

Study on the design, production and interactivity of pop-up books

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Abstract: *To what extent can pop-up books be regarded as timely printed products today? The authors have tried to answer this question by creating and subjecting their own interactive pop-up book to structural analysis and multipurpose examination during their research. They have investigated the limitations and difficulties of production by printing businesses in their quest for efficient technological solutions for the making of pop-up story books for kids. The focal point of their research has been the assessment of the demands of the target audience by presenting a model. Based on the results of this assessment, they have determined the steps of development that are needed to create a full-value story book (the product) from the draft.*

Keywords: *Pop-up book, children's story books*

“Once upon a time...” – reads the ageless aphorism from time to time. The aim of our studies and topic of our research were to see how much timely printed products are pop-up books nowadays. The limitations and difficulties of printing production were investigated with reliance on structural analysis and by creating our own interactive pop-up book. We were in search for the efficient technological solutions of making pop-up story books for kids. Our research also focused on the assessment of the demands of the target audience, as well as the viability of such products in today's world deluged with electronic media creations.

I. A historic overview of pop-up and/or movable books

Po-up, three-dimensional or movable books has been existent since the 1200 s. The topics of these books have often been mathematics, astronomy, geology, physics, biology; their goals have been to demonstrate the given field of sciences in a compact form. First, it was Matthew Paris, cartographer (1236–1253) to apply a volvelle structure in his book, *Chronica Majora* (Figure 1). In a volvelle, there is a separate disk on the flat sheet of the book. The disk can be fixed with a Milton pin that can be turned around the central axis.



Figure 1: Matthew Paris, *Historia Anglorum, Chronica majora, Part III, Chart of winds from London to the Holy Land* [1]

Then, 1700 saw the birth of the first pop-up story book for kids. Robert Sayer, a printer from London published a fold book telling funny stories about Harlequinade. By turning the layers in the two horizontally arranged parts of the folding book independently each other, the individual scenes of the stories could be combined.

In 1840, “pull-tab” structures became popular; here the moving element was inserted as a layer under the plane of the sheet. This solution was developed by Dean Thomas, English printer [2]. By today, the list of these structures has been extended. From the middle of the 20th century, three-dimensional, “pop-up” books and publications opening in 180° became once again popular. A reputable Hungarian artist is Dezső Andrea, graphic designer, who works on book illustrations, pop-up books, book arts and installations.

2. Format and typography of children’s story books

One of the important elements of creating a story book for kids is the selection of the font type and size. The typography lends an atmosphere and style to the book, while the shapes and sizes of the fonts give an impression of the whole work to the reader. Children’s story books mostly use sans-serif fonts that are larger than 12 points [4]. They often apply font types that harmonize with the illustrations in order to achieve more uniform graphic presentation.

After writing the story, the font size was chosen to be 14 points, because our goal was to make all the textual parts easily legible on the pages of the story book. With the selection of the font type, the typographic visual editing of the book was deemed to be essential so that the appearance of the text could support the mood of the story. The story book we were to create intended to mirror the style of folk tales, and therefore we used the That’s Font Folks! font type. The font included a set of letters for the English alphabet, and therefore we modified the fonts with the FontForge program so as to have the accented letters of the Hungarian alphabet, such as *ű*, *ő*. After selecting the That’s Font Folks! font type, we examined the various font sizes (*Table 2*).

Table 2: The That’s Font Folks! font in various sizes

Betűméret	Betű képe
10	<i>Misi a kapitány</i>
12	<i>Misi a kapitány</i>
14	<i>Misi a kapitány</i>
16	<i>Misi a kapitány</i>

Betűméret = Font size; Betű képe = Font image

The pages of children’s story books are generally of square (AN, BN) format. For our book, we also opted for the square (*Figure 2*) as the shape (205×240 mm). When selecting the format, an important aspect is to have an appropriate area distribution for the three-dimensional pop-up and other two-dimensional elements. The width of the page was influenced by the standard A4 and A3 paper sizes that were available for printing. To prevent folding edges from becoming damaged, the corresponding page pairs were printed together, and therefore the paper had to have 42 cm lateral length.



Figure 2: Cover page of the story book

3. Writing the story of the book

The next step of designing the book was in fact the creation of the story. We decided on writing a folk tale with a moral where the hero has to tackle a problem by fighting off various trials brought over him by a series of minor characters. When determining the length and parts of the story, it was considered that each pair of pages in the illustrated story book pictured a different scene, and the texts belonging to the individual scenes were relevant only in the given environments (Figure 3). The story was altogether 5712 characters long, while the texts belonging to the individual scenes made up 12000 characters on the average.

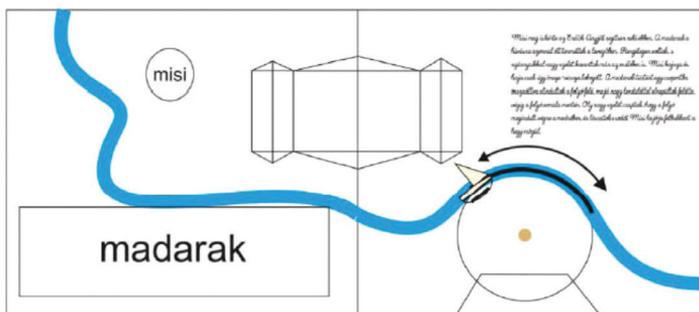


Figure 3: A pair of pages from the story book

4. Designing the graphic elements (backgrounds, characters, cut patterns)

A method of creating the images was freehand drawing, then digitalization and modification. The other method was pure digital drawing, where the drawings were made with computers, in a fully digital way. To create the images, we chose the method of digital drawing, because then the drawn lines, shapes, colours can be instantly changed. For vector graphics, we had CorelDRAW X6 and Adobe Illustrator, while for pixel graphics we could apply Adobe Photoshop CS6. We created drawings in both systems, but in Adobe Photoshop CS6 the colours could be manipulated more simply, and the images became better toned, refined. The CorelDRAW X6 program could rather be used to make the cut patterns by importing the characters, backgrounds created in the Photoshop program to this latter application in PDF format. To make the cut patterns, we outlined the pop-up elements with accurate dimensions, and then these shapes were filled with the appropriate image details taken from the shapes and forms drawn in Photoshop, with the use of an intelligent form filler.

The characters were first outlined manually, on wood-free paper, and then scanned. To colour, further shape the scanned images (with the use of the Photoshop CS6 program), simple brush and filler tools were used. The colours of the image were later modified until the appropriate tone was reached. The individual sets were modeled after “living” images. The “dummy” was photographed in preset postures, and then the images were opened in the Photoshop CS6 program, and the given position of the character traced in an empty layer in front of the actual image, with a brush.

5. Paper selection – Paper studies

An aim of the research was to select the most appropriate print carrier for the three-dimensional story book. The fundamental requirements in relation to the print carriers of pop-up books include good flexibility and appropriate thickness in view of the correct opening and operation of the pop-up elements. The lengthwise and crosswise directions were determined, further studies were conducted on the surface pH and smoothness of the paper (Table 3).

The total weight and saddle thickness of the story book could be calculated in the light of the properties of the selected papers and cardboards.

Table 3: Results of the measurements for weight per square meter and thickness

Sample number	Description of the print carrier	Nominal weight per square meter, g/sq m	Measured weight per square meter, g/sq m	Measured thickness, mm
1	Canon I	200	204	0.29
2	Canon II	250	254	0.29
3	Fine art paper	200	205	0.27
4	Wood-free drawing paper	170	172	0.2
5	Cardboard	1000	1018	1.45

Smoothness describes the unevenness of the surface of the paper. By measuring the smoothness, the wire side and top side of the paper can be defined. Smoothness is related to the surface brightness of the paper. When printing story books for kids, it is important to present colour images in lively, bright tones, and in our case it was feasible on the smoothest print carrier surface. The smoothness was studied with a Bekk air permeability tester, which is also suitable for measuring smoothness. On the basis of the test results, the smoothest paper was Canon II, with its wire and top side featuring 1.13 s and 1.20 s, respectively (Table 4).

Table 4: Smoothness values of the examined print carriers

Sample number	Description of the print carrier	Smoothness, s	
		wire side	top side
1	Canon I	1.50	1.54
2	Canon II	1.13	1.20
3	Fine art paper	0.78	0.85
4	Wood-free drawing paper	0.69	0.71

With respect to the selection of paper for our pop-up book, the determination of folding endurance was regarded as one of the most important paper test, because the largest single stress on the pop-up (three-dimensional) parts was folding. Folding endurance is the number of double folds that the test strip endures before the paper breaks. In crosswise direction, all the four papers had larger folding endurance values. The Canon I print carrier broke after 345 and 241 folding cycles in crosswise and lengthwise direction, respectively. In comparison with the values for the other print carriers, this paper proved to be the most suitable for making the foldout elements of the three-dimensional story book. In lengthwise direction, the measurement yielded smaller values for all the four papers, because in the lengthwise direction the filaments were parallel to the line of folding, and therefore they could be easily separated at the folding (Figure 5).

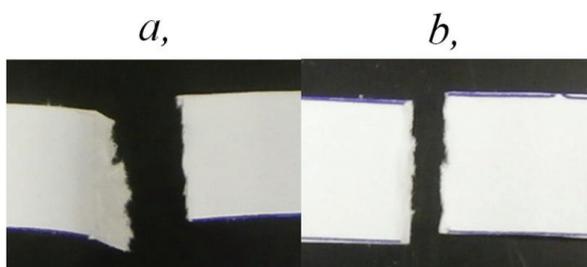


Figure 5: Breaking differences in the Canon I sample a, lengthwise, b, crosswise

6. Printing, modeling, binding operations

The elements of the book were printed with a Canon Imagepress C1 type digital printer. The making of the model containing the images and movable elements was supported by preliminary model. The pop-up structures were elaborated in page pairs, while proper care was taken of the segmentation of the text. For the preliminary model, the pairs of pages were cut out from A3 half wood-free paper (205×250 mm) (Figure 6). Thereafter, in a chronological order the three-dimensional elements were outlined, and the places for the texts were indicated on the pages.



Figure 6: Preparation of the preliminary model from half wood-free paper

The preliminary model was followed by the computer-made, illustrated cut pattern, and then the preparation of the model with the use of the ultimately selected base materials. To make the 3D elements of the cut patterns, a Kongsberg XE cutting table was used. With respect to their vulnerability, the edges of the cut plates were covered in edging tapes, and then the printed background elements were mounted on them. Before mounting, the pop-up and movable structures had to be assembled and pasted to the appropriate places, because the tabs of the fold-out elements were located under the cover sheets, and therefore they could not be attached

thereafter. With wide self-adhesive tapes, the pairs of pages were put together, and then the completed saddle was reinforced with a linen tape to make the story book more resistant to folding stresses.

7. Examination of the interactivity of the book, investigation of user demands

After making the model, the book was examined for its suitability for satisfying the demands of book users. In kindergartens, as well as the first and second grades of schools, the book was presented, while the opinions of children about the reception of the book were assessed with the use of checklists, their playing with the book and the impressions the book had on them were all examined. The kids involved in the survey were 4–8 years of age. The book was read out and shown, and the book was used for playing in groups of 4–5 kids (*Figure 7*).



Figure 7. Presentation of the book in groups of 4–5 kids

This assessment routine took 30–35 minutes. One of the members of the assessment team was in charge of the presentation of the book, and the led controlled game. The other member observed the group members, and recorded their reactions, responses in the checklists. In all these cases, the kindergarten and school teachers were acting in assistance with the kids.

The summary assessment was compiled from the checklists of 6 groups, recording the responses of altogether 27 children. It can be claimed that the large majority of children received the pop-up storybook gladly and very actively. No one refused to take it, though there were some introverted kids, as well.

Without exceptions, everyone wanted to play with the book, move whatever was movable. Moreover, they often preferred retelling the story – incorporated new variations from time to time. There were some kids who had already seen pop-up books, but all those who did not knew them wanted to have such books at home. The assessment highlighted the necessity of a few structural modifications. In the imagination of the kids, some of the moveable elements should have worked in other ways, as well. Sometimes, use with force caused structural damage to the books.

8. Experience, improvement opportunities

The currently available model is used to analyze and set the steps of the creation of the story book into a technological framework. By the presentation of the model, we could assess the final consumer demands. Still, to make a full-value story book (the product) out of the model, as suitable for printing reproduction, certain improvements are needed. The areas to be developed include the refinement of the cut patterns for illustration, the broadening of options for and the strengthening of the moving structures; technological renewal primarily in the field of manual binding procedures. For cutting, in order to diminish the volume of manual work, the use of a cutting plotter is recommended. For the pages a linear cutter, whereas for the 3D elements a plotter should be deployed. The materials we have used for binding the book – the wide, self-adhesive paper-based film joining the pages – may become frayed and disintegrated over time,

they are not suitable for long-term use, and therefore we are planning to apply linen instead. The assessment of the reception of the pop-up books by kids has shed light on a few other important aspects and potential directions for the development of these books.

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