

**Marta Serrano Sánchez** martaserranosanchez@gmail.com  
**Mª del Carmen Hidalgo Rodríguez** hidalgor@ugr.es  
University of Granada

Blucher Design Proceedings  
Dezembro de 2014, Número 5, Volume 1  
[www.proceedings.blucher.com.br/evento/icdhs2014](http://www.proceedings.blucher.com.br/evento/icdhs2014)

## ***Paper Engineering In Children's Literature Design of paper mechanisms***

### abstract

In this study, we will go through the paper engineering and the mechanisms to make children's pop-up books. We will briefly develop each design and its appearance in traditional children's literature. The information is divided into several parts. First, we will define the engineering of paper and the task of engineers. Second, we will go through the different ways in which we can divide the mechanisms according to the effects we get from them, the kind of children's books according to their technical mechanism, and lastly, the final classification as the main goal of this research. So we will show the most important mechanisms of paper, distinguishing those which retain the bi-dimensional nature of the book, remaining on the surface of the page, of those which lift up above it, resulting tri-dimensional figures made of complex structures and combination of different designs. Furthermore, by knowing the origins, we can understand its influence in subsequent creations and its evolution until nowadays. There are other areas that include paper engineering in their language, such as artist's books, but in this paper we only study the use of paper mechanisms in children's books.

### keywords

design, paper, engineering, mechanisms, pop-up

### Introduction

Pop-up books constitute a genre in itself, they are the result of a wide development over time, and an important part in the history of books and children's literature, as well as a great advance in paper design.

Pop-up books, in their origin, were used as educational and didactic tools for adults until the 18<sup>th</sup> Century, in which contextual factors for the development of children's literature took place.

### Paper Engineering

Design and creation of paper mechanisms for pop-up books. It's similar to origami, because it uses folded paper. The difference is that origami is focused in the creation of exempt objects, while pop-ups use one base paper, which is more suitable for these particular books. Pop-ups are movable figures that turn into 3D and then into 2D when moving into another page.

### Paper Engineer

"The paper engineer is the one who illustrates with paper" (Van der Meer 2013). Noting the illustrator sketches, he must imagine the necessary mechanisms to bring them to life, creating the most imaginative actions suitable for each part of the image. His task

should be creative, functional, and practical. He is a designer and an artist who makes illustrations move, transform, or gain three-dimensionality to refold when the book is closed.

### Types of books

*Novelty (Bi-dimensional):* Simple and flat elements over the surface of the page producing movement effects or an image transformation.

*Pop-up (Three-dimensional):* Self erecting three-dimensional structures; figures that "skip" when the page opens, gaining volume and movement.

*Multiple Construction:* Combination of various construction techniques, adding other materials besides paper. (The Smithsonian Libraries 2010: 19).

### Types of effects of the mechanisms

*Movement:* A picture element is moved through the operation of a pull-tab or a wheel through the reader, or automatically when turning the page.

*Transformation:* The first image is transformed into a second one. It can be operated by a pull-tab, flaps, a revolving wheel or a dissolving picture.

*Three-dimensionality:* A three-dimensional figure brings up when the page is opened, it is lifted up a flap or pulled a pull-tab. (Desse 2013).

### Types of Mechanisms

After consulting the sources of these books, we have developed a classification system establishing the basic mechanisms that can be found.

#### 1 Bidimensional Mechanisms

##### 1.1. Flaps

A Piece of paper attached by the outermost to the page, which covers an illustration, text or moving figure. It can be lifted by hand or powered by a pull-tab; extending the page's size when it's at the page's outermost and unfolding it (Gatefold).

Traditionally in children's books there are two types based on this mechanism:

*Turn-up books:* Illustrations or full text page, cut into equal pieces and joined at the spine of the book, and can freely combine parts of each page.

*Harlequinades:* (Robert Sayer, 1765, London) First children's books to entertain, not to indoctrinate. A sheet folded perpendicularly into four parts, with gatefolds folded up and down, changing the illustration and forward the story by the reader.

##### 1.2. Wheels (revolving pictures)

Paper disk attached to the base page by the centre, either by a circle of paper or a rivet (hinge pin). There may be cut-dies in the base page that allow the illustrations of the wheel spin to go showing through the holes. It can be used to activate another device, or can combine differently sized wheels, relating the drawn or written content on them.

*Volvelle:* Considered the first mobile design paper that appeared in a book, used as a tool for mathematical calculations, astrological, calendars, navigation routes, etc.

*Origin – 13<sup>th</sup> Century:* First mobile book: "Chronica Majorca" by Matthew Paris (1250, London). Flaps are used to assign the english pilgrimages, and volvelles to calculate Christian holidays.

##### 1.3. Pull-Tabs

Strip of paper (or illustration cut-died element) that moves a figure of the illustration

when pulled or pushed in the given direction, scrolling it through the page, or lifting it up three-dimensionally. It can activate multiple movements in the image involving an elaborate system of joints.

*19<sup>th</sup> Century:* First Golden Age: Jean-Pierre Br s (French) was the first to connect the images to strips of paper to move them in his book "Livre Joujou" (1831).

*Lothar Meggendorfer:* Produced 200 pop-up children's books, inventing new shapes and giving life to seven elements of an illustration simultaneously, moved in different directions with only a single pull-tab.

#### 1.4. Metamorphosis

Two designs in which the original image is transformed into a different image hidden beneath, by pulling a pull-tab, turning the page, or turning over a flap:

##### 1.4.1. Dissolving Wheel

Two circular illustrations share a central axis and have cuts along the radius, dividing the image into equal sectors that intersect each other. This allows them to be crosslinked by sliding one over another when gliding it, so that the top illustration spins, showing the bottom picture through the cuts.

##### 1.4.2. Dissolving Window (Venetian blind)

Two cut illustrations into equal strips, and overlapping each other, so that when moving them, the slats in the bottom picture slide over the other, dissolving the image you saw into a new one.

*Dean & Sons (1850, London):* Introduced books with dissolving pictures and "Living Pictures" (with tab to move the characters). They published the first mass-produced pop-up books and they established an expert department to build the mechanisms.

*Ernest Nister (1877, London):* He was a German editor who combined the British design and the German print media, creating books of a high quality and color, with a distinctive style.

#### 1.5. Die-Cut or Cut-Out

Cutting out a certain shape on the top page, which shows part of the image of the page behind. They may also be elements exempt to play.

*19<sup>th</sup> Century:* "Paper Doll Books" of Fuller (London). Books with dolls to dress with trimmed and interchangeable clothes. They could be stood upright standing or incorporated them into the scene of a story.

#### 1.6. Transparencies

Transparent or translucent papers that allow you to see the illustration below the current one, or in which a drawn element will be join to it when superimposing it. It is usually used to simulate water or other transparent elements, or as an "invisible" component to make a piece appear floating or flying.

## 2 Threedimensional Mechanisms

### 2.1. Peep-Show

No self-erecting folding of several pieces of paper of equal size, connected by paper strips and bellow folded, in which the die-cut scenes with representations of different planes one after another; lifting up the illustration above the level of the page. Observed from a "peephole" on one side, it is seen in perspective forming a multilayer three-dimensional scene of great depth.

*TUNNEL BOOK (Peep-Show):* Special opening book with the same principle and structure

of the mechanism.

18th Century: First peep-shows emerged from cinema machines, using the same principle of observing planes of an image through a hole. They were made for adults until 1820, when appeared the firsts for children.

*CAROUSEL (Circular Peep-Show)*: 360° displayed book forming a “carousel”. When it's completely open, the front and back part touch each other and are tied with a ribbon, keeping all pages opened forming sectors. They may be combined with constructions such as “little theater” (Star Book), or represent any rooms from a building to play with cut-die characters (House Book).

## 2.2. Added Foldout

No self-erecting foldout added to the page, consisting of a piece of paper that unfolds in a larger size.

*POSTER BOOK*: The pages of the book unfold resulting only one sheet of large paper, with a continuous illustration.

*LEPORELLO*: Book made with a long strip of paper folded in zig zag or accordion. They can be read as a normal book, opening the pages and passing them in a traditional way, or displaying along its length. Origin: Style in which Leporello, a character in the opera “Don Giovanni”, bent a list of the conquests of the protagonist.

## 2.3. Self-Erecting Models

Figure or illustration that when activated, by opening a page, lifting a flap or actuating a pull-tab, it rises automatically above the level of the page in a three-dimensional way, folding itself and returning to its flat condition when closing the book.

S. Louis Giraud (1929, England) published the first “self-erecting living models” in his “Bookano Stories” with which he provoked the birth of the true pop-ups. The technical contribution was that the action should occur when opening the book, without pressing anything, and that the figures could be seen from all the angles of vision.

**2.3.1. ONE PIECE**: Figures are achieved from cuts and bends of the page. They can be parallel or at an angle (V-fold) in respect to the spine of the book, and will be fully displayed when the page opens at 90°.

90° *STAGE-SET*: Reproduce scenes on each double page, using a page as a base or ground and the other one as a support wall of the parts.

*Vojtech Kubasta (1950, Prague)*: Illustrator and graphic designer, who after World War II created more than 120 books through this simple and economic method, with which he built scenes without being glued.

**2.3.2. ADDED PIECES**: Mechanisms will be completely lifted when opening the page at 180°.

*V-FOLD*: It is a piece of paper folded in two halves attached to the page in an angle forming a “V” with the apex at the spine of the book.

**2.3.3. FLOATING LAYERS**: Added pieces of paper in a parallel way to the surface of the page and in different heights. They sit on flanges or “legs” like a “table”, and above them, other parts are placed to create the illusion as they are floating and getting depth. The mechanism lifts up completely with the opening of the book at 180°.

180° *STAGE-SET*: Scenic images that rise up and represent different compound spaces by the different parallel planes that give them depth.

*Dean & Sons (1860)*: They developed them using the principle of “peep-show” without peephole, with scenes that are lined up one after another. In some cases, they represented real theaters that acquire depth when pulling a ribbon (Scenic-Books).

**2.3.4. POP-UPS:** Multipart structures that can be formed by certain basic shapes (floating layers or V-fold), to which other pieces of paper are added to increase its complexity. Self-erecting structures that completely lift up when opening the book at 180°.

**2.3.4.1. Geometric Figures:** Cube shapes, Box, Cylinder, Tent, Ship, Cone, Pyramid and “Mouth” placed in a parallel way or at an angle to the center of the book, are lifted up when opening the page.

**2.3.4.2. Arch Piece:** It is a parallel piece to the spine of the page, which rises in the form of vault, through a band attached to the opposite page that “pulls” from it lifting it up when opening the page.

**2.3.4.3. Pivot:** Mechanism that produces a rotational movement or spin of a figure attached to it, when opening the page. You can also actuate it by lifting a flap or by a pull-tab.

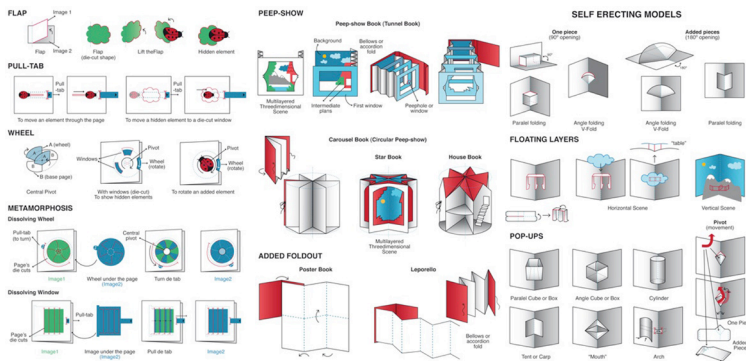
**2.3.4.4. Sliceforms:** Shapes made from several sheets of paper, cut like a grid in the same and parallel strips. When crossing them in “X” way, are connected to by creating a sort of grid structure forming the volume of the figure.

*Blue Ribbon (1932, USA):* Although Giraud patented his work, the term “pop-up” was registered under this label, that he published over a series of books based on the british serie, but for a richer market, with better graphics and a higher level of production.

### 3 Other Mechanisms or Interactive Elements

Or added “ad hoc”: Holograms, chips of light or sound, real objects, textures, cd's, etc. The addition of these effects in many books has contributed to a greater surprise and entertainment of readers of all ages.

*20th Century:* Second Golden Age: Mass production is generalized and markets are established emerging publishers and authors of a higher quality. We Highlight famous engineers from USA, England and France who are overcoming the previous pop-ups with a more sophisticated creations.



**Figure 1.**  
(left) - Bidimensional Mechanisms  
(middle) - Three-dimensional Mechanisms (Peep-Show and Added Foldout).  
(right) - Threedimensional Mechanisms (Self Erecting Models)

### Conclusion

We have checked the value of paper engineering as a technique, and their attractiveness to any audience. Studying the language, its forms and history, we verify the interests and the development opportunities that it offers, only limited by the designer's ability and the physical possibilities of paper; although we expect developments regarding the materials, in the search of a more suitable one according to the wear on the hands of the reader. Currently, the quality of pop-ups in the market is very high, but the world of paper engineering is always open to all innovations brought by new creators.

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