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WHERE IS A POLYHEDRON? ABOUT SYMMETRY IN ORIGAMI MODELS.

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Abstract*: We present typical constructions of 3D origami models based on the modular origami technique: face modules, edge modules and vertex modules. We discuss the correspondence between the polyhedron as a geometrical structure and a source of symmetry and the actual origami model. Several examples of polyhedral symmetry of models are presented. Making origami models may be effectively used in mathematics education to improve spatial imagination skill and better understanding of symmetry.*

Keywords: modular origami, polyhedron, education.

1. A FEW WORDS ABOUT ORIGAMI

Origami is often associated with Japan, but in fact it has several independent origins. Now it is usually defined as art (figurative and abstract), a form of sculpture using paper as the main substance and folding as the main technique. Modern origami usually requires that no glue or cutting is used to make a model.
Modular origami is a branch of origami that uses multiple, often same-shaped pieces which are joined into a model, usually geometrical in nature.

2. ORIGAMI MODULES AND POLYHEDRA MODELS

2.1 Types of modules

There are three standard types of modules used in origami to build polyhedral structures: a face module, a vertex module and an edge module (Burczyk, 2001).
A face module corresponds to a face of a polyhedron. A number of modules used to build a model is equal to the number of faces of the corresponding polyhedron.

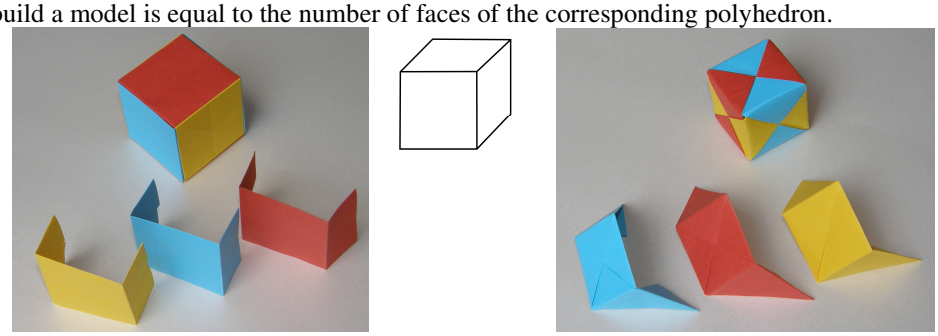

Figure 1 Examples of face modules: a cube built from 6 face modules by Paul Jackson (Mitchell 1999) and a cube built from 6 face modules by Mitsunobu Sonobé (Kasahara, Takahama, 1989).

A vertex module corresponds to a vertex of a polyhedron. A number of modules used to build a model is equal to the number of vertices of the corresponding polyhedron.

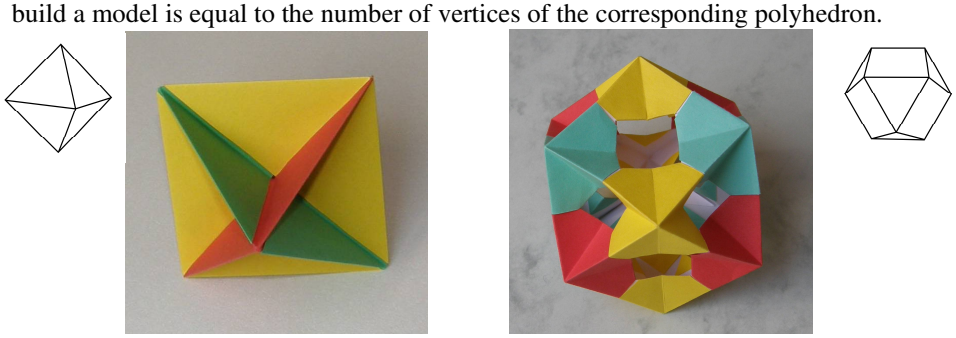

Figure 2 Examples of vertex modules: a skeleton octahedron built from 6 vertex modules by Robert Neale and a cuboctahedron built from 12 vertex modules by Lewis Simon (Simon et al. 1999).

An edge module corresponds to an edge of a polyhedron. A number of modules used to build a model is equal to the number of edges of the corresponding polyhedron.

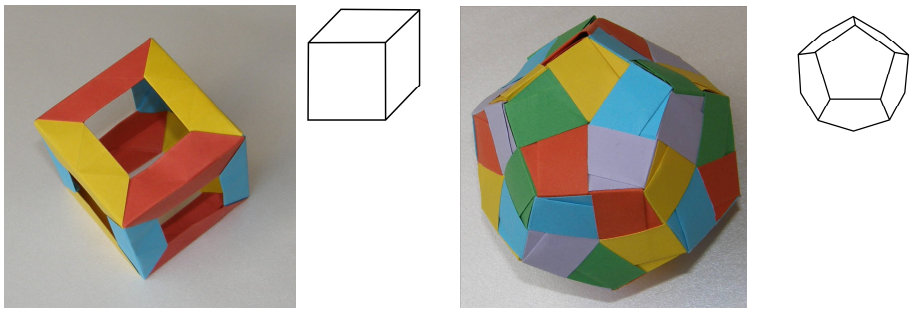

Figure 3 Examples of edge modules: a cube built from 12 edge modules by Tomoko Fuse (Fuse, 1990) and model of a dodecahedron built from 30 edge modules by Silvana Mamino.

Sometimes different types of modules are mixed in one model.

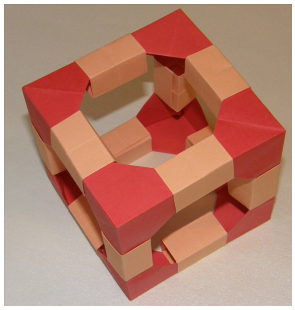

Figure 4 Example of mixed modules: a cube built from 12 edge modules:and 8 vertex modules by Miyuki Kawamura (Kawamura 2001).

2.2 Macro-modules

A twirl module is a type of module where tension of paper formed into spirals is used to join modules together (Burczyk, 2002). A standard twirl module (Goubergen, 2000) is a vertex module.

A two-step approach may be used to build origami polyhedra models from twirl modules (Burczyk, 2008). First, several modules are joined into a subassembly that is used as a second-degree module (a macro-module) to build a model. Such technique is especially useful in case of twirls. Base modules are joint together into a macro-module corresponding to a polygon. Then polygons are assembled into a polyhedral structure.

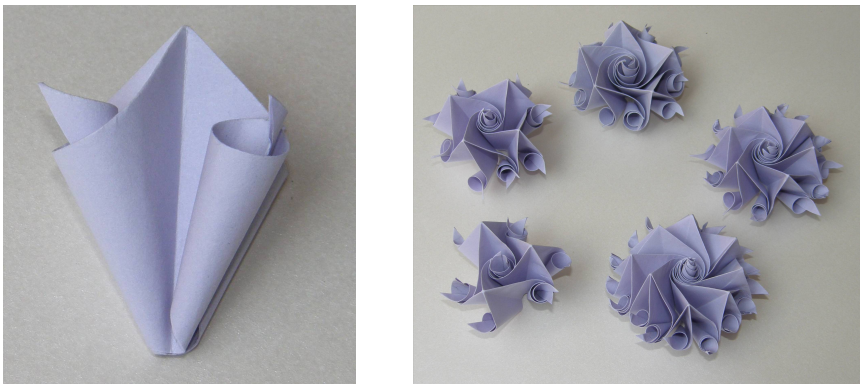

Figure 5 A standard twirl module (Goubergen, 2000) and macro-modules (Burczyk, 2008) corresponding to a triangle, a square, a pentagon, a hexagon and an octagon.

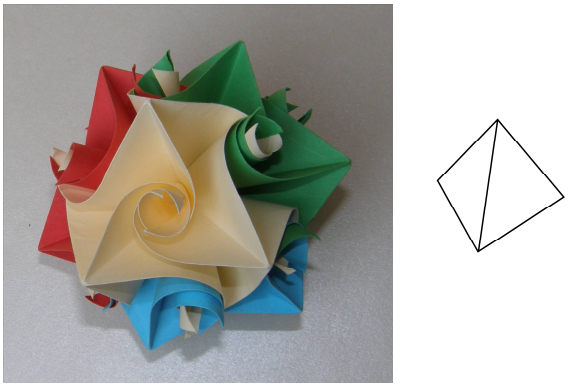

Figure 6 Four triangle macro-modules form a tetrahedron.

3. CAN YOU SEE A POLYHEDRON? FIVE WAYS TO ASSEMBLE A TWIRL MODEL FROM 24 STANDARD MODULES

Compare five models made from 24 standard twirl modules: