ROTATIONAL GEOMETRY AS A TEACHING TOOL : APPLYING THE WORK OF GIORGIO SCARPA

PINO TROGU – SAN FRANCISCO STATE UNIVERSITY

FACULTY RESEARCH AND CREATIVE ACTIVITIES RETREAT :

INNOVATE AND CREATE

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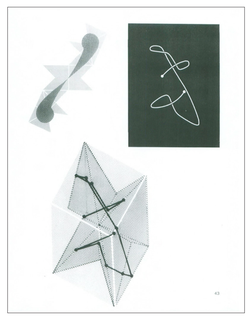
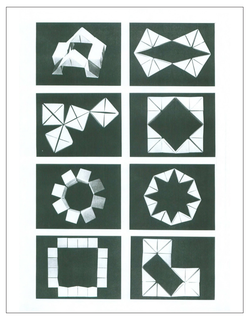
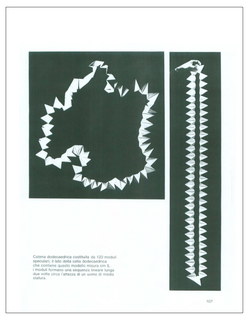
THIS POSTER IS BASED ON A PAPER PRESENTED AT THE SIXTH INTERNATIONAL CONFERENCE ON DESIGN PRINCIPLES AND PRACTICES. LOS ANGELES, JANUARY 21, 2012







Giorgio Scarpa, Modelli di Geometria Rotatoria [Models of Rotational Geometry]. Bologna: Zanichelli, 1978. Cover and sample pages: 43, 77, 107.

Genesis of form.
Motion is at the root of all growth
– Paul Klee

Although rotational geometry is a difficult field of mathematics available only to specialists, the physical models that apply its principles are highly useful for courses in sketching and drawing. Students at San Francisco State have found rotational geometry to be one of the most valuable segments of the drawing course, offering such remarks as: "I feel that this project used all of the skills that we learned in class, from drawing the basic shape in orthographic/axonometric views to the cubic modules in the perspective." "This project challenged my design thinking by taking a 2D object and rendering it in a 3D environment."

I was able to teach this segment of the course thanks to the teaching and writings of the Italian scholar Giorgio Scarpa (1938-2012). This presentation introduces his work to English-speaking specialists, and illustrates how the subject can be made useful to design students.

Giorgio Scarpa taught Descriptive Geometry at the Istituto d'Arte of Oristano and Faenza, Italy, and Theory of Perception at the Istituto Superiore Industrie Artistiche (ISIA) in Faenza. His book *Modelli di Geometria Rotatoria*, which was part of a design series edited by the late Italian designer Bruno Munari, is the basis of this study. This teaching unit in drawing for design uses and applies Scarpa's principles and methods, and tests their validity through the construction of physical models built by the students. Through this process, students learn to apply a visual grammar based on rotational movements and folding which transform two-dimensional shapes into three-dimensional solids. These solids are modules derived from the sectioning of regular polyhedra such as the cube.

In theory, any regular polyhedron can be used as the basis for the section. In this study only the cube is used, due to its simple, intuitive symmetry.

Drafting and Sketching for Design is a required course for all students entering the Design and Industry Department at San Francisco State University. In the class, all drawing is done by hand with drafting tools and free hand sketching. The class covers orthographic projections, axonometric projections, and perspective. These techniques are also explored within a unit called Cube Section.

The unit begins with the simple problem: dissect a 4″ x 4″ x 4″ cube into two or three solid modules (polyhedra), having identical surface area, volume, and shape.

The three-dimensional modules that will form the final cube can be connected at a later time by means of hinges. The connected modules can be arranged into open or closed chains. The modules may or may not fold back into a minimum volume enclosure depending on the type and orientation of the hinges used. The materials used in this process are pencil, paper and tape or glue.

While the students are able to improve their manual skills through the use of these materials, the alternative use of CAD and 3D printing would allow for faster testing of the various configurations.

We'll call the process for the section that divides the cube into two modules the "twin" section. The process that divides the cube into three modules will be called the "triplet" section.
Text and images in this poster are adapted from an article by the same title.

More details can be found at the URLs below. Thank you. PT

TWIN SECTION

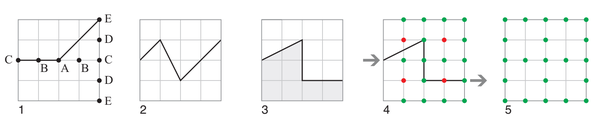


Fig. 1 – *The square is sectioned into two parts, starting at the mid-point on the left edge and ending at any point on the right edge, but avoiding "stops" on the four red dots.*

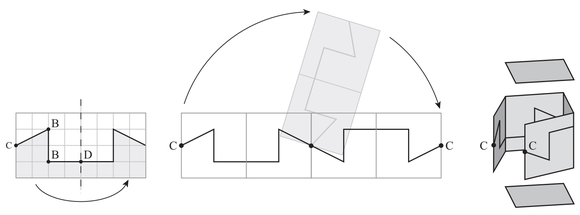


Fig. 2 – *Mirroring and rotations of the basic square.*

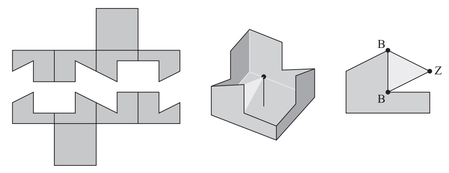


Fig. 3 – *At left is the complete template for the outside of the cube.*

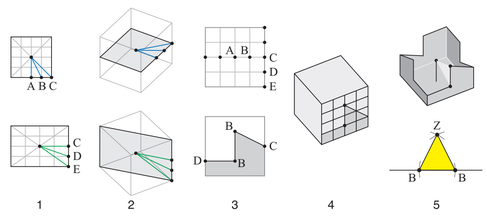


Fig. 4 – *The triangles needed for the internal surfaces are constructed from a combination of external and internal lines.*

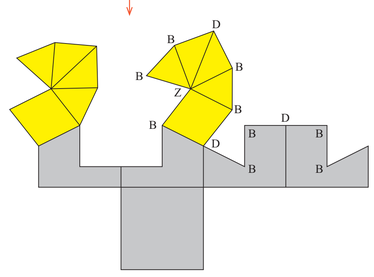


Fig. 5 – *Foldout of internal and external surfaces combined.*

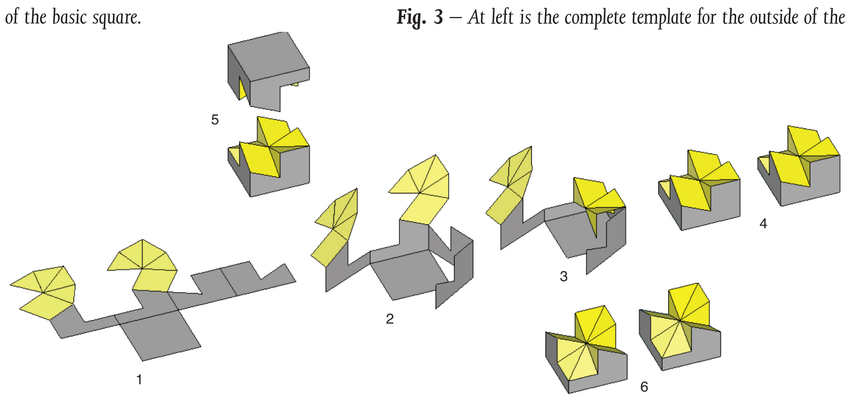


Fig. 6 – *Folding sequence from flat polygon to completed solid.*

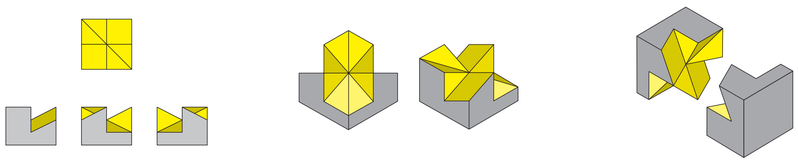


Fig. 7 – *Orthographic and isometric views of the modules.*

TRIPLET SECTION

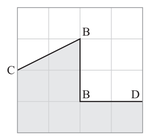


Fig. 8 – *Two-part section.*

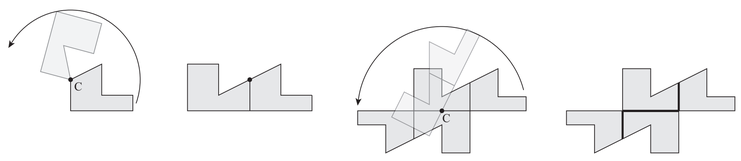


Fig. 9 – *After one of the parts is rotated, the two shapes share one edge. The resulting shape is rotated by 180 degrees, resulting in the complete external surface of the module.*

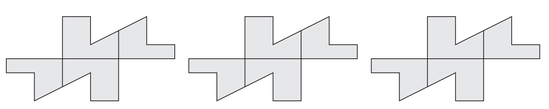


Fig. 10 – *Complete external modules.*

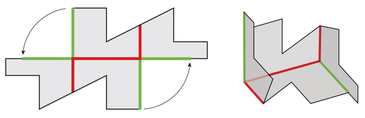


Fig. 11 – *Folding the parts of a single module.*

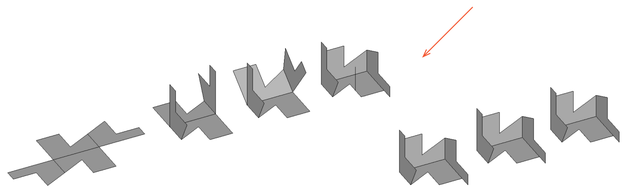


Fig. 12 – *Folding of the single module and three modules side by side.*

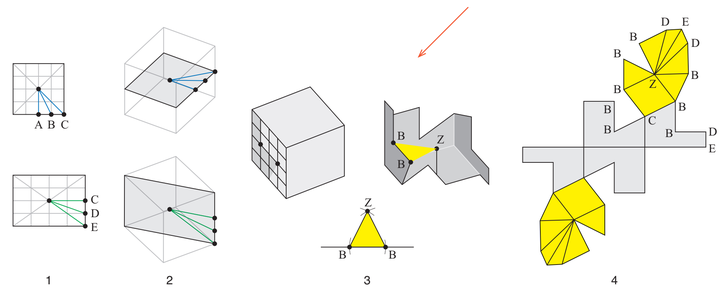


Fig. 13 – *Construction of the internal triangles using the external line segments in combination with the lines provided by the cross-sections.*

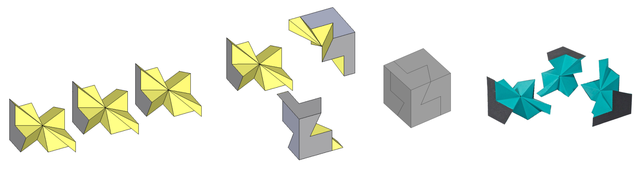


Fig. 15 – *The three modules and the completed cube. Cube made with card stock and glue.*

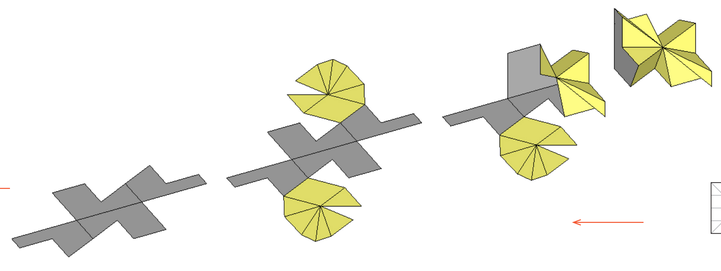
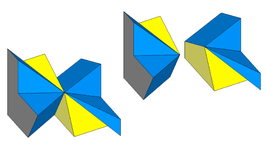


Fig. 14 – *Folding sequence of one module.*

HINGES AND ROTATIONS



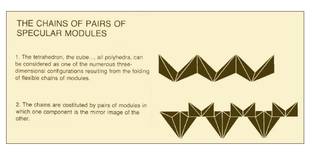


Fig. 16 – *One-third module is split into two parts.*
At right: illustration from Modelli di Geometria Rotatoria, showing hinged symmetrical pairs of modules.

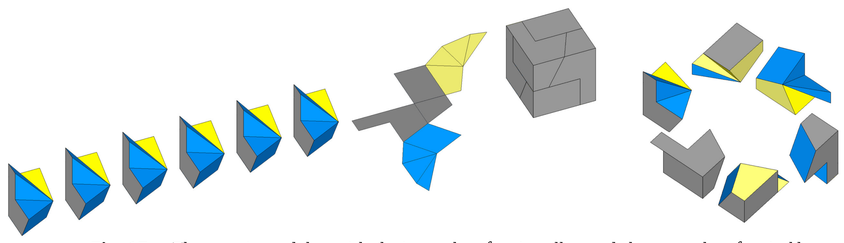


Fig. 17 – *The new six modules, with the internal surface in yellow and the external surface in blue.*
At right is the exploded view of the six modules forming the cube.

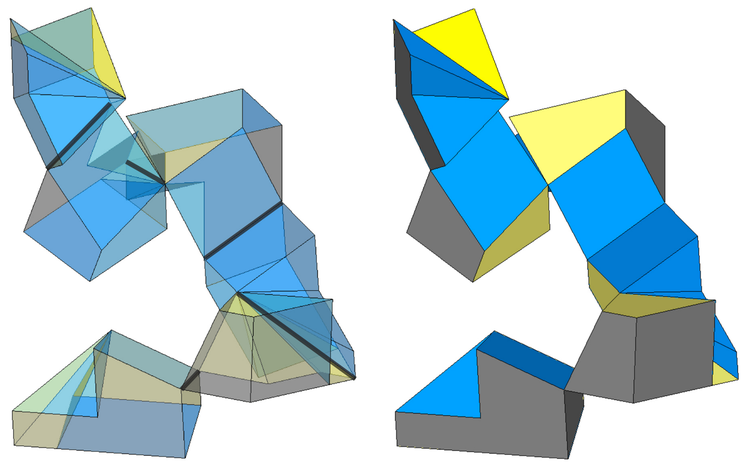
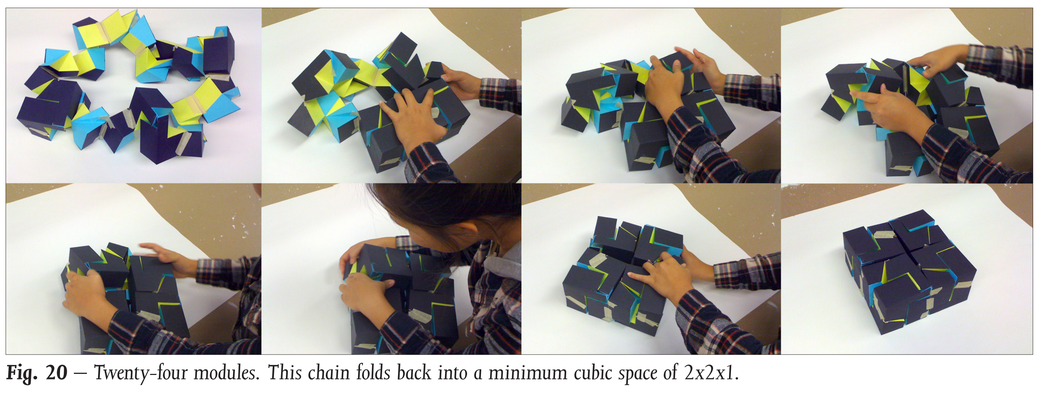


Fig. 18 – *The six modules that will form a cube are hinged together along the thick black lines.*



Paper models by Florence Gold Yuen, SFSU.

Fig. 20 – *Twenty-four modules. This chain folds back into a minimum cubic space of 2x2x1.*

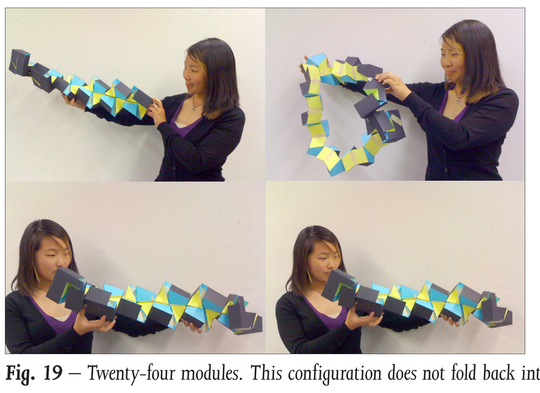


Fig. 19 – *Twenty-four modules. This configuration does not fold back into a cubic shape.*

REFERENCES

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Munari, Bruno. *Design e comunicazione visiva.* Bari: Laterza, 1974.
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Thompson, D'Arcy Wentworth. *On Growth and Form.* Cambridge: Cambridge University Press, 1942.

LINKS

Cube section – trogu.com/projects/getProject/20051225082001/project_html
Giorgio Scarpa – online.sfsu.edu/trogu/scarpa
Slides and paper – trogu.com/Documents/conference/design-principles-and-practices