Vuitton. n.d.

26. A. J. Witt, "Paris Museum Proves that BIM Really Can Be a Team Sport," *Journal of Building Information Modeling* (2012): 13-15.

27. Autodesk, *Rising to New Heights with BIM* (Autodesk, 2014).

precise data of each design element to support the informative processes of parametric design and project collaboration.²⁸

The BIM model of Fondation Louis Vuitton Museum developed through a collaborative approach between the client, architects, engineers, and fabricators as shown in Figure 8. The project involved ten firms each in a different country which collaborated in real-time on a centralized 3-D information model on a cloud server. The BIM model incorporated parametric geometries and adaptive engineering intelligence. For example, it encompassed predictive routine maintenance information to support the decision-making process throughout the building's lifecycle, while the mathematical optimizations smartly generated accurate 3-D geometries of the unique facade panels that fabricated using computer-controlled fabrication processes on-site.²⁹

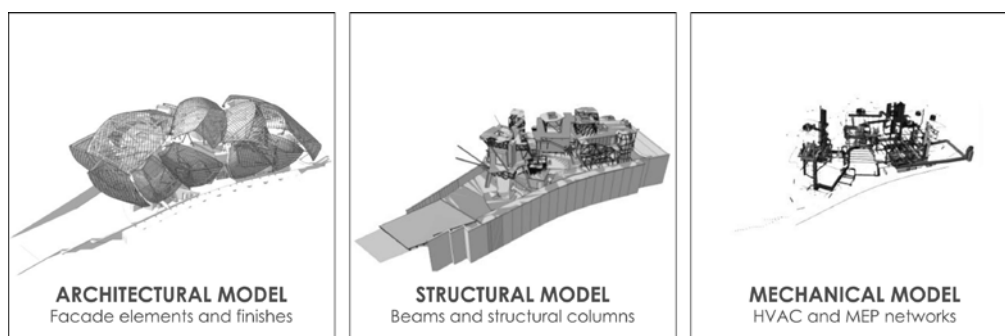


Figure 8. *The Core 3-D BIM Model of Fondation Louis Vuitton Museum Incorporated All the Architectural, Structural, and Mechanical Information*

Source: American Institute of Architects n.d.

The BIM model of Shanghai Tower embodied the designer's idea through early collaboration between the client, architects, engineers, and contractors. The parametric digital model was beneficial for the architects on two levels, the first one was designing the tower using advanced modeling techniques to accurately manipulate its complex geometry as shown in Figure 9, while the second one was the coordination of the complex building systems inside one entity to ensure efficient structural support and mechanical networks.³⁰ The tower geometry and structural systems responded effectively to the wind forces affecting the tower, thanks to generated variations, digital simulations, and wind tunnel testing that informed the entire design process.³¹

28. R. Garber, *BIM Design: Realising the Creative Potential of Building Information Modelling* (UK: John Wiley & Sons, 2014).

29. American Institute of Architects, *Building Information Evolved: Fondation Louis Vuitton* (USA: American Institute of Architects, n.d.).

30. L. Smith, *BIM: From Concept to Construction: Sustainable Shanghai Tower, Asia's Tallest Skyscraper*, 2012.

31. Garber, *BIM Design: Realising the Creative Potential of Building Information Modelling*, 2014.

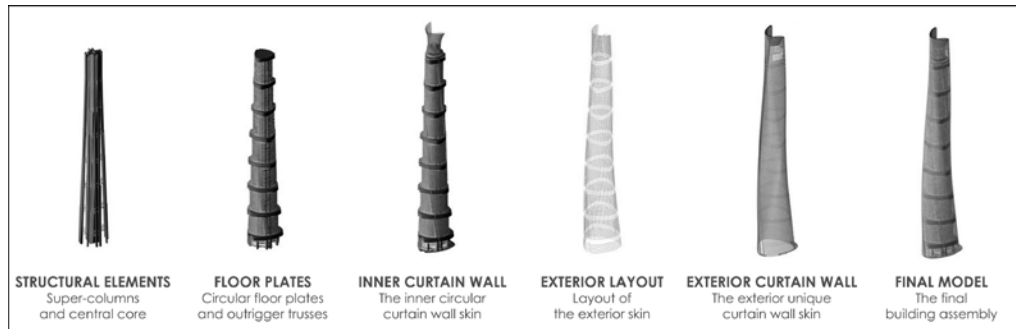


Figure 9. *The 3-D Model of Shanghai Tower Encompassed Informative Models of the Unique Architectural and Structural Elements of the Building*

Source: Pham 2011.

Discussion

Collaborative Environments Now and Then

The architectural design process is a collaborative cycle that integrates reflecting and making approaches among multidisciplinary designers. The establishment of ancient Egyptian buildings and artefacts required this collaboration between architects, workers, and craftsmen to create the elegant masterpieces of that civilization. For example, the massive pyramids of Giza required distinct cooperation between workers to construct the equipment needed for moving, lifting, and stacking the huge and heavy stone blocks for establishing the pyramids. While the ornamental columns of the temples required seamless communication between architects, builders, and painters to construct and finish them. The clear collaboration and communication methods in the current information age are the cornerstone of the effective planning, design, and construction processes of buildings. Using the beneficial technology of cloud computing, the common data environment creates an online entity that integrates and organizes data from multiple sources into one platform to allow coordinated sharing of information. This technology reflects its concepts on the building information modeling paradigm where the BIM model represents a single source of truth for all design elements which may be shared within a worldwide common data environment and produce innovative, cost-effective, and unique designs.

Afterlife vs. Life Cycle

The concept of sustaining the architectural information is embedded within the flow of the design process from ancient times till the current era. The 3-D models found in Meketre tomb targeted this concept as they preserved the sense of space, lifestyle, and daily activities of ancient Egyptians to aid the souls after the resurrection afterlife. The details in the 3-D models transferred the spatial character of the ancient Egyptian buildings that might have been obliterated without their 3-D representations. The value of sustainability is inherited within the current digital 3-D

BIM models through integrating strategic information for design and construction elements that describe their futuristic manipulations. For example, BIM models allow the designers to integrate information related to the maintenance or replacement times of construction elements such as bolts. These bolts are represented within the digital model of the building as 3-D models that comprise specific data which describe them such as their length, diameter, type, material, and durability. The BIM tools then utilize this information to plan the strategic maintenance and replacement routines for these elements throughout the lifecycle of the building; and by that, a clear BIM workflow is adopted between 3-D models, data, and strategic decisions.

Finely Tuned 3-D Models

The 3-D model of a slaughtering house found in Meketre tomb narrated the historical event of meat processing in ancient Egypt through a cognitive 3-D representation of every element inside the space. It comprised the major floor area of the space where structure columns and beams existed, stairs finely modeled, and upper balcony established where secondary structural columns stood. It included the door openings showing the details of their leaves and frames. It also included the pieces of meats, the clothes of the people and their gestures, and the textures of the oxen. The finishing of the model added life to the final scene and enhanced the representation of the function in the space by using colors and adding people and animals. The integrated entity of the 3-D model that showed the organized duty of each person in the scene resembled the adopted collaborative behavior of the ancient Egyptians in their daily life activities. While the 3-D miniature of a porch and garden showed different values of the exterior spaces of ancient Egyptian architecture and landscape elements. Within a wooden cuboid, it comprised the exterior space of a porch where a central pond located, and trees surrounded it. The water, trees, and columns of the porch were finely represented and detailed. For example, each leaf of the tree was modeled precisely, and the fruits were positioned within their dense allocations strategically. While the columns were accurately colored and modeled to create a colorful heavenly scene.

Information-Rich 3-D Models

The 3-D digital models of Fondation Louis Vuitton Museum created a holistic and integrated informative entity that flows real-time data about each design element between the project parties. The advancements of cloud computing facilitated the coordination process between the architectural, structural, and MEP 3-D models to prevent clashes between different components of the building and generate accurate simulations of structural elements and environmental aspects. The complex formations of the building and the comprising of different materials and structural elements and systems required the advanced parametric modeling techniques offered by BIM and computational design to enhance the decision-making and construction processes. The BIM models of Shanghai Tower

responded to the challenges of the site and the function of the building. They created a robust integration between digital and physical simulation that established on the basis of accurate information of the building model. The parametric techniques of BIM modeling allowed the designers to generate several form alternatives to facilitate the flow between modeling, simulation, and decision-making to select the optimum design solution that responds to the challenges of the location such as high-speed winds. The 3-D model comprised informative design and structural elements that embodied the artistic creations of the designers exactly as they imagined.

Conclusions

The study showed the radical role of 3-D models in describing architectural spaces. It compared two robust approaches of using 3-D models in creating spatial compositions in two different eras to emphasize the importance of the third dimension in perceiving spaces and boosting the sense of space. Ancient Egyptian 3-D miniatures were innovative and ahead of their time. They created a significant contribution to the current knowledge of Egyptology as they accurately represented a lot of the ancient Egyptian lifestyle. Current digital information models are rapidly evolving into more advanced modeling techniques and progressive methods of design collaboration. They offer a full perception of design elements and their information and support the decision-making process dramatically.

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