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Discussing Practical Work Methods in Digital Tools-Performance Based Architecture Assignments

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Abstract---*This study discussed practical work methods for architectural tasks based on digital technology. We carry out a series of data thefts and analyze them under a phenomenological approach. Among other things, we code the data, evaluate interpretations and draw conclusions to get valid and convincing answers. Searching for data electronically on publications released between 2010 and 2022 is because, during this era, there was a rapid development of the use and transformation of lodges in the world. After reviewing the data, we reported it qualitatively by relying on secondary data in a systematic review design. The results include that digital applications have helped architects' world tasks effectively and efficiently. We hope these findings contribute to the works of academics, researchers, and policymaking.*

Keywords---*architect assignments, digital tools, discussion, practical works, work methods.*

Introduction

The science that continues to develop from time to time influences various aspects of human life and the world's works. One of them is the development of digital and virtual technology, which continues to grow in line with the development of science—coupled with various companies that compete to produce a variety of the latest technology (Sauvé et al., 2016). The term digital is no stranger to everyday life. At this time, digital technology has entered various aspects of life, starting from the education sector, the transportation sector, the health sector, the economic sector, and various others—other fields. Likewise, the world of architectural design is also not immune from the influence of digital technology. Digital technology helps architects or designers in the process of producing product images and in the process of creating a design. Even lately, digital technology has also helped architects to the development stage. This, of course, makes it easier and makes the work of architects or designers more efficient (Monsalve-Pulido et al., 2022).

The development of fabrication techniques begins with mass manufacturing, which Henry Ford, founder of the Ford Motor developed and expanded in the early 19th century (Attaran, 2017). This technique generates a duplicated model. As a result, the prediction of quantity, time, and quality is accurate, and operating expenses are lower. In architecture, where CAD technology replaces drawings, like in Lisa Iwamoto's Architectural Engineering and Materials Digital Manufacturing, digital fabrication gives new insights and stretches the bounds of architectural form and structure (Iwamoto, 2013). Furthermore, Seely stated that digital fabrication impacts the architectural design process due to its importance in supporting architectural models. Dunn, like Seely, explains why students and the architectural industry build models. In design-related occupations, creative concept representation is crucial. particularly in architecture, because we seldom get to see the finished product, i.e., the building, until the completion of the design process (Attaran, 2017).

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Initial concepts are created by allowing the designer to study, modify, and improve ideas in increasing depth until the project design is ready to be implemented. Models may be adaptable in this process, allowing designers to express themselves freely (Hienerth et al., 2011). As in the digital era, digital fabrication has bridged the gap between ideas and manufacturing. They were directly creating digital linkages using a numerically controlled manufacturing (CNC) "file-to-factory" procedure. Digital design and manufacturing are becoming more essential skills for architecture students. Stoutjesdijkas defines the industrial period 4.0 as a paradigm for digital design and fabrication technology that aspires to make digital fabrication methods accessible to everyone (Putro & Wirasmoyo, 2020). This represents a move from a consumer to a producer world, where anybody may manufacture energy, information, food, and commodities via shared knowledge networks and digital fabrication tools. Researchers will present the learning process of laser-cut digital manufacturing applications utilizing the parametric design technique to generate designs based on Voronoi diagrams in this study (Di Roma, 2017).

The incorporation of digital technology into architectural design occurs in two stages. In architectural design, digital technology first appeared as a tool for visualization (Nambisan, 2017). However, as digital technology has progressed, it is now possible to use it as a thinking tool and as part of the design or design process. As a result, the architectural design process gets different. Designers, architects, and even students can look for novel design innovations (Mödinger et al., 2022).

Additionally, digital technology can perform a variety of design analyses and evaluations. For architects or designers, this is extremely helpful in creating a better design. Because of this, architects and designers benefit from digital technology throughout the architectural design process. As a result, the world of architectural design must be connected to digital technology in this modern era. However, it cannot be denied that the architectural design process sometimes requires traditional design methods like conceptual sketches. According to Ashby & Johnson (2013), in the early stages, digital technology only had an impact on architectural design in the form of tools that made drawing or producing product images more efficient and precise, both in the form of initial concepts and detailed drawings (Orengo et al., 1997; Senkul & Toroslu, 2005).

When drafting, sketching, or modeling, the computer is only used as a substitute for paper, pencil, or other drawing tools at this stage. The computer is a passive medium at this point. In order to teach computers to generate lines, geometric patterns, and objects, among other things, architects or designers play a crucial role. Computer-Aided Design (CAD), one of the most widely used software among engineers, architects, and designers, is not the purpose of the computer in this instance but instead as a tool in the design process. Due to the high cost of the first CAD systems, which utilized mainframe computers with advanced graphics technology, only large businesses utilized CAD. Barrie (2016) states that AUTODESK was the first vendor to offer CAD-based PCs with the AUTOCAD CAD system (Compher et al., 2006; Hillmayr et al., 2020).

Moreover, now WINDOWS is the central operating system for CAD1. Initially, CAD could only work on 2-dimensional graphics, which could assist designers in producing images with more precision and saving time on drawing product completion. In the 1960s, CAD was still used in various fields of aerodynamics in the manufacture of airplanes and cars, not specifically in the field of architecture (Barrie, 2016). However, as technology advanced, mainly digital technology, CAD could move into 3-dimensional graphics from 1985-1986. This is extremely useful for architects or designers in creating models that can be used as an initial conceptual design or for other reasons, such as simulations and analyses, without requiring mock-up modeling with traditional methods (Fucci, 2011).

As previously explained, in the early stages of CAD, 2D and 3D CAD only function as tools in designing/designing or as drawing aids, not as tools that can produce or create a new design or design (Shih et al., 2017). This means that the role of architects and designers is the biggest in operating software or computer. In general, CAD can do several things, including; 1) 2D drafting to create architectural working drawings; 2) 3D modeling to make mass/geometry/space/shape research; 3) Rendering for the presentation/study of lighting/architectural materials; 4) Animation for a sequential space investigation on a human walking/floating scale; 5) Maya (virtual) for examining architectural work/room/mass perfection. Digital technology in the world of architectural design is not only limited to CAD. Various other software can help the work of architects or designers, such as 3ds Max and SketchUp. In principle, this program works almost the same as CAD because this program also functions as a tool that can help process drawings more efficiently, not create new designs (Ghajargar, 2018).

Besides that, in the world of architectural design, several digital programs are also known that help in the process of final presentation or presentation, such as CorelDraw and Photoshop. This software or program helps architects and designers produce more attractive image presentation products. Computing as a Design Methodology Along with the advancement of digital technology, software or programs relevant to architectural design have been created (Chan & Blikstein, 2018). If digital technology in architectural design began as a tool to assist designers in producing product pictures more quickly and correctly, it is now acting as an actor in the architectural design process. In this case, the computer not only functions as a tool that helps architects and designers speed up the production of drawing products but also helps architects and designers in the design process and discover new design concepts. This means that at this stage, the computer has been used as a thinking tool to solve problems in the architectural design process. At this stage, architects and designers can explore the computer design process in various aspects, such as form, spatial, structure, materials, and other aspects. Thus, geometric shapes with a high level of complexity can be completed with the help of digital technology, in this case, computing as an architectural design process. Even at this time, simulation or analysis of environmental influences on buildings or vice versa can be done with the help of a computer. The computer is an instrument for exploring and innovating designs (Balletti et al., 2017).

Computation is used in exploring complex geometric shapes as a simulation to obtain shape innovation. Now, computation in the design process can also be used as an analytical instrument (Ergün et al., 2019). One example is Autodesk software, Ecotect Analysis, which functions to simulate building performance. One of the uses of this software is that it can simulate the influence of the environment or building design land, such as lighting, shading, and ventilation, which will affect the thermal conditions inside the building later. Computing technology influences changes in communication and representation in architecture. The ability of computing technology to change communication and representation in architecture is based on six computer properties (Kavakoğlu et al., 2021). 1) Flexibility. The ability to modify the appropriate degree of abstraction without rebuilding the representation from the ground up. 2) Interlinking. The capacity to connect information represented in multiple ways such that when one is changed, the others are likewise changed. 3) Information Management. The capacity to organize and retrieve large amounts of information. 4) Visualization. The capacity to generate realistic images without artifacts and surroundings. 5) Intelligence. The capacity to include design rules, limitations, and objectives inside the representation, transforming it into an active collaborator in the design process. 6) Connectivity. The capacity to swiftly communicate information (Kołata & Zierke, 2021).

Research Method

The goal of this research is to talk about realistic working approaches for architectural jobs that use digital technologies. Here, we examine numerous pieces of scientific data demonstrating how digital technologies may be used effectively in today's architectural occupations (Fonseca et al., 2014). For the variables above, we have conducted a series of data searches on literary sources for architectural work and the presence of digital applications for heavy tasks, which we have reviewed under a phenomenological approach. Among other things, we try to code, come to verify the data, analyze, evaluate, interpret and draw conclusions that we believe are valid to answer the problem (Thorne, 2016). We designed this study in a descriptive qualitative manner where we wanted to understand how digital applications can make tools that complete architectural tasks. This study also relies on published data in the form of secondary data, which we focus on data released from 2010 to 2022, bearing in mind that recently digital applications have been used in various aspects of business and government life. Data search will be carried out electronically by placing keywords so that we will get some data that can explain and back up our findings. After a series of analyzes and proofs, we report it in a descriptive qualitative report study in the form of a literature review report in the field of architecture (Rantala et al., 2020).

Result and Discussion

Digital Technology's Impact on Architectural Design

Architectural design has been greatly influenced by digital technologies. Prior to the advent of digital technology, the design process was carried out manually, also known as the traditional technique, with paper and pencil or other writing devices. With this traditional method, completing a design process requires a longer time. However, some architects or designers still use traditional methods because it is through strokes that architects can express their ideas more expressively (Gu et al., 2011). As previously explained, digital technology in architectural design makes it easier for architects and designers to work. Image products can be produced in a faster and more accurate time. Besides that, architects or designers can also explore and innovate in various aspects by using the help of digital technology for architecture. For example, software to explore geometric shapes with a high level of complexity cannot be solved manually (Fortin et al., 2011; Münster et al., 2017).

Architects and designers may innovate using computer programs or software such as Rhinoceros and Grasshopper to simulate increasingly complicated geometric designs (Mutaz et al., 2021). Of course, a different experience from architects or designers is required here to comprehend the fundamental parts of geometric mathematics. This is required since the data in mathematical geometry will be needed later. Digital technology has advanced at a breakneck pace during the previous few decades. Architects, designers, and architecture students attempt to include it in their design processes. However, conventional design processes like pencil drawings or other drawing tools are only sometimes eliminated or abandoned, particularly in architectural education. Students of architecture who are involved in this case in their education still combine traditional and digital methods (Wortmann & Tunçer, 2017).

Parametric tools and interactive design

The parametric architecture design process can be broken down into two phases, as we have seen so far; The first step is to develop the "body plan," also known as the generic relationship scheme (Kato & Goto, 2017). The second step is assigning concrete values to the existing parameters to produce a final result with a particular geometry. These values will be entirely up to the designer, who can intuitively dictate them or consider values from tables or other databases. Parametric architecture is fascinating in this second scenario; Data on external phenomena like the sun, wind, noise, topography, etc., can be linked to the formal genesis laws (relational laws). This design strategy can create sensitive geometries directly connected to the surrounding phenomena. Performance-oriented design or "performative" design are terms used to describe this. Professor Michael Weinstock uses a biological analysis to explain this aspect, relating the development and growth of living things to parametric design (Hensel et al., 2013).

We know that a living thing's form is not merely a manifestation of its genetics adapted by the forces of its environment (phenotype) but rather a direct and pure translation of the information in its genetic code genotype (Singh, 2015). The interaction between the body plan and environmental-sensitive parameters and the interaction between internal generic laws and environmental singularities will serve as the foundation for the final form. This phenomenon will be perfectly identifiable within the parametric architecture. The generation of the parametric form is envisioned as an evolutionary process, similar to how living things evolve, in which architecture changes its form to meet the various project requirements. According to Rivka Oxman, this design strategy "transformed the concept from the form into the concept of formation." This will necessitate a change from "objective logic," based on pure, rigid forms and clearly defined dimensions, to process logic, which is much more flexible and unrestricted, with formal guidelines defined by an open genetic code (Inam, 2013).

The interactive design may be developed by including the time component in parametric systems. Because they are permanently connected to sensors or systems that collect information from many events in real-time, some parameters in interactive designs may change in value. There is a wide range of these phenomena: changes in the sun or the atmosphere, information about people's movements and physical actions, etc (Stavric & Marina, 2011). Most of the time, interactive designs were thought of as experiments pushing the field's boundaries and blurring the lines between architecture and machines. Due to this, the concept of authorship, the concept of the finished product, the evolutive capacity of architecture, and several other architectural concepts will all be the subject of debate and questioning. Last but not least, remember that the parametric design may contain varying degrees of experimentality. The parametric design will be very similar to what we previously defined as representational strategies if the designer presents a scheme with direct and apparent relationships and quantitatively defines the parameters (Stavric & Marina, 2011).

On the other hand, the designer will no longer have complete control over the final result, which will remain open to some degree of contingency and surprise if the relationships become complex and the parameters are defined from the large amount of data managed by the computer (de Vasconcelos & Sperling, 2017). The parametric design's computational and algorithmic nature is most evident in this last instance. Different commercial software, including Grasshopper (a plug-in for Rhinoceros), Generative Components (by Bentley), and Dynamo (by Revit), among others, can be used to develop parametric design strategies. Developing a generative strategy is similar to proposing a scientific experiment in which the three fundamental aspects are defined: the elements that are a part of the experiment, the researchers' initial attitudes toward these elements, and the general law that dictates how these elements ought to interact with one another (an algorithm). The researcher must carry out the experiment, which entails calculating and emulating all possible interactions between the base elements to obtain the final result. The computer and its computing power have become crucial tools at this point. In parametric strategies, the designer creates and manages all project-related relationships; the architect explicitly designs the design of the relationship tree's stems and branches (Gobeil et al., 2021).

On the other hand, in generative strategies, the designer only has control over the initial conditions; Within the computer, all of the intermediate stages required to define the final form are developed in an implicit or hidden manner. In generative strategies, it is common for highly complex forms to emerge from relatively simple initial laws, breaking the linearity of human intuition and rationality (Ma et al., 2019). However, regardless of the result obtained, this will always be entirely consistent with the conditions or laws established at the beginning. The need for the computer to explore territories previously inaccessible to the human mind becomes more patent in this kind of strategy. In the case of the Toyo Ito pavilion for the Serpentine Gallery, which is depicted in the image below, the generative processes that are described in the algorithms can either be of natural origin, understood as direct translations of actual processes or phenomena that are present in nature or they can be of artificial origin, which means that they were created by the designer and are based solely on intellectual criteria. The algorithm's formulation results from observing, quantifying, and formalizing actual phenomena in this second scenario, which is typically the most prevalent (Kazi et al., 2017).

BIM and Digital Transformation in Architecture

In the last four decades, the design process in the architectural industry has undergone a significant transformation. Pencils and paper, which used to be the main work tools in producing images, have now been replaced by computer programs. In less than forty years, the techniques of designing and communicating drawings that are applied in both the professional and educational fields of architecture have shifted from manual methods to digital systems (Son et al., 2015). There are many factors behind the design process transformation described above, one of which is efficiency. Based on personal experience as an architecture student, drawing does require more time than if the design drawings are made digitally. Especially when there are errors in the finished drawing, the only way to fix it is to redraw it. For example, if the floor plan of a building changes, the views, sections, and other drawings must also be reworked to suit the new plan. This could be more efficient. Apart from spending more time and wasteful use of paper, the chances of errors and omissions occurring in the manual drawing process are also more significant compared to digital drawings, which have a higher level of accuracy (Souillard-Mandar et al., 2016).

On the other hand, digital technology in architecture gives more significant opportunities to improve architects' performance. Initially, digital technology's involvement in architecture was confined to serving as a drawing medium to replace pencils, paper, and rulers (Souillard-Mandar et al., 2016). BIM's existence converts digital technology into a process that not only displays images but also offers information about the object being manufactured. BIM (Building Information Modeling) is a digital technology that enhances the life cycle of a project, from design to operation, maintenance, and deconstruction. *It holds a wealth of information on the building's numerous pieces, such as material specs, colors, patterns, and textures, as well as the size of a component*. With this variety of information, BIM can be a reference for calculating estimated construction costs and analyzing building performance. Since the initial phase of its emergence, BIM has continued to update itself so that it has grown from level 0, which can only display 2D objects, to level 3, which allows many parties to collaborate *online* in designing (Sacks et al., 2018).

Parties from diverse AEC (Architecture, Engineering, and Construction) disciplines may now coordinate and collaborate to better optimize the design. BIM may increase the quality of design presentations in addition to streamlining the design process (Maliha et al., 2020). The quality of visualization of images and 3D models that are more detailed and equipped with various information in them will enhance the user experience. In the professional world, this will help the client get a more accurate picture of the existing project so that it can be considered for decision-making. Whereas for architecture students, visualization of designs with good visual quality will make it easier to communicate designs to examiners. With all these advantages, will the inclusion of digital technology in the world of architecture erode the creativity of designers? (Khalil et al., 2015).

Various design *software* was created to simplify the design process, but the concepts and designs presented are still the fruit of the designer's creativity. The features programmed in the latest design *software* are beneficial for creating new ideas (Kroll, 2013). BIM's ability to analyze and simulate environmental influences such as ventilation, lighting, and shading will facilitate the process of finding design concepts that are more exploratory and follow the context of the building's location. Based on a computational system, BIM can facilitate designers to be able to explore a variety of complex geometric shapes. So, the parametric design is possible. Superior in various aspects makes digital design technology the leading choice to replace other design tools. However, the dominance of digital technology as a design medium used today only sometimes eliminates conventional design methods. The combination of the two is still widely applied and commonly found in the architectural education process. Manual sketches are still widely used by students and professional architects in the early stages of design (Calori & Vanden-Eynden, 2015). They are considered a way that is still relevant to explore ideas before they are poured into digital form. Thus, mastery of digital technology supported by the ability to draw manually will increase the competence of architects to compete in the global arena (Kossek et al., 2006; Karhu et al., 1977).

The Practice of Architects in the new normal

An Architectural Future When this epidemic emerged, world conditions were experiencing disruption, and many things related to the economy were evolving toward industry 4.0. One of the significant issues in the disruption is employment issues, including professionalism. In the era of disruption, many professions have had their position re-questioned in human life, especially regarding the economy (Kimura et al., 2020). This includes the Architect profession, which is considered to be archaic. The Architect profession is considered to be doing work that can be replaced by applications or later with artificial intelligence (artificial intelligence). Disruption in the field of Architecture began to occur in the late 90s, when the seeds of 3D simulation began to be developed for the film, which later developed into BIM (Building Information Modeling), parametric and coding, including recently micro-robotic technology started to enter into daily processes. Architecture with various objectives, one of which is creating the possibility of new forms and work efficiency (Zhang et al., 2013).

Retrospection of the Role of Architecture All architects and architecture instructors must know that architecture was created to solve problems related to spatial and human activities in it, with due regard to efforts to protect, pay attention to the health and improve the welfare of its user's health, safety, and welfare (Capilla et al., 2016). Architecture is also believed to be an agent of change for the people who use it. From the civilizations of Egypt, China, and Java, which were active in forms and symbols, then changed to space in Greek and Roman civilizations with architectural works such as the Parthenon and Pantheon, to the masterpieces of the Gothic and Renaissance eras, architecture in terms of design and engineering (construction) was almost impeccable. Underwent significant changes. Renaissance and Gothic were the golden ages of world architecture, but after that, there was stagnation and continuous repetition until Modern Architecture emerged. After Modern Architecture, architecture again stagnated; the design was only a repetition and refurbishment until information technology (computing) penetrated architectural design (Carpo, 2012).

Program transition from rigid (class, limited) to flexible (time, amount, and place). Classes that used to be placed as school buildings when they had to go to school from home/learning from home are free to go anywhere as long as they are connected to the internet and a laptop. The number of students that used to be limited has now become free because of the disappearance of the "class wall" boundaries. The institution's existence was suddenly questioned, including the accompanying architectural program, namely the school. The school building, a marker or symbol, suddenly seems to have disappeared. Anyone can learn anything and anywhere is a necessary term when everyone switches to virtual classrooms on the internet media. It is as if the school institution only acts as an administrator, so if this condition continues, the architecture of the school building will be questioned again. When the Covid 19 epidemic occurred, various "shifts" suddenly occurred. Socio-cultural factors that have the most impact, which make various things in architecture questionable again, various living habits such as working, shopping, and going to school are being questioned, including the building that shelters them and economic factors which also have an impact on purchasing power, one of which has an impact on the world construction, especially architecture engaged in the property development sector (Stiggelbout et al., 2015; Parker & Hess, 2001).

Retrospective of the Role of the Architect

The contribution of architects to their role in forming the built environment makes the architect profession have to introspect on their position repeatedly (Merritt et al., 2017). At the beginning of culture, architects played the role of agents for environmental development (environmental builder), then culture advanced and became more aware of the environment, added its role as an agent for protecting the environment (environmental guardian), and now (before the epidemic), when the environment (earth) begins to experience "saturation" "fatigue" and "aging" the role of architects is added as an environmental coordinator (Trevisan et al., 2017). The function of environmental harmony is inextricably linked to the character of the architect, who must "create" circumstances of togetherness (coexistence) of the ancient and the modern in its many manifestations (for example, reality - virtual reality - hyperreality, private - share space - public, territory - blurring - share). Architects play a role in creating this togetherness, especially in translating new social culture into forms or spatial in architecture (Knodel & Naab, 2014). Accommodating various interests is crucial so every interest can work harmoniously, even in conditions like this pandemic. Architects have a role in the social and cultural "experiments" of society. The design of large plazas or park movements is the idea of designers and planners to solve (or create) social and cultural problems in society. The same goes for Mixed Use, Bigness, or Urban Kampung, which various developers or city governments in Indonesia are currently developing. In the long term, the architect's position is again questioned because the existence of architectural works is also questionable (Lu & Qian, 2020).

This concerns the government, developers, and architects because it will involve significant economic value for architects as consultants. However, if you look at a survey from Gensler (an international architectural consultancy) related to offices in 2020 in the US, only 12% of residents in the US want to work from home (Sebastian, 2011). This gives architects and developers a cool breeze because office buildings are still needed. If you look at the survey results, it turns out that offices act not only as administration alone but also as a forum for socializing accessed September 2020. Socialization is essential in determining employees' productivity because it must be translated into spatial when designing an office. The Architect profession, apart from designing for its clients for change, on the other hand, also need to transform its operational processes so that the quality and quality of the designs are not sacrificed, including the quality of construction results which must always be controlled. This causes changes in the Standard Operating Procedure (SOP) caused by social distancing, including behavior in the studio (Iwamoto, 2013).

Conclusion

Our study aims to discuss practical work methods for architectural tasks based on digital technology equipment. By reviewing several scientific pieces of evidence, we have identified and discussed findings related to the above variables on the principle of validity. Designing architects have recently been carried out with the help of digital technology. This energy reliability can do several heavy tasks with innovative power to provide effectiveness and practicality. Elsewhere we see that the interactive design of parametric tools has simplified and practicalized the work tasks of today's architects. Likewise, building information modeling tools have been able to transform architects' tasks where with very modern applications, these tasks will be easy to carry out. Likewise, when Indonesia and the world entered the pandemic era, the practicality of technology encouraged architects to carry out hefty tasks with artificial intelligence capabilities to help architects with their tasks. Likewise, the architect's task, which is very retrospectively part of the development of the architect's work, is to practice the existence of an environment where this tool can provide environmental protection due to the practicality and efficiency compared to work. These included our findings and were backed up by previous friends, so the points we discuss result from a review of several pieces of literature related to practical work methods for architectural tasks in the digital technology era. We hope these findings will be helpful in studies and discussion research for development purposes by researchers, academics, and industry.

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