PARAMETRIC DESIGN AS ACTION RESEARCH METHOD IN ARCHITECTURE

Abdullahi, Jibril Agyo-Ladan
Department of Architectural Technology
School of Environmental Science
Hussaini Adamu Federal Polytechnic, Kazaure, Nigeria

Correspondence E-mail: jibrilabdul71@gmail.com

ABSTRACT

This paper discusses how architectural design processes can be classified as action research for creating new knowledge. It argues that research work in architecture can be pursued through methods that are appropriate to the nature of problem at hand. Action research is introduced as a research method that has much in common with applied design processes, enabling designers to develop research in the realm of design. Furthermore, the paper aims at providing an overview of parametric software packages presenting the possibilities of applying it in architectural research. The study centres on systematic literature review. Some of the relevance of the application of parametric design in architectural research are cost saving, time saving, user friendliness, visualization of processes, accuracy and repeatability among others. The paper recommends intensive tutoring on parametric design for schools of architecture.

Keywords: Action research, Architectural research, parametric design, Simulation

Introduction

The attributes of architecture granted its training towards seemingly an apprentice-like approach. Over the years, the education and training of architects, centre more on the utilitarian attributes (the finished design product-building) and the expressive attributes (the aesthetic values) but totally ignoring the theoretical exigencies that sired the design phenomenon (Uji, 2009).

Designing typically involves the inception and development of ideas as well as their manifestations. However, in architecture, acting (making) goes hand in hand with reflection in design process. Designing cannot be learned from books without applied practice. In architecture, studying design is always linked to practicing design (Herr, 2017). Depending upon the specific architectural phenomenon under investigation, different research methods are employed, ranging from scientific methods used in the areas such as building physics and construction to qualitative methods of inquiry common in area such as housing research or history (Groat & Wang, 2013).

The idea that use of computer is now culturally embedded in our daily lives is mostly taken for granted by all. One recent study, however, is very informative about the benefit of using computer in architectural research. Computing technology has, in the last two decades, achieved an incredible advance.

Andia (2002) in a study, revealed that architectural profession has for the past thirty years incorporated Information and Communication Technology (ICT) in the practice, specifically in countries like the United States of America, Japan and also in Europe. Andia points out that ICT has had a considerable influence on how architects operate at both the level of skills and the level of profession culture. The software field has also progressed considerably with new software development tools, programming languages and methodologies. This new powerful computing environment is packaged and made available to architects in the form of new generation of 'Graphical Workstations' (Guney, 2015). In fact computer-based design tools offer significant advantages over traditional design practice, allowing the performance of design operations in a way that have never been possible before.

Just as the complexity and correlations of variables that are critical to the design of a project increase, we are becoming more aware of the possibilities emerging from a computer integrated design process. There is such great opportunity to use these tools to manage and analyse multi variable design information to create design solutions from computational design. The paradigm shift to computational architecture aims to organize and articulate the increasing diversity and complexity of social institutions and life processes within the most advanced centre of basic design process. Architects that have embraced parametric design strategy as a method of optimization are on the right track of inquiry (Castellano, 2011).Architects have gotten very good using the computer for optimization. The tools now address the qualitative building performance as well. There are so many parameters that influence a design project.

A Brief Review of Literature

Just like any other profession, architectural education is also affected by cultural changes, and many schools of architecture have eagerly jumped on the ICT bandwagon both in their

traditional course offerings and in courses designed to meet the continuing education needs of the professional architects. This zest is reflected in a flurry of publications on the subject in scholarly and professional journals in the field (Wang, 2009).

For the past decade or two, architectural profession has seen an increasing amount of incorporation of digital tools in the thinking and making of space. New formal and structural geometrics enabled by computational techniques become more and more prevalent (Kara, 2015). Computer simulation of evolutionary processes is already well-established technique for the study of environmental, biological and economic dynamics (Stavric & Marina, 2011). This development has availed an evolution of production, tools and methods in the digital architectural research and design. Among the different tendencies on digital architectural research and design is the parametric way (Gallas, Jacquot, & Jancart, 2017).

Architectural Research Defined

Agreeing with James Snyder (1984), Groat and Wang (2013) defined research as a 'systematic inquiry directed toward the creation of knowledge'. Even though Groat and Wang (2002) have laboriously explain the dichotomous stance of scholars concerning what they describe as 'contentious and complicated' debate about the equivalent-or the lack thereof-between research and design, the American Institute of Architects (2007), admits that despite the prevalence of research in practice, however, relatively few architects have training in research methods.

Architectural research, according to The American Institute of Architects (AIA), (2007), has characteristics of both scientific or technical research, on one hand, and artistic or humanistic research, on the other.

While the scientific research asks testable questions, conduct replicable experiments, draw general conclusions, and communicate through peer-reviewed journals or databases, architectural practitioners engage primarily in a far more applied form of research. They ask questions particularly to a project, gather information mostly from existing sources, make decisions based on these findings, and communicate them through such vehicles as memos, drawings, models, and contract documents.

According to the AIA, if architects can be said to do 'basic' research, it typically occurs through design. Much unlike in the core science and social science, however, design research is a less linear, more iterative, which is based less on experiment than on experience, and convey less through written papers and more through competitions, exhibitions, magazines, and monographs.

Types of Architectural Research

The range of architectural research remains quite broad, architectural research can be categorized according to its content or the method used to conduct it. (Goat & Wang, 2002).

Table 1: types of Architectural Research (after Groat and Wang, 2002)

Divided by Method	Divided by Content
Interpretative/historical research	Process of design and construction
Qualitative research	Building habitability
Correlational research	Human security and safety
Experimental research	Conservation of resources
Simulation research	Structural, material, equipment systems
Case study/mixed methods	

Architectural Research as a Basic and Applied Research

Basic research aim at generation of new knowledge and theory building whereas applied research seeks an answer to a practical and immediate problem (Uji, 2009). Since basic research is essential for advancement of knowledge, it is naturally held to be the base for applied research. Asika, (2012) holds that applied research aims at discovering why certain phenomena occur, while basic research aims at discovering what causes the occurrence of a phenomenon. According to the AIA, architectural research, while it is almost always directed to very practical applications, also ranges from basic to applied research.

Table 2: Basic and Applied Research (after James Snyder, 1984)

Basic Research	Applied Research
Knowledge used to understand reality	Knowledge used to solve problems
Useful in the development of theory or hypotheses	Useful in addressing needs of a particular situation
Asking what something means or why it exists	Asking what something is or how it is improved

Evolution of Parametric Design techniques

The work, in 1978, of Ivan Sutherland, Hillyard and Braid (1978) proposed a system that allowed the specification of geometric constraints between part co-ordinates in such a way that possible variations remain restricted to a range given by some particular tolerances. However, not until around 1980s that the main techniques of geometrical modelling of free-form surfaces and solid modelling were developed by Light and Gossard (1982).

During the past twenty years digital media in architecture was used in the different ways and influenced the architectural research and design. With the emergence of digital technology, architecture has found a new tool for conceptual design in digital media. Design was inspired by the various possibilities of digital technology. Using new technique architectural design,

according to Kolarevic (2003), architects have been able to established computational design ideas such as motion kinematics and dynamics (animate architecture), topological space (topological architecture), isomorphic surfaces (isomorphic architecture), key-shape animation (metamorphic architecture), genetic algorithms (evolutionary architecture), fractal geometry (fractal architecture) and parametric design (parametric architecture).

According to Monedero (2000), parametric design implies the use of parameters to define a form when what is actually in play is the use of relations. In this process, the designer uses computer algorithms for generation of virtual entities that will develop its functional and formal properties within the non-linear process of adaptation of complex system (Stavric & Marina, 2011). The first methods and techniques were put into practice during the 1960s and included basic 2D-primitives, as well as new entities like splines. This was extended to 3D wireframes and surfaces patches (Monedero, 2000). Development of the digital design did not end with simple parametric modelling; it has taken a step ahead by using generative algorithm editors like Coffee, Grasshopper, which are directly linked to 3D modelling tools and allow interactive parametric modelling (Stavric & Marina, 2011). Parametric modelling systems engender exploration of new and rich formal possibilities. By varying the inputs to a model, different specific designs are produced. Exploring the resulting design space is one of the grand challenges for future parametric modelling research (Beesley, Williamson, & Robert Woodbury, 2006).

Parametric Design as a Tool for Architectural Research

Parametric design is a dynamic, rule-based process controlled by variations and parameters, in which multiple design solutions can be developed in parallel. According to Woodbury (2010), it supports the creation, management and organization of complex digital design models. By changing the parameters of an object, particular instances can be altered or created from a potentially infinite range of possibilities (Kolarevic, 2003). The term ‘parameters’, means factors which determine a series of variations. In architecture, parameters are usually defined as building parameters or environmental factors. In the architectural design industry, parametric design tools are utilized mainly on complex building form generation, multiple design solution optimization, as well as structural and sustainability control (Yu & Gero, 2015). Generally, in parametric design, the forms of a buildings are determined by values of parameters and the relationships between the forms are described by equations. It can be said therefore that, impudence between forms can be established and their behaviour under transformation can be defined both mathematically and geometrically (Stavric & Marina, 2011).

From it evolutionary period, parametric design has influenced the development of digital architectural design in two major levels, namely, architectural conceptual parametric design and architectural constructive parametric design. (Stavric & Marina, 2011). In conceptual parametric design, it is the parameters of a particular design that are declared, not its shape. But in constructive parametric design, data is encapsulated in a predetermined three-dimensional object. The design concept is achieved using the in various Computer Aided Design (CAD) packages like the ArchiCAD, Revit, Soft Plan, Nemetschek, or Chief Architect.

In parametric design, designers simply insert pre-drawn components like doors, windows, load elements, stairs or roofs, etc. rather than drawing lines. these results in 3D models instead of 2D drawings. Other parametric design software includes Generative component from Bently Corporation, Digital project from Gehry Technology, Grasshopper from McNeel.

Parametric Modelling for Architecture

From the original 2D programs used for drawing architectural designs, the software used for computer-aided design has now turned into intelligent 3D software packages based on parametric modelling. A parametric design model has some rules embedded in the system and when one parameter changes, other parameters will adapt automatically. By varying the inputs to a model, different specific designs are produced (Beesley, Williamson, & Robert Woodbury, 2006). The result of the computational modelling process is not simply a shape or an object but provides the possibility of an infinite space of design solutions (Gallas, Jacquot, & Jancart, 2017). The output variation can be achieved by the variations of the parameters included in the schematic structure of the model. Here, the design method comes out of the linear and vertical design process only controlled by the architect. The designer himself decides what parameters to use. Parametric modelling is often used to design and explore new architectural and structural solutions characterized by a high level of complexity. To achieve this task, the designer needs to evaluate the generated instances behaviour and their ability to support design constraints. The evaluation results helps the designer to select the most pertinent solutions and by implication the most pertinent model parameters(Gallas, Jacquot, & Jancart, 2017).

The modelling represents geometric entities with editable attributes, and relationships by means of associations. These attributes can be expressed by independent values, which act as input to the model; their variations generate different solutions of the model. The process in which the editable attributes and the associations are set is referred to as the parameterization process; and it usually outputs a hierarchical structure describing a dependency chain (Hu, 2018).

The use of parametric modelling involves three phases, in which the expertise and knowledge of the designer is required in order to accomplish a design (Hu, 2018). The first phase is the strategy-definition. This is the analysis of design challenges, abstraction of relations between performances and geometry, and formulation of parameterization strategies based on the design intentions and selected performances. The second phase is the model building. In this phase, the parametric model is constructed according to the logic that emerges in the first phase. And lastly, the third phase, which is solution-assessment. Here, the design alternatives embedded into the parametric model are explored based on performance evaluations.

Computational design has emerged because it has the capacity to resolve multiple constraints and deal with extreme complexity of variables. By optimizing a more holistic set of constraints, computational architecture can truly provide comprehensive design solutions (Castellano, 2011).

Conclusion

This paper has examined, with an affirmative stance, the intellectual discuss regarding the suitability of architectural design processes as research endeavour. The paper also explored the components of architectural design that endowed it to be a research work. Architectural research can be either scientific research, or humanistic research. Emphasis has been laid on the humanistic research for the purpose of this study. Similarly, the paper looked into computational design, particularly parametric design package, ascertaining its major functions and application to architectural design. The study established that in the architectural design industry, parametric design tools are utilised mainly for complex building form generation, multiple design solution optimization, as well as structural and sustainability control. Parametric design is, in comparison with conventional design, quite different, not only because it offers a new design tool, but also a new way of thinking. It is actually a paradigm shift to computational architecture. Parametric design, considered as a research tool, is made to offer design alternatives in terms of building forms as well as design solution optimization. The paper notes that the emergence of computer simulation programs has opened up new possibilities of some significant advantages over traditional research practices. These include increased processing speed, flexibility in handling design process, higher storage capacity, easily reproduced, less energy expended, reduction in operation time, enable visualization of processes, high level of accuracy, more realistic modelling of the proposed structure, testing and evaluation of architectural processes.

Recommendations

It is suggested that, schools of architecture should embrace the packages and teach them at various levels of academic development so that young graduate will be able to apply it during their research projects.

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