УДК 7.012: 688.72

MORPHOLOGICAL DESIGN FEATURES OF MAGNETIC EDUCATIONAL CONSTRUCTION TOYS

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This study presents a comparative morphological analysis of magnetic construction toys within educational play systems. Five representative products—Magna - Tiles, Magformers, Pixio, Geomag Magicube, and Clixo—are examined across three design dimensions: materials, forms, and color systems. The analysis identifies three main morphological types: tile - based systems, voxel modular systems, and flexible surface structures, highlighting different structural approaches in magnetic construction toy design.

Key words: *toy design, construction toys, magnetic construction systems, modular design, morphological analysis*

INTRODUCTION

Construction toys represent an important category of educational play objects characterized by modular components and repeatable connection systems. By combining of simple geometric elements, these toys enable users to construct a wide variety of spatial forms and structures. Furthermore, as Horikoshi [1] points out, the diversity of shapes and colors in modular systems makes them suitable for creating educational tools that can be easily assembled, reconfigured, and reused without specialized equipment. The study by Na Yang and O. Yezhova [2] analyzes the "Phoenix Stamp" educational construction toy based on traditional Luban lock structures, demonstrating how cultural heritage and structural innovation can inform contemporary educational toy design.

In recent years, magnetic connection technology has become increasingly common in construction toys, allowing components to connect through embedded magnets rather than traditional mechanical joints. This design approach simplifies assembly while expanding possibilities for geometric exploration and structural experimentation.

Several contemporary toy systems illustrate different approaches to magnetic construction design, including Magna - Tiles, Magformers, Pixio, Geomag and Clixo. Although these toys share the same magnetic connection principle, they differ significantly in their materials, geometric forms, and color organization.

Despite the growing presence of magnetic construction toys, their morphological design characteristics have received limited systematic analysis. This study therefore investigates the design features of selected magnetic construction

toys through a comparative analysis focusing on materials, forms, and color systems. The present research selects typical systems for analysis and does not include all magnetic construction toys available. A wider range of product types will be explored in future studies.

PURPOSE

The purpose of this study is to examine the morphological design features of magnetic construction toys through comparative analysis. The study focuses on three key design dimensions—materials, forms, and color systems—to identify common design patterns and morphological types in contemporary magnetic construction toy systems.

RESULTS AND DISCUSSION

Tile - based systems represent a common morphological approach in magnetic construction toys, in which flat geometric modules connect through magnets embedded along the edges. Typical elements include squares and triangles that can be combined to form various three - dimensional structures. Representative examples of this design approach are Magna - Tiles (Fig 1) and Magformers (Fig 2). These systems share several features: plastic components with embedded magnets, simple polygonal forms, and bright saturated colors that enhance visual recognition and highlight geometric patterns during construction.

Despite these similarities, their structural designs differ. Magna - Tiles use solid plastic panels that create continuous surfaces when assembled, sometimes incorporating translucent materials that emphasize color and light effects. Magformers, by contrast, use hollow plastic frames with magnets positioned at the vertices, producing lightweight skeletal modules. Consequently, Magna - Tiles emphasize surface - based constructions composed of colored planes, whereas Magformers create more open, wireframe - like structures defined by linear outlines.

Fig. 1. Magna - Tiles [3]

Fig. 2. Magformers [4]

Voxel modular systems are based on cubic elements that function as volumetric pixels. By repeating identical cubes, users can construct three - dimensional objects in a way like digital voxel modeling. Representative examples include Pixio (Fig 3) and the Magicube series by Geomag (Fig 4). Both systems use colorful cubic modules whose repeated accumulation forms figures, objects, and abstract structures with a clear voxel - like appearance.

However, the two systems differ in scale and interaction design. Pixio cubes are very small modules (approximately 8–9 mm) with strong internal magnets that require polarity alignment during assembly, enabling highly detailed structures resembling pixel art. In contrast, Magicube uses much larger cubes (around 4 cm) designed for early childhood play. Each cube connects on all six faces regardless of orientation, allowing intuitive assembly and easier tactile manipulation.

Although both systems employ cubic modules and voxel - based construction logic, Pixio supports high - resolution modeling, while Magicube emphasizes large - scale tactile interaction and intuitive play.

Fig. 3. Pixio Happy Family [5]

Fig. 4. Magicube Try Me 64 [6]

Fig. 5. Clixo Mega Pack [7]

Flexible surface systems represent another distinctive morphological approach in magnetic construction toys. Unlike rigid tile or voxel systems, these toys employ bendable components that allow structures to change shape through folding and curvature. A representative example of this design strategy is Clixo (Fig 5).

Clixo components are made from flexible plastic materials that allow each piece to bend without breaking. This material property enables the modules to be folded, twisted, and curved during construction, expanding the range of possible forms beyond rigid geometric assemblies.

The pieces are designed as flat elements with rounded edges and cut - out shapes. Embedded magnets positioned at connection points along the edges allow the modules to attach to one another, structures can transform from flat configurations into curved three - dimensional forms.

The components are typically produced in bright contrasting colors that help distinguish individual pieces and enhance the visual clarity of assembled structures.

As a result, Clixo differs from tile - based and voxel systems by introducing flexibility as a central design feature. Instead of rigid volumes, users can create dynamic forms that combine planar surfaces with curved spatial structures.

The analyzed magnetic construction toys exhibit three distinct morphological strategies: planar surface assembly (Tile - based, e.g., Magna - Tiles), volumetric voxel accumulation (Voxel - based, e.g., Pixio), and flexible surface transformation (Flexible - based, e.g., Clixo). These systems differ significantly in their module geometry and material behavior, where rigid components prioritize structural stability and geometric clarity, while bendable elements introduce curvature and elastic adaptability to the construction process.

CONCLUSIONS

This study analyzed the morphological design features of four representative magnetic construction toy systems—Magna - Tiles, Magformers, Pixio, and Clixo—through a comparative examination of materials, forms, and color systems. The analysis identifies three main morphological strategies in contemporary magnetic construction toys: tile - based surface assembly, voxel - based volumetric construction represented by Pixio and Geomag's Magicube, and flexible surface systems exemplified by Clixo. These design approaches demonstrate how variations in module geometry, material properties, and structural flexibility shape different modes of spatial construction and play interaction. The results provide a morphological framework that may support future research and design development of modular construction toy systems.

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МОРФОЛОГІЧНІ ОСОБЛИВОСТІ ДИЗАЙНУ МАГНІТНИХ РОЗВИВАЛЬНИХ КОНСТРУКТОРІВ

У дослідженні представлено порівняльний морфологічний аналіз магнітних конструкторів у системах навчальних ігор. Проаналізовано чотири репрезентативні системи — Magna - Tiles, Magformers, Pixio та Clixo — за трьома проектними вимірами: матеріали, форми та кольорові системи. В результаті аналізу визначено три основні морфологічні типи: плиткові системи, воксельні модульні системи та гнучкі поверхневі структури, що демонструє різні підходи до розробки структури магнітних конструкторів.

Ключові слова: *дизайн іграшок, конструктор, магнітні системи конструкторів, модульний дизайн, морфологічний аналіз.*