Geometry Material and Ergonomics

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Introduction

Furniture is a ubiquitous feature of the designed environment. It can be critical or perfunctory, useful and inspirational, pragmatic and artful. It is a realm of design, like many others, that holds diverse if not divergent meanings for its users and designers alike. This article presents an introductory furniture design exercise for architecture students; an educational experience that considers furniture a microcosm of architecture, explored through the lenses of geometry, material and ergonomics.

Furniture and Architecture

The English word furniture is derived from the French word fourniture(s), which means "supplies". The word furniture shares its root with furnishing, defined as "fitting out or equipping" and being furnished as the "condition of being equipped whether in body or mind." One can then consider furniture to be that which equips the mind or body, presumably in preparation for or accommodation of a particular activity. Despite the French origin of furniture, the French use the word meuble when referring to what English speakers call furniture. Meuble is derived from the Latin mobilis, meaning moveable. In contrast, the French use the word immeuble for building, which means immovable. European languages universally employ the concept of mobilis when referring to furniture, from the Neo-Latin languages to the Germanic and Slavic. These etymological and cross-cultural dimensions suggest similarities and distinctions between architecture and furniture. Furniture, like architecture, facilitates a physical and psychological experience through equipping the mind and body of its users. The distinction, while general and not absolute, lies in mobility; architecture is immovable and furniture is moveable. One can then interpret furniture to be moveable architecture.

Inherent to movability is smallness, rendering furniture a microcosm of architecture; both sharing performance criteria rooted in the timeless Vitruvian principles of firmitas, utilitas and venustas. By virtue of size, furniture design is readily conducive to material realization in an educational context. As a microcosm, furniture design and fabrication offers unique opportunities for architecture students; providing the ability to experience a comprehensive design process that begins with conceptualization and concludes with the realization of an actual product that can be evaluated for physical integrity, use and aesthetics. Furniture design is an opportunity to supplant the speculative nature of traditionally hypothetical academic design exercises with one that is verifiable.

Mechanism for Objectivity

Architecture students are inclined to approach furniture design and fabrication with great zeal. As with architectural design, they are quick to develop personal attachments to the things they create, whether in concept or physical form. It is understandable; good design demands that the designer be inspired and draw upon the full breadth of one’s innermost resources, a decidedly personal endeavor. This critical dimension of design often evolves into a loss of objectivity for the beginning design student. This loss of objectivity is evident in the phenomenon
known as the IKEA effect, where people overvalue the fruits of their labor, becoming delusional about the value of the things they have created and expecting others to share their opinions. When this occurs students have great difficulty objectively developing a design. In order to manage this phenomenon it is paramount to introduce a mechanism for objectivity. This exercise considers furniture to be a trivium, the intersection of three conceptual realms: geometry, material and ergonomics. Objectivity is encouraged by requiring the students to establish clear performance criteria in each of the three realms. Students are encouraged to consider the process of synthesizing the three realms a dialectic negotiation; where the three realms converse or argue as a means of establishing consensus.

Project Proper

This exercise challenges students to design and fabricate a prototype of an object for human use. It is comprised of two stages: Conditioning and Prototype. The conditioning exercises give students the opportunity to explore the abstract conceptual realms of geometry, material and ergonomics. The prototype stage requires students to further their exploration of the conceptual trivium through application in the programming, design, development and fabrication of a full-scale prototype.

Conditioning

The conditioning exercises are conceived as a learning and orientation experience to prepare students for the prototype design. In the absence of conditioning exercises students are confined to their pre-existing knowledge and understanding of the conceptual realms, which may be absent, distant, abstruse or finite. It is important that the students be given the opportunity to explore the conceptual realms in order to discover or rediscover the meaning and value of the respective realms immediately before application. During the conditioning exercises the conceptual realms are considered autonomous and abstract.

Students are asked to select subjects as precedents, one for each realm, proceeding with an activity such as drawing, making or use as a means of evaluating the role of the conceptual realm in the applied context of the respective precedents. In the spirit of Educere, the Latin root of the word education, meaning to draw out, the conditioning exercises are conceived about learning, rather than indoctrination or pedantry. It is important that the students be given sufficient latitude to discover the value and meaning of the conceptual realms on their own terms. It is this intuitive understanding that leads to fluency and the necessary malleability that enables integration and negotiation between the realms. The three conditioning exercises are executed concurrently over a three-week period.

Geometry

“Where there is matter, there is geometry.” The term geometry is of Greek origin meaning, “to measure the earth”. Geometry is the branch of mathematics that describes the properties and relations of points, lines, planes and solids. Everything has geometric properties but it is geometry as a construct of human imagination that renders it an instrument for understanding and interacting with the world. Geometry can be implicit and explicit; it can be generative, organizational and mechanical.

As a conditioning exercise, students are directed to select a precedent, natural or manmade, that they find geometrically compelling. Students are challenged to seek an understanding of the role of geometry in the precedent. They are encouraged to utilize manual technical drawing: as opposed to digital on the premise that drawing by hand is slower and inherently more reflective than drawing through the computer.
The geometry conditioning exercise is exemplified by the study of a dragonfly [Fig. 1]. The student utilized conventional orthographic projections to define the comprehensive anatomy as comprised of its components including the head, abdomen, thorax and appendages. She understood the efficiency, lightness and relative strength of the wings to be rooted in their geometric hierarchy and venation. Through the use of proportioning systems the student discovered the geometric basis of aesthetic dynamism, the distribution of mass and the location of its centroid at the convergence of the fore and hind wings.

Material

"One must not separate the head and the hand, the idea and the means of realizing it." The realm of material is physical, sensorial, structural, economical and inclusive of fabrication processes. To render an idea in material is to invite the nature of the specific material and its inherent fabrication process into the conversation. A canoe has the program of buoyancy and movement through water, which governs the logic of its geometric form and performance; yet a canoe rendered in aluminum will be fabricated by a different means and provide a different tactile and acoustic experience than one rendered in white cedar.

The material conditioning exercise requires students to select a material and a corresponding fabrication process (e.g. glass / casting, wood / lamination, sheet steel / brake forming). They are asked to fabricate a simple object that exploits the properties and maximizes the potential of both the material and the process. This exercise is conducted in two steps: Naïveté and Sophistication.

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Fig. 1: Geometry Conditioning Exercise, Dragonfly, Graphite on Vellum [J. Martin]

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Fig. 2: Material Conditioning Exercise, Bistability in Paper and Sheet Steel [JL. Cuisinier]

The material conditioning exercise is exemplified by a student’s exploration of sheet steel and bistable formation [Fig. 2]. The student began the exercise with sheet steel then utilized paper as a facile material surrogate; returning to steel with a more informed understanding of the geometries that governed the forms, stresses and integrity of the bistable configurations. The sheet steel is perforated via plasma torch, and then biased in one of two directions to render a pre-stressed, stable form.
**Ergonomics**

"If people are made safer, more comfortable, more eager to purchase, more efficient, or just happier, the designer has succeeded." Ergonomics is the human dimension, conditions, program, anthropometry and the physical and psychological aspects of use. The ergonomic realm is perhaps the most elusive for students; in their youth they are inherently tolerant and less sensitive to the incompatibility of physical objects and the human body.

The ergonomic conditioning exercise requires students to select a physical precedent that is engaged by the human body. They are asked to study the ergonomic characteristics of the precedent and to diagram the accommodation of or relationship to the human body. Through this exercise students describe and evaluate the ergonomic performance of the object, disclosing critical ergonomic strategies, ranges and limits.

Fig. 3: Ergonomic Conditioning Exercise, Recaro Racing Seat [E. Schaeffer]

The ergonomic conditioning exercise is exemplified by a student’s study of a Recaro racing seat [Fig. 3]. Car racing, by virtue of its nature, presents specific challenges for the driver. High-velocities generate gravitational forces, while turning and changing lanes generate dynamic lateral forces. These conditions impose clear challenges for the driver, who requires great control and stability, relying on the seat to mitigate the forces by supporting and securing the driver’s body. It is also imperative that the seat be comfortable such that it doesn’t impede the driver’s focus, and adjustable to facilitate calibration for a particular driver’s body. The Recaro racing seat mediates the body and the vehicle by holstering the driver’s body from below, behind and from the sides while enabling movement of the arms.

**Prototype**

The prototype stage challenges students to conceive, program, design, develop and fabricate a full-scale prototype of an object for human use. Students are free to draw upon any source or means for inspiration. The experiences or products of the conditioning exercises may or may not be directly incorporated into the design of the prototype. The students’ concepts are typically rooted in a single conceptual realm, reflecting a student’s interest in a particular material or use. If one-dimensional in origin, the concepts must evolve and adapt to include performance criteria from the complete trivium. Students are encouraged to consider the design process to be the integration of and dialectic negotiation between the realms of geometry, material and ergonomics. The potential relationship between the realms begins as a contradiction; simultaneously autonomous and abstract yet malleable and conducive to seamless integration. The prototype is developed over twelve weeks, facilitated by biweekly collaborative work and critique sessions.

**Sexpartite**

As a demonstration the instructor undertook the prototype exercise concurrently with the students. The product of the exercise is a sexpartite table base [Fig. 4].
The fundamental concept for the table is based in geometry [Fig. 5]: a circle in plan considered radially in three and six parts.

The legs and arms of the base are comprised of six angled pieces of 18-gauge sheet steel. The pieces are identical and laser cut. A custom bender was fabricated in order to render a specific curvature [Fig. 6]; the material was secured during the forming process by a series of registration pins inserted into holes later used for assembly. The arms receive a glass tabletop and the legs meet the surface of the ground with hard rubber nested between the steel sheets and secured by two pins to prevent rotation.

The material and ergonomics are synthesized yet remain self-respecting identifiable dimensions of the design.
The sexpartite is designed as a table specifically for three people [Fig. 7]. The ergonomic criteria were simple yet critical; the number of occupants determines the numeric basis of the geometry and the diameter of the tabletop. The vertical and horizontal extents of the legs and arms of the table base are calibrated to maximize stability and accommodate the legs of the occupants.

**Rawhide**

Figure 8 illustrates a student’s prototype of a rectangular table proportioned for two people. It is made of rawhide stretched and dried taut over a lightweight steel compression frame. The rawhide table surface is sufficiently rigid that one can set a glass of wine atop with confidence, yet it has a percussive resonance when strummed.

Fig. 8: Table, Rawhide and Steel [R. Olson]

**Weapon**

Figure 9 illustrates a student’s prototype of a multipurpose custom weapon that is defensive and offensive with interchangeable armaments. It is designed to distribute impact forces uniformly over the breadth of the forearm, while allowing the arm to disengage through rotation upon release of the grip. It is made of 3/8” steel round, heat forged and laced over an aluminum cast of the student’s forearm.

Fig. 9: Multipurpose Weapon [C. Pifer]

**Conclusions**

The conceptual trivium serves as a mechanism for portability. Each of the three conceptual realms is as relevant to architectural design as it is to furniture design. By defining the conceptual realms as abstractions that evolve, interact with and adapt to one another through application in the context of furniture design, the exercise aspires to render the students’ understanding of the realms as abstract and therefore portable; able to be transposed and expanded through application in architectural design.

**Notes**


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