Cuboids and Planetoids

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Abstract

Currently, introductory design studios are witnessing a critical intersection between the pervasiveness of the Cuboids and the emergence of the Planetoids. Many instructors still explicitly base their exercises on the well-rehearsed cube problem as a conceptual device and the foundation from which to explore the configuration of an object. However, visiting websites, Tumblrs, and Instagram accounts of junior faculty currently teaching at schools in the American Midwest and West Coast, the objects and aesthetics of first year studio projects do not strictly appear platonic. Is the cube problem still relevant to the contemporary architectural discourses? This article will revisit the formulation of the cube problem and compare mechanisms of spatial investigations of the Cuboids and the Planetoids. The objective is to investigate disciplinary inquiries embedded in both the Cuboids and the Planetoids.

A cube problem is not unique to a particular architectural school; it is somewhat universal. Its staying power appears to profess that it will still be used for some time in the future as a didactic problem.

- John Hejduk[1]

For almost seventy years now, many beginning design instructors have issued an exercise commonly referred to as the cube problem. Charles Graves and Tom Sofranko reviewed the development of the cube problem in an article at the 2010 NCBDS conference, *Ubiquitous Cube*. A historic overview, the article identifies the Gestalt and Bauhaus as the precursors of the *cube problem*, and reviews the cube pedagogy transferring from Europe to the *Texas Rangers* and later to Cooper Union and ETH. Referencing Daniel Libeskind and Zaha Hadid's work, the article questions the relevance of the Cube and stopped the observation at the 1990s. With the emergence of planetoids, a similar but seemingly unfamiliar derive of the cube, this article will revisit the cube problem. This revisit will be situated at the intersection between pedagogical and the theoretical contexts.

One could argue the cube problem provides an ideal petri dish to initiate and develop an approach to architecture. Its origin as a piece of avant-garde pedagogy can arguably be attributed to the *Texas Rangers'* architecture curriculum developed at UT Austin in the mid 1950s. The Rangers recognized that prevailing basic design exercises rooted in the Bauhaus and Vkhutemas schools of the 1920s were no longer catalyzing architectural discourse. Nor did those models seem relevant to the concerns of the time, in theory and practice. Therefore, the origin of the cube problem derived from the intention to reconnect beginning design to a contemporary context.

From this contemporary perspective, we ask: is the cube problem still relevant? Beginning design is currently at an intersection. Some believe that the cube problem is exhausted and is not shaping contemporary discourse. Alternatives, things that might be described as planetoids - loosely arranged parts or Boolean intersected chunks - perhaps represent culture writ large better and promote interesting discussions, but their ambiguous form, characteristics, and qualities are not didactic, and rather emphatically do not intend to be easily discernible in terms of the process of their creation. Some others believe the cube still provides a useful, maybe even ideal, framework for students to develop an understanding of and explore topical issues on certain general architectural principles. The cube may no longer be radical but it represents a seemingly neutral environment for the studies of formal organization in a Cartesian space. The embedded architectural investigation is not only about abstract spatial composition but also the possibility to transform the abstract cube into architectural conditions. The cube problem can be a vehicle to introduce modernism by emphasizing the concepts of the grid, figure-ground, phenomenal transparency, and architectural promenade.

The Nine-Square Problem

The Nine-Square problem invented by the *Texas Rangers* (1952-1954) at UT-Austin can arguably be the first clearly defined cube problem. Hejduk's reflection on the Nine-Square problem reveals its essence. "Working with the problem the student begins to discover and understand the elements of architecture. Grid, frame, post, beam, panel, center, periphery, field, edge, line, plane, volume, extension, compression, tension, shear, etc. The student begins to probe the meaning of plan, elevation, section and details. He learns to draw. He begins to comprehend the relationships between two-dimensional drawing, axonometric projections, and three dimensional (model) form." [2]

The Nine-Square problem seems to be an abstract structure for investigating space, inheriting a critical statement: the relevance of architectural pedagogy to its contemporary context. Before the emergence of the *Texas Rangers*, the fifty years of architectural pedagogy witnessed the Ecole des Baux-Arts and the Bauhaus, the classicism tradition and the modernism tradition. "Both systems denied the dynamic status of the present: formed out of the past, yet sufficiently malleable to transform the future. Rowe argued that the Bauhaus's disregard of formal issues as such led to a neglect of the past and a tendency 'to see the future as a perpetuation of the present,' while conversely 'the Beaux-Arts… came to see the present merely as a perpetuation of the past."[3]

From existing literature, multiple *Texas Rangers* contributed to the evolution of the Nine-Square problem from various approaches, reflecting distinct meanings and theoretical frameworks. Bernhard Hoesli was in charge of organizing and conducting the introductory course to design. In terms of concepts, he emphasized space and composition; in terms of process, he emphasized rationality: specific actions producing specific results. Robert Slutzky and Lee Hirsche initiated the Nine-Square problem by incorporating a structure of a 3 by 3 even grid in a design project. This grid functioned as a framework for students to study spatial configurations, such as enclosure, definition, and division, by inserting a given number of grey panels of grey cardboard on the edge of the grid. Slutzky admitted in a conversation with Alexander Caragonne, "My interest in Gestalt psychology led me toward the discussion and investigation of aspects of sparsity and density, tension and compression, the kinetics of geometric configuration, and Gestaltic enclosure." However, "it was always going no place relative to architecture, other than the fact that we were talking about the plastic extension and compression of planes."[4] John Hejduk "awakened" Slutzky with the "architectural possibilities" of the nine-square grid work by reinterpreting "the verticals and horizontals as post and beam."[5] This is the first time when an abstract or painterly grid was concretized with architectural meaning: "a frame structure would emerge. From this, the base would signify the plan, vertical panels and half-panels would be space-defining partitions, and the horizontal panels supported by the 'beams' would of course represent the roof."[6] In the same period, Colin Rowe and Slutzky conceived the "transparency" theory, whose framework coincides with the abstract grid of the *Nine-Square*. These approaches are the foundation of the Nine-Square problem. Further, they are the foundation of the cube problem.

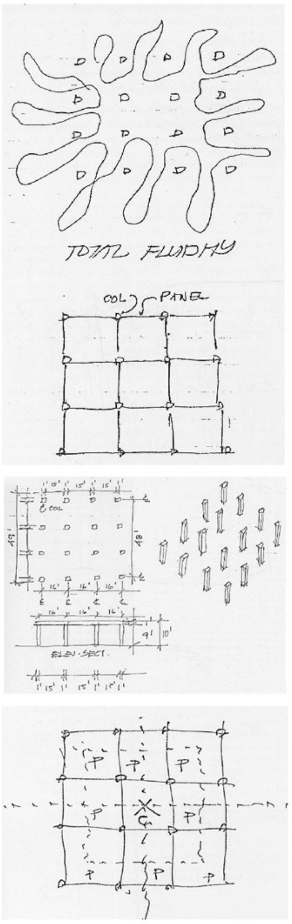


Fig. 1 John Hejduk sketches of nine-square problem framework. Reproduced from Mask of Medusa

Hejduk's Flatness of Space

Among the key figures who worked closely around the Nine-Square problem, Hejduk continued for the longest time and in a way closest to the actual grid. His work acknowledges the importance of both the nine-square and the cube. To him, both problems present unlimited interpretative possibilities. The Nine-Square "has nothing to do with style. It is detached: The nine-square is unending in its voidness."[7] The interest of the cube lies in "how it is viewed. It is typical that the architect is given a program from which an object emerges; it does seem possible that perhaps the opposite could occur. That is, given an object, perhaps a program could emerge."[8]

Hejduk's exploration with the Nine-Square problem and the deriving cube problem led to pedagogical results and a body of design work, including the *Texas Houses*, the *Diamond Series*, *Red-Yellow Houses*, *Bernstein Houses*, and *Element House*. Besides possible construction interpretations as post, beam, and panel, the Nine-Square structure inherits critical spatial properties. First, the bigger square composed of nine squares provides a grid that equally suggests the possibility of a rigid plan and the possibility of the fluidity of space. Second, the nine squares diagram a center and periphery configuration. This configuration was a key of Cubism and was later explored in Hejduk's *Diamond Series* illustrating the neutral center versus the tension on the periphery, the flatness of space.

The flatness of space was the undertone of Hejduk's and his students' works. Majority of these works show an emphasis on single layered square thickness instead of the verticality presented in a cube. In other words, the cube is a result of vertically layered squares. The boundaries among the layers never disappear and the spaces across the layers never merge. This characteristic in achieving three-dimensionality as well as transitioning across two-dimensions to three-dimensions reveals an attitude that privileges the plan over the section.

The clearest expression of flatness is in Hejduk's oblique projection drawings of the *Diamond Series*. The profile of all the three projects of the series are approximately a cube. The final oblique project loses the appearance of one side by utilizing a planar 45-degree rotation as a projection result. Again, the plan of the cube is the key factor but not the whole cube as Hejduk's diagram explaining flatness is composed of three squares but not one cube.

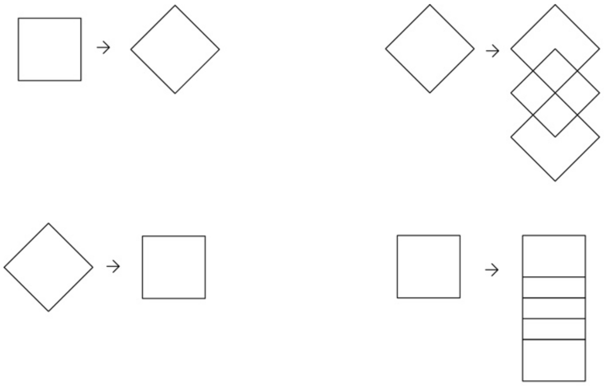


Fig. 2. John Hejduk Axonometric Rotation Reproduced from Mask of Medusa

Rowe's Grid Versus Frame

From the Nine-Square problem, Rowe developed an analytical framework capable of turning literal structure into conceptual device. In Rowe's terms, they are "grid" and "frame." Such analytical framework is evidence in *The Mathematics of the Ideal Villa, Transparency: Literal and Phenomenal,* and *Chicago Frame*. In *The Mathematics of the Ideal Villa,* Rowe does not use either terms. Instead, he uses a sequence of illustrations with distinct graphic elements, such as dashed lines, diagonal lines, and annotations, to visually delineate proportion, symmetry, and repetition. One can see the underlying grid without a textual confirmation. In *Transparency: Literal and Phenomenal*, grid is the critical device for analyses. In both painting space and architectural space, Rowe's argument about transparency is built upon the properties that grids exemplify: the geometry of the grid (oblique and rectilinear), the center versus periphery in the grid, and the relationship between the grid and its implied depth. As a key statement, Rowe claims, in Villa Garches, the "gridding of space will then result in continuous fluctuations of interpretation"[9] as the basis of phenomenal transparency. In *Chicago Frame*, Rowe replaced grid with frame in order to focus on the structural system and its symbolic statement. This shift reminds us of Hejduk's interpreting the Nine-Square as beams and columns. The difference is: Hejduk made an architectural move while Rowe made a conceptual move.

Besides the structure, both literal and conceptual, Rowe's observation on the facade establishes a relationship between the horizontal and vertical planes in a cube. Architectural organization might best be represented in the strategies of a plan, which we might think of as a rationalizing scaffold focused on the interiority of an object. But that scaffold supports the vertical plane which is architecturalized through the optical bias of the façade. The articulation of the frontal wall connects architecture not only to gestalt and cubist painting, but also to the relationship between the ability to read a building as a kind of text. While the nine-square problem struggles to escape the limitations of the horizontal datum, the cube is not simply three stacked floors, but as Robert Slutzky points out, "after recognizing that a floor is not a wall and that plans are not painting, we might still examine these horizontal planes in very much the same manner as we have the façade, again selecting Three Faces as a point of departure." [10]

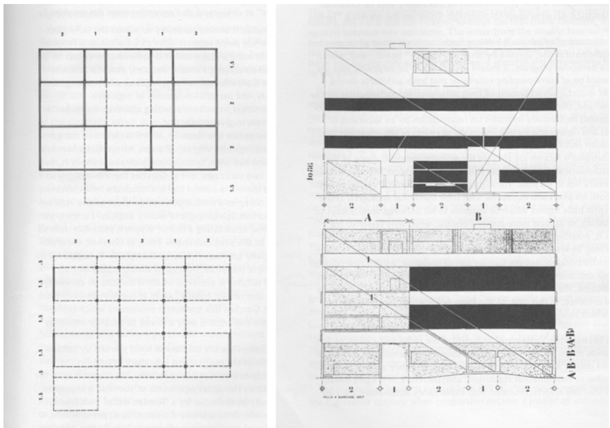


Fig. 3. Colin Rowe's Palladio – Corbusier Comparison
Reproduced from The Mathematics of the Ideal Villa

Hoeseli's Kit of Parts and Structure

Bernhard Hoesli's contribution to the Nine-Square framework is embedded in how he organizes design studio problems, evident both in Texas and at ETH after the *Texas Rangers* years. Instead of adopting the Nine-Square grid, Hoesli seemed to accept the Cartesian coordinate as a universal structure, emphasizing possible spatial variations as a result of combining the given elements with certain rules.

In a first week exercise in 1961, for example, Hoesli gave students three pieces of rectangular cardboard as design elements. A set of rules were set accordingly: 1) the sum of length and width of the rectangular cardboard is 23 centimeters; 2) the thicknesses of the cardboards are determined by student; 3) only right angle is allowed; 4) three pieces of rectangular cardboard are required; and 5) each piece should have at least one contact point to the other two pieces. Immediately following this exercise, a two-day exercise used more pieces of cardboard and with more undefined dimensions: 1) five pieces of rectangular cardboard with length, width, and thickness to be determined by the students; 2) one piece of 23-centimeter-long whose width and thickness to be determined by the students. The students were asked to use these six elements to define a cube with a 7-centimeter-long edges. Further, the rules to combine these pieces are more complex: 1) the corners cannot be enclosed; 2) no intersections are allowed among the pieces; 3) the spatial relationship among the boards remains the same. Overall, the composition should express a movement tendency.

Two characteristics are evident in Hoesli's exercises. First, they demonstrate the model of "kit of parts" which may be traced back to Froebel's building gifts. *The Gifts*, published by Friedrich Fröbel in 1838-1840, is a set of playing blocks and rules that stimulate children's spatial imagination. The creative mechanism lies in numerous combinatorial possibilities based on a limited amount of vocabulary and rules. Second, a critical rule for the combination is introduced as a process maintained within an orthogonal structure. This structure is essentially a form of the Cartesian coordinate where a cube is the basic unit. Differentiating from Hejduk's layering strategy, Hoesli's cube treats the X, Y, and Z axes equally. The linkage to the Cube is demonstrated in the second exercise when the cube defines the overall profile of the project.

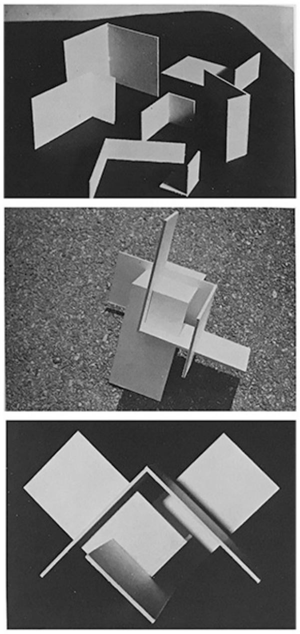


Fig. 4. Student Work from Bernhard Hoesli's Basic Design Course
Reproduced from Teaching Architecture

Fig. 5 Photograph of studio project final model. This work was done by UC Berkeley, College of Environmental Design undergraduate first year student Mary Yap in James Michael Tate's Introduction to Architectural Design studio course.

The Planetoids Phenomenon

More than half a century later, many first-year studio instructors still explicitly base their studio exercise on the well-rehearsed cube problem as a conceptual device and the foundation from which to explore the configuration of an object. However, visiting websites, Tumblrs, and Instagram accounts of junior faculty currently teaching at schools in the American Midwest and West Coast, the objects and aesthetics of first year studio projects do not strictly appear platonic. While one could speak to the particularities of what is happening in each school, for the purpose of this article, the goal is to point out some things they have in common. What is to follow is more a series of casual observations than a scientific study.

Planetoids are the product of an introductory formal exercise, they are both a way of thinking about architecture and an object that has internal and external characteristics. To this end, much like the cube problem, their construction is evaluated at both a tactile and conceptual level. Planetoids are a removed from building programs, they're abstractions intended to challenge incoming students to understand architecture as not being defined through functional arguments.

Who is leading these studios? By in large, they are junior faculty whose own architectural education happened toward the end of "The Digital Turn," a term coined by Mario Carpo to describe what was happening in Architecture between the years 1992 – 2012. While the digital turn is important, equally important in the air between 2005 – 2010 were terms such as Projective, Post-Critical, Discipline, and Fundamentals. Seminars were popping up that weren't afraid to engage architecture from the 1980s. To this end, the newness of the digital had started to transition into the naturalization of it. This meant that architects needed to substitute digital craft with an alternative. Perhaps a byproduct of the exhaustion of digital formalism, many junior design faculty began their teaching career in recent years by revisiting topics and frameworks that had been largely ignored since the mid 1990s. Among these included a curiosity about things like the use of precedents, the Nine-Square problem, and geometric primitives. These were approached, for better or worse, in a kind of flat ontology, mixing mediums, sharing stuff, and taking things on in a seriously playful manner: a borrow and subvert mentality.

Such thinking and output is finding its way into the framework of many first year design studios. While the effects of Carpo's *Digital Turn* have been part of upper level studios for a long time, many schools continue to withhold introducing digital ways of working in beginning design courses. What's happening in the Midwest and West Coast though suggests this is perhaps changing. Especially as students arrive into architecture programs today as digital natives, expecting to do research and design experiments in the computer, unable to conceive a world devoid of computational influence. This leads to what we would like to acknowledge as, not a rejection of the cube problem, but the reworking of it for our current historical moment.

The Essence of the Shift

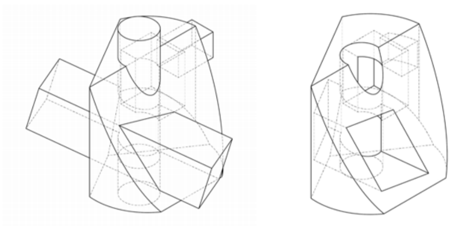
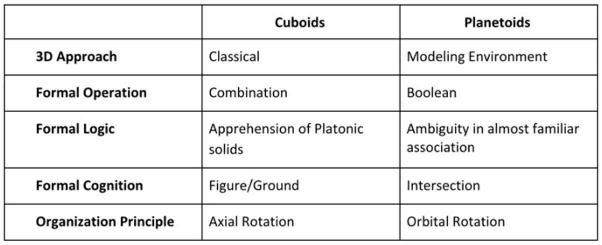


Fig. 6. Boolean Massing Diagram from Taubman College FORM studio. This studio is taken by all incoming MArch1 students at The University of Michigan.

The investigation in this article foreground the significant time of the current beginning design education. Informal conversations offer reasons why the search for an alternative other than the cube problem are occurring. They range from the cube and its spatial ordering biases being out of touch with spatial thinking today - to the integration and impact of digital tools in first year - to the cultural associations that closed platonic forms reinforce historically - to new aesthetic genres - to the sense that our understanding of part to whole today is something other than a fifteenth or even twentieth century conception of that formative idea in architecture. All of this suggests that architecture looks and behaves differently now.

Perhaps the following table could highlight the contrasts between the Cuboids and the Planetoids in terms of their formal characteristics.



	Cuboids	Planetoids
3D Approach	Classical	Modeling Environment
Formal Operation	Combination	Boolean
Formal Logic	Apprehension of Platonic solids	Ambiguity in almost familiar association
Formal Cognition	Figure/Ground	Intersection
Organization Principle	Axial Rotation	Orbital Rotation

Fig. 7. Contrasting Cuboids and Planetoids

The most immediate and visually apparent difference is the external character -the outer geometry- of planetoids. Both the cube and planetoid rely on a bounding box. The difference is in how cubes (or any nameable geometric primitive) tends to reinscribe the stable bounding limits, versus planetoids which prefer to imply the limit or intentionally carve away from it. Cubes benefit from being stable and legible, but planetoids strive to flicker in and out of recognition. That said, depending on the school, some planetoids are rich with ambiguity, others have almost familiar associations, and still others are more directly apprehendable in the spirit of the cube.

The cube problem is historically rooted in point-line-plane-volume relationships whereas planetoids start with multiple, at least two but possibly more, 3D geometric primitives that are superimposed onto one another in the virtual environment of a software program. Boolean operations are then used to trim away the unshared areas of the overlapping primitives, ultimately producing a Boolean object. This is where it could be argued that the 2d gestalt figure-ground attempts to produce figure-figure relationships in planetoids.

The role of intersection is critical in comparing cuboids and planetoids. The cube problem and planetoids deal with 2d and 3d geometric intersections. A major difference though is that the cube problem has historically privileged coplanar and elemental relationships among parts while planetoids form plastic relationships among parts.

Additionally, as representational constructions, cubes are very much reliant on the position of elements as viewed through a picture plane. That kind of spatial tension is disrupted with planetoids, not because of 3D modeling software as a tool can perform sophisticated actions, but because of how we navigate its environment. cube problems preserve a classical understanding of vertical and horizontal planes, cartesian space, reinstating architecture's relationship to a ground plane. The simulation space of 3D modeling software environments lacks physics and gravity that physical models are forced to acknowledge. For this reason, many planetoid exercises explore what it means to orbit around and continuously tumble a 3D digital model, to not have a primary façade or fixed orientation to the ground for as long as possible.

Perhaps it is possible to say the cube problem is more pragmatic and applicable to real world applications than planetoids. Its kit of parts of point-line-plane-volume-opening are more easily substituted for buildings elements such as column, beam, wall, floor-ceiling, room, stair, door-window than the potential equivalence between surface modeling and stereotomy! Perhaps this should not be seen as a shortcoming of planetoids or maybe it is really detrimental. We would like to think it is an opportunity, a chance to push architecture somewhere exciting; to get beginning students to believe in and argue for what's possible just around the corner.

We suspect such contrast results from the drawing and modeling tools with which the Cuboids and Planetoids are created and manipulated, i.e. analog versus digital. When the Cuboids were formulated, analog drawing and physical modeling dominated the architectural field; currently when the Planetoids are forming, digital drawing and modeling provides alternative ways for contemplating form. The observation of analog drawing tools and digital drawing tools seems straightforward: a compass, a parallel bar, and triangles for the analog versus a mouse for the digital. On a deeper level, these drawing tools imply distinct strategies in suggesting drawing scale and emphasizing how projection systems function, which leads to the difference in conceiving 2D-3D relationship and even aesthetic intention resulted from such relationship.

Fig. 8. Photograph of studio project model. This work was done by first year MArch students Sam Bonnell-Kangas and Hermon Habte at The Ohio State University Knowlton School of Architecture. This studio is taught by Erik Herrmann and Sandhya Kochar where they use the framework of "A Thing Inside A Thing Inside A Thing"

Continuity and Change, or Something Else?

Despite the attempt to outline a universal language and set of basic principles of architectural form, the cube problem as it came out of the *Texas Rangers* curriculum at UT-Austin was discursively constructed in a particular historical moment. Its framework, constituent parts, and the potential relationships among those elements reflect the values and interests of particular individuals teaching in a postwar American context. One could not anticipate what would happen a decade later (1960s), the advent and mainstreaming of personal computing, and globalization; all of which have and continue to significantly impact architectural thought and production within the academy.

Both the Cuboids and Planetoids invite beginning design students to explore how to use representational devices and geometry as instruments to organize and configure an object. Constraints are established in both to give students the opportunity to test out ideas and focus on relationships between elements while remaining close to first principles. Both challenge beginning students to develop logics and visual acuity to drive a design process. Both introduce abstract relationships such as proportion, symmetry, solid-void, and part-to-whole. They introduce architectural moves and actions such as add, subtract, split, trim, extend, mirror, offset, rotate, scale, extrude, copy-paste, crease, fold, etc. Despite the contrast, the modernist cube, or at least the grid, is still implied in planetoids. The suggested organizational principles are not overtly expressed but covertly utilized.

Perhaps not so apparent, maybe even a little surprising to some, but it turns out that a lot of faculty who run a Planetoid exercise in their studio ask student to use historical precedents to initiate the development of the internal organization and characteristics of the proposal. In a lot of ways this parallels Rowe's argument in *The Mathematics of the Ideal Villa* when he compares Corbusier and Palladio. It is as though external expression changes with the zeitgeist but internal characteristics and structuring logics are uniquely specific and enduring to architecture as a medium. At the very least, such continuity provides a mechanism to comparatively evaluate how a contemporary work inserts itself into a particular genealogical constellation of architectural projects and preoccupations that transcend periodization.

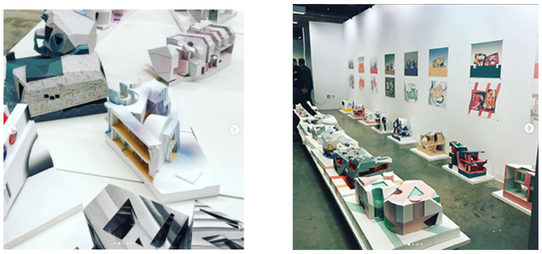


Fig. 9. Photograph of models in the FORM studio at the University of Michigan. This studio is taken by all first year MArch 1 students. Taught by Adam Fure, Ellie Abrons, Jacob Comerci, and Jeff Halstead

Can the cuboids and the planetoids transform into each other like D'Arcy Thomson's grids? Given that current instructors came from the modernism tradition, perhaps the true breakaway from the modernism cube will only happen when this tradition fades? To speculate on these questions, perhaps Hejduk's comment could summarize the formal investigation embedded in both the cuboids and the planetoids.

"The problems of point-line-plane-volume, the facts of square-circle-triangle, the mysteries of central-peripheral-frontal-oblique-concavity-convexity, of right angle, of perpendicular, of perspective, the comprehension of sphere-cylinder-pyramid, the question of structure-construction-organization, the question of scale, of position, the interest in post-lintel, wall-slab, the extent of a limited field, of an unlimited field, the meaning of a plan, of section, the meaning of spatial expansion- spatial compression spatial tension, the direction of regulating lines, of grid, the forces of implied extension, the relationship of figure to ground, of number to proportion, of measurement to scale, of symmetry to asymmetry, of diamond to diagonal, the hidden forces, the ideas of configuration, the static with the dynamic, all begin to take on the form of a vocabulary."
- John Hejduk, Mask of Medusa

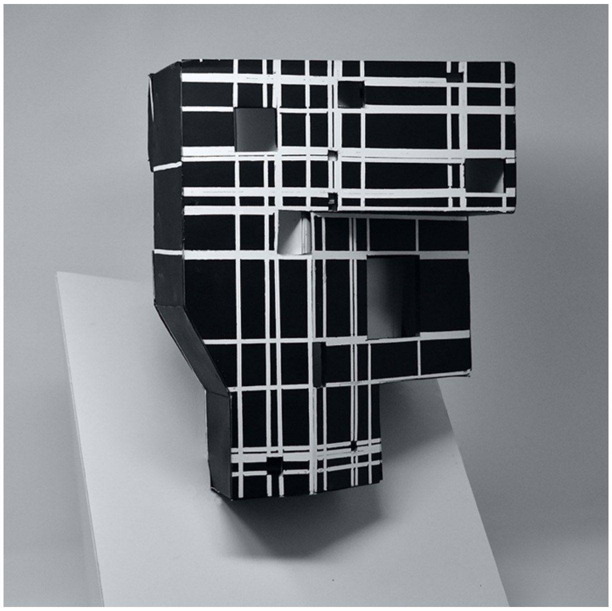


Fig.10. Photograph of models in Introduction to Design Principles at Texas A&M University. Student work by first year undergraduate student Shannon Sumner. This course is taught by the co-authors of this paper.

Notes

[1] Hejduk, John. *Mask of Medusa*. Rizzoli International Publications; 1st Edition. 1989. p 65.

[2] Hejduk, John. *Mask of Medusa*. Rizzoli International Publications; 1st Edition. 1989. p 37.

[3] Caragonne, Alexander. *The Texas Rangers: Notes from an Architectural Underground*. MIT Press. 1995. P 156.

[4] Caragonne, Alexander. *The Texas Rangers: Notes from an Architectural Underground*. MIT Press. 1995. P 190.

[5] Ibid.

[6] Caragonne, Alexander. *The Texas Rangers: Notes from an Architectural Underground*. MIT Press. 1995. P 191.

[7] Hejduk, John. *Mask of Medusa*. Rizzoli International Publications; 1st Edition. 1989. p 65.

[8] Ibid.

[9] Rowe, Colin and Slutzky, Robert. "Transparency: Literal and Phenomenal" in *The Mathematics of the Ideal Villa and Other Essays*. The MIT Press: Cambridge, Massachusetts, and London, England. Sixth Printing, 1989. p 170.

[10] Rowe, Colin and Slutzky, Robert. "Transparency: Literal and Phenomenal" in *The Mathematics of the Ideal Villa and Other Essays*. The MIT Press: Cambridge, Massachusetts, and London, England. Sixth Printing, 1989. p 169.

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