The Impact of Mathematical Logic and Philosophy in Contemporary Architecture

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Abstract:
This paper aims to shed light on the current conceptual vision that has crystallized since the end of the twentieth century and the beginning of the twenty-first century. This is to identify the intellectual and philosophical features of this period and the conceptual differences that occurred as a result of the great scientific and technological revolution. The research will discuss in some detail the expansion of linguistics and mathematical logic that resulted from the great development in the twentieth century through the encoding of the mathematical language to become a unified language of science. These attempts ended with the emergence of “digital” technology, which succeeded in converting all symbolic patterns into digital patterns.
The research assumes that architecture today is a direct product of the digital revolution brought about by the great development in mathematical logic and the subsequent cognitive revolution. The paper also focuses its study on identifying the intellectual and conceptual influences that shaped architecture and the influence of mathematical logic and the philosophy of language on the formation processes. The research also presented an inductive critical vision of contemporary architecture based on monitoring and studying the intellectual and philosophical influences that influenced the formation of the intellectual and material propositions of contemporary architecture. The paper also sought to monitor and identify the architectural trends that resulted from the change in conceptual vision by monitoring and analyzing changes in form and concept in contemporary architecture.

Keywords:
Logic, Contemporary, Mathematics, Philosophy.

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1. Introduction:
The twentieth century witnessed major and fundamental conceptual shifts that occurred in philosophy, as mathematical logic played a major role in the development of rational and cognitive philosophy. Empiricism has also become, in the light of mathematical logic, one of the most important foundations of knowledge, which paved the way for an attempt to formulate empiricism in a precise logical language until it became the language of science. The development of mathematical logic and the philosophy of language made the philosophy of the twentieth century bear a logical character centered mainly on language, as logic studies the laws of thought represented in the transition from one linguistic issue to another.
Among the most important philosophers who shed light on language and its relationship to logic was Charles Peirce, who emphasized that language is the essence of thinking and that it is the actual subject of logic and the raw material it deals with. Logic studies the relationship between thinking and language and thrives in the atmosphere in which linguistic investigations flourish. Hence, the relationship between thinking and language appears to be a distinctive force for man, so logic is fully compatible with thinking and language. When mathematical logic became the backbone of the philosophy of the twentieth century, philosophy moved strongly towards language, and the philosophy of language became one of its most important axes.
Hence, philosophy pushed toward the linguistic approach, and other branches of science that emerged in the twentieth century may have joined logic, such as theoretical linguistics, computer science, the study of artificial intelligence, and information software. However, the role of mathematical reasoning was the main effective reason for creating a new language, as mathematics is not a metaphysical reality but rather a language that tells about reality and a tool for accurate inference.
As for the analytical philosophical movement and its philosopher, Bertrand Russell, he was one of the biggest advocates and supporters of the philosophy of language, in addition to several philosophers of the logical positivist school who mainly specialized in mathematics. By reducing mathematics to logic and the mathematical formulas of physics to symbolic logic, language breaks down into discrete units of meaning, all linked and united by the logical structure of a sentence. Gottlob Frege also emphasized the connection between language and logic, and one of his most important contributions was the development of modern logic and the foundations of mathematics. His book, "Foundation of Arithmetic," is the basic text of the logical Method. Early in the 20th century, the British philosophers Bertrand Russell and Alfred North Whitehead attempted to formalize all of mathematics in an axiomatic manner. Scholars have even subjected the empirical sciences to this method, as J.H. Woodger has done in The

Axiomatic Method in Biology (1937) and Clark Hull (for psychology) in Principles of Behavior (1943) (https://www.britannica.com). Von Wright also saw the indirect role played by David Hilbert in the philosophy of language through an intuitive approach (Popper, 2005).

The role of Austrian philosopher Ludwig Wittgenstein also appeared as the one who had a wide and profound impact in imbuing twentieth-century philosophy with a logical character and rationing, tightening, and controlling thinking through language in formulating empirical phrases and logical relationships. Wittgenstein represents the meeting point of empiricism and the mathematical logic that later became the backbone of contemporary philosophy. Thus, it seems that the difference between schools in the origins of mathematics and mathematical logic pushed philosophy toward language until it became the focus of a philosophical revolution in the twentieth century (Copi., 1978). Most of its philosophical currents are interested in language but no longer consider it a transparent means of expression and communication. The linguistic and logical researchers continued to search for a way of communication on which a person can meet and find through it the ability to communicate and integrate with others.

2. Mathematical Logic and Language:

Mathematical logic was developed by many logicians, such as J. Paul and A.D. Morgan, who first formulated the theory of relationships in symbolic form. The efforts of the logical positivism philosophers also began in the critical search for the origins of mathematics, and instead of returning logic to mathematics, they tried the opposite, that is, to return mathematics to logic. This is the path paved by Gottlob Frege and Giuseppe Piano, and Whitehead and Bertrand Russell continued it until they published their book "Principia Mathematica", meaning "Fundamentals of Mathematics", which reveals the analytical nature of mathematics.

The pure mathematician David Hilbert researched the origins of mathematics from another direction, which is the formal approach, which believes that mathematical issues are formulas that agree with the meanings of their symbols without having external connotations. Von Wright argues that Hilbert's project was in a way a revival of Leibniz's 17th-century project, which aspired to develop a universal symbolic language that all people, regardless of their native languages, would unite in using, just like mathematics symbols (Popper, 2005).

Leibniz remains the first herald of the possibility of creating a mathematical language, despite the many prior attempts to encode the language into a unified language of science. These attempts ended with "digitization" technology, which succeeded in converting all symbolic formulas into digital chains of zero and one. Digitization is based on the simple concept that all types of information can be transformed into a digital exchange. Thus, appeared multimedia technology that easily dealt with this digital bullion. All these avatars had turned into gushing torrents of One Zero Chains. Hence, this technology has reached the highest degree of mathematical, logical, and physical abstraction (Russell, 1959).

In light of this digital revolution, modern technology appeared in the second half of the twentieth century, which contributed to the development of electronic industries and information technology, and also contributed to the advancement of computer science, communications technology, and satellites that made the world a small village. This digital revolution made it possible to reach all cultures and opened all borders through the temporal and spatial convergence brought about by the development of communication technology. This led to the emergence of a new conceptual vision with intellectual, philosophical, and technological features different from what preceded it.

According to this vision, the receiver has become more stable. Informatics accelerated and reached all parts of the globe through the communication network, which facilitated the immediate exchange of information and opened new horizons through which it gave a taste of imaginary pleasures and virtual life through smart screens. Information technology has also played a huge deconstructive role in culture, and the Internet has turned into a new, exciting, and dangerous medium at the same time with its ability to bridge the information gap and connect cultures.

After the intellectual and conceptual review of the current conceptual vision, which was characterized by the great contribution of mathematical logic in the development of rational and cognitive philosophy, which formulated empiricism in a precise logical language to become the language of science in the modern era. The research will attempt to study the impact of this new language on changing the context and content of contemporary architecture.

3. Mathematical Logic and Architecture:

This digital transformation led to the ease of temporal and spatial communication in the universe and the transformation of the world into information atoms. It also led to philosophical reactions and formulations reminiscent of mechanical effects, which have emerged as a ruling conceptual vision since the beginning of the Renaissance. They dominated the conceptual vision in the sixteenth and seventeenth centuries, and their influence extended to the first half of the eighteenth century. Mechanical effects have varied in light of the contemporary conceptual vision from being only formal effects to being objective and fundamental effects.

The tremendous development in information technology and the development of programs and applications have contributed to changing the vocabulary and language of architecture, dissolving the boundaries between form and function, and working to integrate space and time. This encouraged the emergence of complex architectural ideas that had previously been difficult to realize. This complexity is evident at all levels of architecture, from small buildings to monumental buildings and urban design, and initial conceptual plans to building execution. Hence, the building was transformed into an intelligent machine that thinks, moves, monitors changes around it and inside it, anticipates what its residents need, and responds to all their needs mechanically. The machine entered as an active element in the process of designing, building, and managing the building and its mechanical services, as it became an integral part of the architectural formation process (McGrath, 2013).

In the second half of the twentieth century, computer science emerged, searching for advanced methods and programs to perform tasks and calculations similar to those attributed to human intelligence. This field is now known as "artificial intelligence," and it has been reflected in all fields and has brought about clear changes in the field of architecture, especially in the first decades of the twenty-first century. This major development in the science of artificial intelligence has pushed the architect's imagination to unlimited dimensions and has also provided him with many design and expressive alternatives that enable the architect to imagine what the building can develop into.

3.1. Smart architecture:

As the applications of artificial intelligence have expanded, the term artificial and its accompanying term (intelligent) have been associated with many applications in which artificial intelligence is used. Then the science of artificial intelligence quickly developed and entered all areas of life. In the early 1980s, information technology (IT) and building management systems (BMS) were combined to produce what is known as smart buildings. Smart buildings are buildings that have been able to benefit from the inclusion of artificial intelligence in building management processes and use some characteristics of automatic response and automatic reaction to adapt to certain conditions and variables. One of the most important features of the performance of these smart buildings is their ability to respond to the surrounding conditions. It also has the effective ability to adapt to the variables of the internal and external environment of the building, daily changes, and seasonal conditions. In light of this scientific and technological boom, the outer layer of the building turned into something similar to human skin, acquiring new scientific and technological properties. The architectural skin in the era of media learned to see, hear, smell, taste, breathe, speak, and be affected by all the sensitivity of the nervous system. Hence, smart architecture has transcended the architectural imagination into the realm of truth, although the imagination still has the potential to add.

Today, architecture has achieved what the men of the digital electronic revolution intended fifty years ago. In light of this revolution, buildings became computer-controlled in all basic natural and technological services, such as using energy generated from the sun or wind as alternative sources of heat and lighting to save traditional energy consumption and make buildings self-sufficient. The photovoltaic cells on the walls, ceilings, and glass curtain walls have been integrated through advanced technologies to become the source that supplies the building with the energy it needs. These systems operate without any human intervention, as they operate on their own according to the needs and environmental conditions surrounding the building. These smart systems and technologies permeated all elements of the building, so that Bill Gates, head of the global Microsoft Corporation, had expected that everything in the house—the building—would think and that there would be smart systems for all activities.

Figure 1: Nicholas Grimshaw, The English Pavilion, Sevilla, 1992.
http://www.compagno.ch/EN/Vortrag_EN_wien.htm
http://www.amazon.co.uk/Pavilion-Exposition-Nicholas-Grimshaw-Architecture/dp/0714827479

Artificial intelligence is still trying to increase the capabilities of smart buildings and give them many of the characteristics of living organisms to control their needs and functions. So, it resorted to biological comparisons or natural similarities, meaning that nature in general, and the human body, in particular, represent the ideal model and source of inspiration. Smart buildings have inspired many levels of measurement, from structural configuration, as the building has the same structural system as the human body, to vital devices. It also borrowed the ventilation system and fresh air circulation systems in the building from the process of breathing and the respiratory system in the human body. Artificial intelligence also added the ability to control the heating and cooling processes carried out by the air conditioning system, which largely represents the role played by the vital devices that regulate the temperature of the human body. Smart buildings also borrowed the idea of the human nervous system controlling involuntary actions, voluntary control of the body's muscles, heartbeat, etc., that occur in the human body and are controlled by the brain.

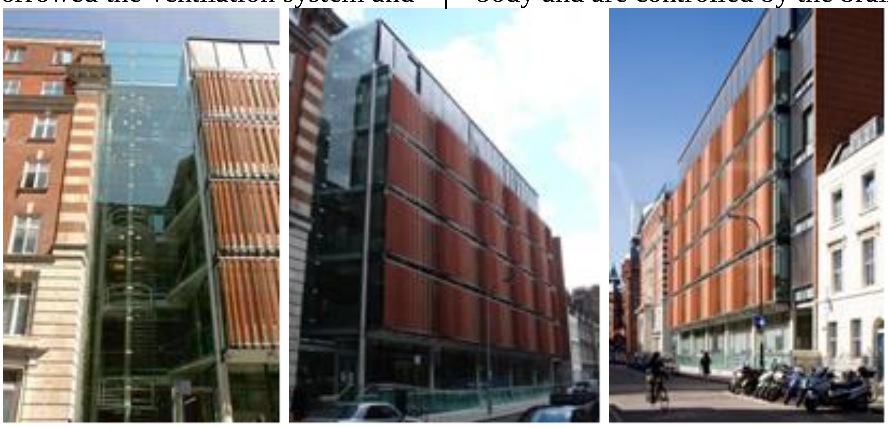

Figure 2: Nicholas Grimshaw, Cancer Institute, London, 2007.
http://www.flickr.com/photos/67385262@N00/page5/
http://www.e-architect.co.uk/london/ucl_cancer_institute.htm

The idea of smart buildings has become a tangible reality since the last years of the twentieth century. The development of building and construction technology goes hand in hand with the development of artificial intelligence. In addition to taking advantage of technological informatics and building control systems to reach the highest functional and technological performance of the building and to provide the resources, elements, and energies of the building at the lowest operating cost.

3.2. Sustainable Architecture:

By the 1980s, global warming and climate change had occurred as a result of significant technological development and expansion in energy consumption. In addition to the emergence of other obstacles to development in the world, such as lack of water resources, depletion of fossil fuels, and environmental contamination. This prompted the architects to reduce energy consumption at all stages of construction and to use recycled materials. They also sought to make the building efficient in energy consumption, developing the building to become an energy generator instead of just a consumer, through modern technologies and programs that control the building from the inside and outside so that it becomes self-sufficient and harmless to the environment. On an international level, many institutions contribute to setting codes that motivate energy saving through developing programs that will help, encourage, and provide guidance in the inclusion of sustainability measures in the design, construction, and operation of buildings. Eventually, sustainability is adopted into building codes at different levels.

There have been continuous attempts to develop architecture and adapt it to the requirements of the times and the needs of users. The great developments in computer science and artificial intelligence have contributed to the development of architecture by trying to maintain environmental balance through certain mechanisms and technologies that are added to the building so that it can manage resources such as water and electricity and control the energy consumed. Architecture also resorted to reusing building materials to reduce the consumption of natural resources to meet the needs of the current generation without compromising its ability to meet the needs and requirements of future generations (McGrath, 2013).

Artificial intelligence has recently become an essential element in building construction. Controls the building's power generation mechanisms. It also controls all automated factors such as elevators, electrical and air conditioning systems, generators, building management systems, etc. All these elements are controlled through automated management and operation systems.

For sustainable architecture to achieve its goals, it has resorted to using many techniques, enacting standards, and necessary codes in designing buildings. Therefore, architects sought to achieve environmental and climatic compatibility of buildings through environmental treatments and architectural devices that move automatically based on computer technologies and programs that work independently to control the environmental and climatic conditions inside the building. This is in addition to controlling the internal environment of the building through technologies and programs that control the building's facades and controlling lighting through various architectural treatments such as transparency, glass color, and the inclination of sunscreens (Brower, 1990).

Figure 3: Atkins, World Trade Tower, Manama, Bahrain, 2008.
http://de.academic.ru/dic.nsf/dewiki/134181
http://airlinesthatflyto.com/http:/airlinesthatflyto.com/tag/bahrain/

Hence, the research concluded that sustainable buildings must be smart and must pass through three stages, the first of which is that the building must include many means of information and communication and be equipped with systems that enable the building to implement the requirements of the designer in the future during the building's life cycle. The second is to develop the building's ability to respond through advanced technology to user requirements on several levels according to the virtual arrangement of each element. The third is for the building to become effective and responsive to the environmental conditions surrounding it and to have a positive impact on energy generation and the preservation of natural resources, in addition to achieving an appropriate indoor environment that reaches the level of complete user satisfaction in all aspects while conserving energy and improving the productive efficiency of users.

3.3. Virtual Architecture:

The twenty-first century is the era of the technological and digital revolution that has directly affected all aspects of life, including architecture, which has been affected by the use of computers in the field of architectural design, which has become a virtual environment that simulates reality and through which three-dimensional architectural configurations and elements can be modified and developed. The twinning of imagination and reality in architecture has grown significantly at present as a result of the tremendous expansion in the use of technology in imagining and creating architectural spaces, which are increasingly enriched with imaginative logic and through programs and applications that help visualize architectural spaces and blocks (A. Ali, 2006).

Through the development of artificial intelligence on the Internet, which turned it into an artificial world, computers built imaginary worlds to simulate the real world. They are imaginary worlds generated from numbers and symbols, and the user immerses himself in them thanks to the illusion of sight, the possession of the senses, and the effects of automatic interaction to carry out experiences that are difficult for him to practice in his real world. To practice experiences that are difficult for him to practice in his real world, and to take "cognitive incubators" through these imaginary worlds and practice their experiences without fear or restrictions.

Figure 4: Marcos Novak, Conceptual Drawings for Virtual Architecture, 2000.
http://www.asa-art.com/virtus/novak.htm
http://www.archilab.org/public/2000/catalog/novak/novaken.htm
http://www.turkishairlines.com/en-INT/skylife/2008/july/cityscope/turbulent-topologies.aspx

The virtual reality experience aims to fully coexist with the recipient inside the building or urban space by walking inside the computer-designed space that does not exist in reality and interacting with it by walking forward, backward, right and left, and dealing with the space as if it existed in reality. These applications fall within the scope of showing architectural work as well as evaluating the design process in a deeper way for the creators, judging it before implementing it, and proposing any amendments that may be added to the proposed design. Through these programs and applications, the designer can study the movement of people within the space, create models for movement and lighting, and know the effect of the movement of shadows on the building at different hours of the day. The virtual movement also enables him to know the possibility of space responding and changing after days or years of use and change. Virtual reality mechanisms have multiple benefits, as the project is not implemented until it has all the potential for success as an imaginative visual image that can be modified, developed, and re-presented over and over again.

The information culture industry helped the emergence of pixel architecture and provided various contents based on virtual reality and digital photography, which helped build artificial environments that simulate reality and transcend it into illusions that cannot be built in reality. The use of multimedia to express virtual reality and persuade the viewer of their imagination also helped to create a cyberspace composed of plastic digitization of ones and zeros that embody shapes and symbols in hyper architecture and hybrid architecture with a changing interactive surface. This imaginative architecture toppled the barriers of reality and matter and transferred them to computer screens, opening new horizons for architects and allowing imaginative experiences and events to be freed from the constraints of physics, nature, matter, and society without attachment to predetermined forms or images.

Thus, progress in computer programs and applications used in architecture was not limited to architectural presentation but rather tended to assist in the process of architectural thinking and design, which computers transformed from an absent, invisible, and abstract imaginative process into a visible process. One that can be applied to all aspects of life, and one that promises to revolutionize the process. Architectural design and imagination as a whole are linked to the emergence of architecture that blends the real and imaginary worlds. Dutch historian Bart Lootsma said: "Instead of trying to ensure the permanent life of existing architecture in a different setting, our plan today should be to mix architecture with other media and systems to produce a new and powerful hybrid" (Zellner, 1999).

One of the first architects to benefit from the technological and digital revolution was the architect Frank Gehry, who used computer programs in the field of architectural design. He also benefited from the capabilities of virtual reality in developing and modifying the external configurations and internal spaces of his buildings, and this appeared in many of his works at the end of the twentieth century and the beginning of the twenty-first century, such as Experience Music Project, Seattle, USA, 1995–2000, Disneyland Music Hall, Los Angeles, USA, 1999–2003, and Le Revo Center for Mental Health, Las Vegas, USA, 2007–2009, and other buildings in which Jerry used the same techniques to reach expressive formations and vocabulary that express his ability to create and innovate through computer programs. Many architects sought to benefit from the creative capabilities of imaginative architecture and the rapid development of advanced technologies, programs, and applications, such as Zaha Hadid, Daniel Libeskind, Peter Eisenman, and others.

Figure 5: Frank Gehry, Music Experience Center, Seattle, USA, 1995-2000
http://www.idealog.us/2008/02/tear-the-roof-o.html

Figure 6: Frank Gehry, Disneyland Music Hall, Los Angeles, USA, 1999-2003
http://edgeoftheplank.blogspot.com/2010/12/walt-disney-concert-hall-by-frank-gehry.html

The technology and applications influenced by the significant development in mathematical logic have grown until artificial intelligence (AI) has a direct and influential role in architecture. It has also become a powerful and widespread tool among architects, especially in the third decade of the twenty-first century. AI can solve simple, practical problems, such as how to arrange a floor plan, with unparalleled speed and versatility. He can draw wide-ranging and creative visions culled from images available across the entire Internet with just a brief text message.

4. Conclusions:

By observing the intellectual and philosophical features of the current conceptual vision, the research concluded that mathematical logic played a major role in formulating and shaping philosophies and ideas throughout the twentieth century as a whole, and its influence continued at the beginning of the twenty-first century. It opened the way to formulating a unified language for science and colored the philosophy of the twentieth century with a logical color that focused primarily on language by studying the relationship of the logic of thinking to language.

Philosophy moved towards interest in language, and the philosophy of language became one of its basic axes, which produced many intellectual and philosophical schools that influenced the formulation and formation of conceptual visions in the twentieth century until the first decade of the twenty-first century.

Linguistic philosophies developed until they attempted to develop a mathematical symbolic language that unites all people regardless of their original languages, such as mathematics, whose letters form a unified alphabet for human thought. These linguistic philosophical experiments appeared in the works of Leibniz, George Boole, and other thinkers and philosophers until a mathematical language was reached through digital technology that succeeded in converting symbolic formulas into digital strings of zeros and ones.

Computer science and information technology developed rapidly beginning in the second half of the twentieth century and were able to influence the formulation of architectural results and trends through the influence of multimedia and the tremendous development in information technology. She was also able to change the vocabulary and language of architecture, removing the boundaries between form and function. Information technology also accelerated and reached all parts of the world through the communications network, which facilitated the exchange of information and opened new horizons for virtual life and imaginative pleasures through smart screens.

These developments were reflected in all fields and brought about changes in the field of architecture in particular. These techniques have been integrated into architectural products since the beginning of the 1980s. A type of building controlled by computer programs emerged, and it was called smart buildings. Smart buildings have some human characteristics, such as automatic response and automatic reaction, to adapt to environmental conditions and variables. The most important feature of these smart buildings is their ability to respond to and adapt to internal and external environmental variables and all daily and seasonal climate changes.

Modern technologies and various computer programs have been integrated to control the lighting, temperature, and ventilation that the building needs under different environmental and climatic conditions and under multiple uses to provide biological comfort to humans while preserving energy and natural resources.

The architecture was influenced by the use of computers in the field of architectural design, which became a virtual environment that simulates reality and through which three-dimensional architectural configurations and elements can be modified and developed. Imagination and reality have also been mixed in architecture as a result of the tremendous expansion in the use of technology in visualizing and creating architectural spaces, which is increasingly enriched with imaginative logic and through programs and applications that have helped to visualize architectural blocks and spaces.

5. Reference:

1- A. Ali. Author, Editor · C. A. Brebbia. Editor (2006). Digital Architecture and Construction Abstract by S. Hatzellis, University of Technology, Sydney, Australia. page 51, 54.

2- Barker, Chris. The Sage Dictionary of Cultural Studies. London Sage Publications Ltd, 2004.

3- Brower, Michael; Cool Energy, (1990). The Renewable Solution to Global Warming; Union of Concerned Scientists.

4- Collins Jeff, Mayblin Bill, (2014). Introducing Derrida, Icon Books; 4th ed. edition, London, UK.

5- Derrida, Jacques, Eisenman, Peter. (1997). Editors Jeffrey Kipnis, Thomas Leeser, Publisher Monacelli Press.

6- Derrida, Jacques, (1998). Of Grammatology, Johns Hopkins University Press, Baltimore, USA.

7- Douglas, Christopher, (1997). Glossary of Literary Theory". University of Toronto English Library.

8- Gympel Jan, (1993). The Story of Architecture from Antiquity to the Present, Konemann, Imago publishing L.T.D., Hong Kong.

9- Hamlyn, Paul, "The Life & Times of Michelangelo", (1967). Published by The Hamlyn Publishing Group Ltd, Verona, Italy, P.16.

10- Iris Murdoch, (1992). Metaphysics as A Guide to Morals, Published by Penguin Books. U.K. P.185.

11- Irving M. Copi. (1978). Introduction to logic, Macmillan, New York, 5th ed. P.264.

12- Jencks, Charles, (1988) Deconstruction: The Pleasure of Absence, in A. D. Profile 72, "Deconstruction in Architecture, Vol. 58, Nos 3/4.

13- Jencks, Charles, , (1999). Ecstatic Architecture, Academy Edition, UK.

14- Kostof, Spiro. (1995). "History of Architecture setting and Rituals", second edition, Oxford University Press, New York, USA.

15- Lenartowicz, J. Krzysztof. "Architecture of Terror", Published by Website: http://www.zowje-scrolls.com/zwoje40/text25p.htm

16- McGrath, Brian. (2013). Resilience in Ecology and Urban Design, Springer Dordrecht Heidelberg New York London, pp. 230-235.

17- Popper, Karl, (2005). "The Logic of Scientific Discovery", Taylor & Francis. P.15.

18- Russell, Bertrand. (1959). Wisdom of the West: a historical survey of Western philosophy in its social and political setting, London: Macdonald, U.K.

19- Steele, James. (2001). Architecture Today, Phaidon Press Inc., New York, 2001.

20- Zellner, P., (1999). Hybrid Space, New Forms in Digital Architecture, Thames and Hudson Ltd, London. https://www.britannica.com/science/axiomatic-method