IEREK PRESS Academic Research Community
http://www.press.ierek.com
ARChive
CrossMark
ISSN (Print: 2537-0154, online: 2537-0162)
International Journal on:
The Academic Research Community Publication
**DOI:** 10.21625/archive.v2i3.348

# KITOPARTS: A Virtual Playground to Explore Form, Space, and Order

**Derek A. Ham**[1]
[1] *NC State University College of Design*

## Abstract

Architecture students use both analog and digital tools throughout their design process. Ideally, the affordances of each tool complement each other. Our goal with Kitoparts is to move beyond two-dimensional screen based computer modeling environments to create a system that feels analog but harnesses all the affordances of digital modeling environments. With the usage of VR and haptic controllers, we hope to provide a rich and flexible methodology for investigating forms and space. In educational settings, Kitoparts aims to solve three major problems with traditional beginning design exercises. First, it solves the scaling problem, allowing design students to see their designs visualized at full scale and in real-time. Second, it overcomes the combinatorial nature of physical building blocks by allowing 3D shapes to overlap and embed into each other in ways they could not within the physical world. Finally, we include the designer's "hands" in the creative process. Virtual hands prove to be much more intuitive to use than the traditional mouse and keyboards commonly utilized in most CAD and modeling software. With Kitoparts, the computer model is no longer just a tool for representation; it becomes the user interface for design. Kitoparts allows both seasoned designers and novices to simply play, build, and explore.



***Keywords***

Education; Representation; Hands on learning; Slow computing; Shape grammars; Real and virtual; Play and design

## 1. Introduction

How do designers imagine their projects during the design process? Do they imagine shrinking themselves to inhabit the physical models they make? Or, do they imagine scaling their models into gigantic forms belonging in the real world? Do designers inhabit their sketches as the ink touches the paper? Some do. Designers rely on their imagination throughout their entire process, and when imagination fails technology attempts to lend a helping hand. Digital modeling offers the designer the ability to control cameras and walk through spaces in first- person perspective. As Friedberg (2009) points out, the computer model feels scale-less and intangible. Oftentimes, computer screens are barriers that can situate the designer something like Alice looking through the looking glass, desiring to get in.

In our proposed VR design system, Kitoparts, computer modeling is no longer a process involving clicking a computer mouse. We have created a new intuitive process that involves using your hands to build and design digital architectural models at various scales (Figure 1). With Kitoparts the hand-held scaled model becomes the user interface (UI). This is not just a new way to ”experience design” but also a new way ”to design”. The UI and UX are of special interest for any design software because of how it can enable or thwart creativity. Recent HCI devices that track the body have offered touch-less interaction for computer modeling, but their instability and lack of tactility have left much to be desired. The contemporary VR market's response to human interaction in virtual spaces has been with wireless controllers that give the user a free domain of movement, haptic feedback, and several programmable analog buttons.

Figure 1. Screenshots of the Kitoparts design tool running on Oculus Rift using Oculus Touch controllers.

Figure 2. Screenshots of the Kitoparts design tool running on Oculus Rift using Oculus Touch controllers.

Virtual hands, provided by the Oculus Rift, bring back the action of "holding objects" to the design process. Manipulating blocks with one's hands is a design tradition that goes back a long way, even before the Bauhaus. This type of object manipulation is what Knight (2012) calls "slow computing." Designers can manually carry out geometric transformations by sliding and rotating their pieces around in space. In the virtual environment, designers can now use their hands to scale objects with a simple stretch of the shape primitive. Without gravitational or physical constraints, the pieces can be explored with three-dimensional embedding and form overlap.

## 2. Background

### 2.1. Using VR In the Design Process

The recent usage of VR in architecture and design do not use VR as an actual work environment, the place where designs are conceived. Designers often use pen and pencil, CAD, digital modeling, and various rendering tools. In the early stages of the design process it is important for the tools of use to be flexible and offer ”0” resistance in the creative process. Because of this, pen and pencil has been the tool of choice; they are easy to use, and allow designers to work beyond combinatorial logic. Some digital tools claim to offer the same ease of use and fast ideation as pencil and pen. *SketchUp* and *Rhino* offer dimensionality to the design process in ways sketching does not. Yet, these ”easy to use” tools still present hurdles and blockage of thought that naturally comes when operating a computer mouse and navigating a software's UI. Several of these popular CAD software packages have now begun to implement VR functionality.1 With most, the approach to provide added VR support is only for the end- visualization of constructed projects. Architects then use the virtual environment at "stopping points" or moments of reflection. Users are not given the opportunity to carry out design and modeling activities within the VR space.

### 2.2. Design Representation, Scale, and Proportions

The way architecture responds to scale and proportion is often difficult to grasps for novice designers. This has a lot to do with the reality that scale in relation to the human body is left to the imagination of the designer. Much of the design process is spent translating scale through imagination. Design students are rarely afforded opportunities to design at a 1:1 scale. As a result the designer may have difficulty considering the spatial ramifications of his/her design, as the design itself is only as good as they can use their imagination to speculate scale (Corbusier, 1946). Designers do use scaled down models, and often populate them with miniature representations of humans to indicate the relative proportions to the body, but much can be lost in this cognitive translation.

In some instances the usage of "full scale" models and/or drawings have been used to explore design ideas (Figure 3). This is always an informed experience because we truly do not have a sense of how large or small something is, until we experience it at a 1:1 scale. While full-scale exploration can give the designers affordances to be reflective about their design decisions, the thought process is paused during the time used to model or draw. The lengthy natures of this process can sometimes thwart creativity, and time + cost constraints do not lend these exercises to be frequently repeated. Furthermore, all projects do not lend themselves to this type of exploration due to the enormous scale of the end design.

Figure 3. adesign student using a 1:1 scale drawing to better understand their designdecisions

1

[1]1 V-Ray has released several VR plugins for Autodesk modeling software including 3DS Max and Maya. Likewise, several VR plugins (including Autodesk Live) have now come on the market allowing users to import Sketchup and Revit, BIM models to be viewed on Oculus Rift and HTC Vive. These tools come with crowded user interfaces, as they are industry- focused tools.

### 2.3. Design Education: Kit of Parts Exercises

Educational approaches and the tools we use for design education are of important interest to our work. The traditional "kit of parts" exercise was the metaphor this project was designed (and named) from. The "nine- square" design project is a common exercise using a kit of parts given to students in the beginning-design curriculum. Within this exercise, students are forced to work in complete abstractions. Love (2003) writes, "By reducing possible design solutions to reductive elements like 'walls-as planes' and 'piers,' students were encouraged to think about spatial relations" (p. 44). This kit of parts exercise provides students with a scaffold introduction to thinking about form and space (Figures 4 & 5).

### 2.4. Shape Grammars and Computational Play

Shape grammars expand the kit of parts exercise from looking solely on the kit of part pieces to an explicit usage of rules and a vocabulary system to explain the structure and order of a design system. An example of this type of computational approach can be seen in the Kindergarten Grammars described by Stiny (1980). The Kindergarten Grammars are a formal description for the Froebel building gifts made popular by architects, such as Frank Lloyd Wright. Within this system, shape grammars work with a kit of parts and their configurations, serving as the vocabulary and a category system that make the language of design. Just as it is in all games, the constraints of the system often bring out the elements of play (Ham, 2016). In doing so, they produce creativity. While Froebel blocks are combinatory in nature, they still demonstrate the ludic offerings of shape grammars. When designs move beyond combinatory systems, we can move beyond 0-dimensional elements to allow for more "play moves" that include embedding and shape emergence.

Figure 4. Design students working on a traditional kit of parts project

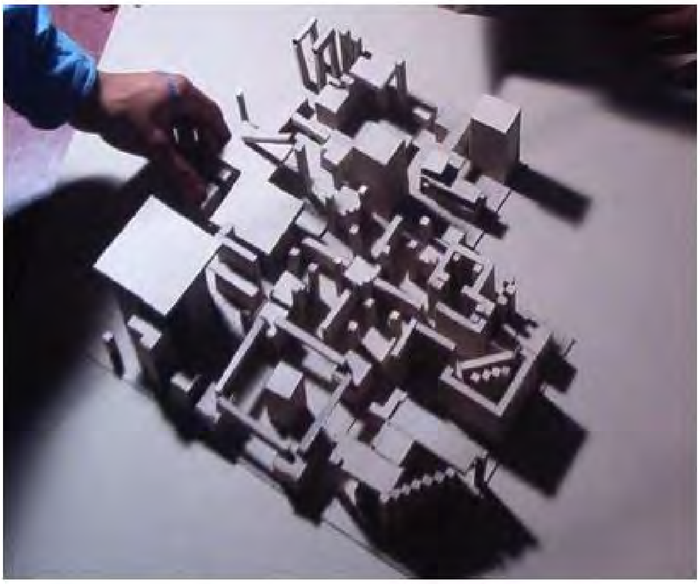

Figure 5. Design students working on a traditional kit of parts project

## 3. Tool Creation

### 3.1. Coding Process and Environment to Designing the Tool

The constructor-programming environment for Kitoparts is built in the Unity 3D game engine. Unity is robust; it allows program designers to create tools and projects that extend well beyond mobile and console games. Unity allows designers to code in both JavaScript and C#, both which were used to construct the Kitoparts design tool. Kitoparts was built for the Oculus Rift and the compatible Oculus Touch hand controllers. The Oculus Rift and HTC Vive are both flagship devices that have taken to the Unity Game development as a platform for content development. These devices represent high quality VR experiences with relatively affordable prices. This has enabled the industry to push the boundaries on the level of immersive experiences.

### 3.2. Description of the Kitoparts Environment

The Kitoparts tool situates the designer between the traditional experience of building a scaled model and inhabiting that same model at 1:1 true scale. The virtual experience becomes surreal in that real-scale representation is carried out in real time as the user manipulates the virtual scaled model with their hands (Figure 6). In Kitoparts, the designer is given instant access to the understanding their design decisions related to scale and proportion.

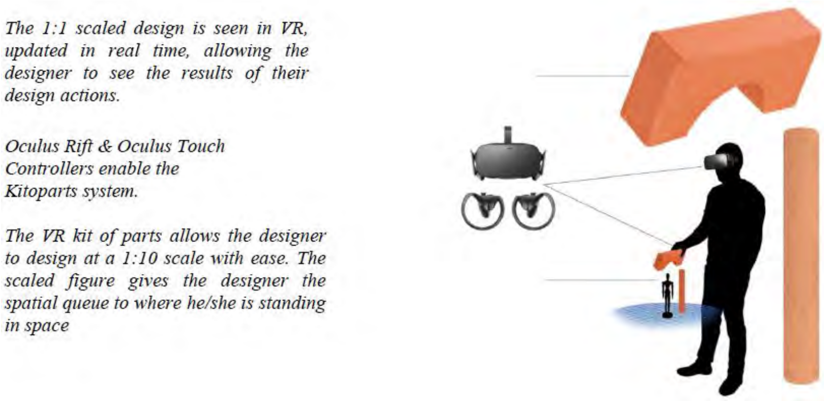


Figure 6. Kitoparts modeling environment and components

Navigational elements are placed on each "virtual hand" that include buttons for easy access to an array of new shape primitives, buttons to toggle visibility of the scaled model and 1:1 model, and buttons to change material properties of building blocks. Kitoparts is designed to provide an easy to use creative environment that quickly constructs VR projects with a minimal time investment. The goal of the Kitoparts software is to provide a user interface that incorporates features akin to physical design-play experiences.

## 4. Results & Discussion

### 4.1. Live Demonstration + User Test

A recent exhibit at the 2017 East Coast Games Conference in Raleigh, NC allowed us to gather critical feedback from a user group outside of the architectural and design community (Figure 7). The results were overwhelmingly positive. One tester said, Kitoparts "returned me to my childhood." Kitoparts takes a familiar activity and moves it beyond 0-dimensionality. Each component in the kit of parts exercise is no longer treated as a single discrete element. Pieces can fuse together as you hold them in your hands. With these virtual building blocks we find embedding that produces the emergence of new shapes and spaces. This methodology of design is both playful and computational.

Figure 7. Kitoparts testersat the 2017 East Coast Games Conference in Raleigh, NC

The 0-dimensionality of the traditionally physical kits of parts are combinatorial like Legos. That approach to design can be limiting and offers fewer possibilities than designing with pencils and trace paper. Kitoparts removes the combinatorial limitations of traditional building blocks, but still allows users to play with combinatorial logic should they choose. Ideally, studio design exercises should allow students to play within the upper limits of multi-dimensional shapes to account for embedding, recursion, and emergence of new shapes.

### 4.2. Formal Descriptions of VR Gestures

Tangible learning through manipulatives has a great lasting impact on the learner. Kitoparts provides several opportunities to see the relationship between learning with the hand and seeing with the eye. The hand play can be understood as the "kit-of-actions" the players use to perform the game. These actions can be further characterized by the unique hand positions players took in game play.

The traditional kit of parts project can be characterized by Stiny's shape grammars so that each shape can be represented by the variable "x" as they go through several transformations, best understood by the schema $x \rightarrow t(x)$. Shapes are then held by the user's hand as he/she translates, rotates, and reflects the geometry in space. However, these transformations are combinatorial in the traditional kit of parts exercise because the wooden blocks cannot pass through each other through embedding. In the virtual domain, the user can design without these constraints. Designers can move shapes with their hands to generate compositions that include embedded shapes. Three dimensional shapes can pass through each other in ways they do not in the physical world. For the designer, this opens up an array of possibilities.

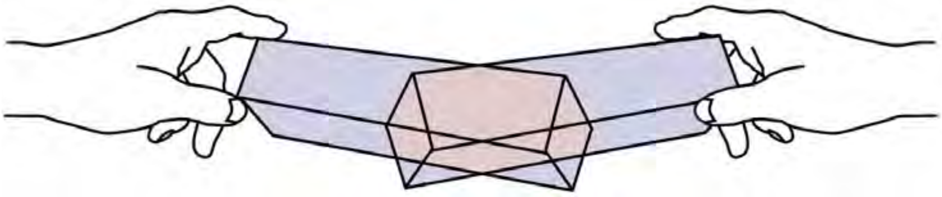

Figure 8. Kitoparts enable users to explore shape embedding where they could not with physical blocks

Piaget notes that as the child develops, learning with the hands was essential. The same can be said about adult learners and students of design. The connection a child's hands have with any toy is a beautiful dance of control and imagination. For users playing with Kitoparts, the hands are intuitive tools to carry out calculation. In this teaching approach, design composition is not taught through formal lectures but rather done through doing, making, and play. Hands and eyes become the instruments necessary to carry out computations. VR becomes a form of playful calculation that enables the designer to play between the physical and digital.

Hands-on inquiry can lead to experiential understanding of material and shape qualities of a subject matter. The strength of hands-on inquiry in understanding shape rules is the ability the user has to discover all of the in-between stages of a transformation. If we apply, for instance, a 90-degree rotation to a shape via a traditional computer-based system, the shape would just snap into its new orientation. What we miss, then, is the opportunity to see all the degrees of rotation that lie between 0 and 90 degrees. If this happens we might lose sight of all of the transformed embedded shapes that evolve during the course of the transformation from 0 to 90 degrees. From hands-on actions and slow computing, we can find so much more.

### 4.3. Future Studies

With the Kitoparts tool complete, future studies of its use in the educational setting of the architecture design studio will look to answer several questions (but not limited to):

- How does instant access to full-scale visualization impact design education? Are concepts better understood? How well does the tool enable the student to think about scale and proportion?

- How does learning that situates the student between working with scaled models and their designs at 1:1 experiential scale (in real time) impact student learning? How do they (and how often) navigate between model view and full-scale view?

-How well does the tool enable the student to bring their design ideas into fruition? Limitations? Compare risk taking with other CAD tools.

-How many design iterations do students go through with this VR system? How many iterations/tweaking do they go through with each design?

## 5. Conclusion

For a long time, designers have placed a great emphasis on tactile approaches to learning such as hand drawn sketching, diagramming, and model building. In many cases, designers used these techniques to separate themselves from other professions; it was the skill that gave them creative superiority over other professions. While sketching is not being removed from design education, this method of process thinking is in desperate need of a reboot. Designers must adopt new methods to reach places where they are not only just "users" of new technology but hackers and creators of new technology themselves.

When a scaled model becomes an interface for design, there are opportunities to include intuition and visual calculation. Design becomes child's play. Holding a design element in our hand (albeit virtual) helps us to carry out geometric transformations radically different than the experiences we have dragging objects along a computer screen with a mouse. The tangibility of learning is once again brought to the forefront of design activities. Furthermore, this new type of virtual tangibility through the use of haptic controllers allows designers to explore gestures that would ordinarily be impossible to achieve. Design elements can be handled in a non- combinatory manner. This is not unique to computing environments, but is definitely a new experience for the "hand-guided" design experience. Matter can now pass through matter. Embedding can occur with 3D blocks in the same way we slide compositions drawn on tracing paper along a table. The process is tangible, intuitive, and non-combinatorial, all ingredients that deliver a new and novel design experience.

## 6. References

1. Corbusier, L. (1946). Towards a New Architecture / by Le Corbusier. London: Architectural.
2. Friedberg, A. (2009). The Virtual Window: From Alberti to Microsoft. Cambridge: The MIT Press.
3. Ham, D. (2016). "How Designers Play: The Ludic Modalities of the Creative Process." Design Issues 32 (4): 16-28
4. Knight, T. (2012). "Slow Computing: Teaching Generative Design With Shape Grammars." In Computational Design Methods and Technologies: Applications in CAD, CAM and CAE Education, edited N. Gu and X. Wang. Hershey, PA: IGI Global, 34-55.
5. Love, T. (2003). "Kit-of-parts conceptualism." Harvard Design Magazine 19: 40-47.
6. Stiny, G. (1980). "Kindergarten Grammars: Designing With Froebel's Building Gifts." Environment and Planning B: Planning and Design 7 (4): 409-462.