Chapter 3

The Craft of Pop-ups

Chapter 2 presented an overview of crafts: their definition, tradition, and value as a children's activity, as well as a framework for the study of craft learning. Moving from this general discussion of crafts, it is time to introduce the craft of making pop-up books and cards.

This chapter is primarily concerned with the pop-up book. While many children make isolated pop-ups, or pop-up cards, it is the pop-up book that introduces most children to the genre and that provides the inspiration for the pop-ups that children make. It therefore presents a reasonable starting point for this exploration. Children (and adults as well) love pop-up books. With approximately 300 new books published each year, popular titles being produced in printings of up to half a million books, and books for adults joining the usual children's titles, most people in the United States are exposed to pop-ups as part of their culture:

> Today these books are finding wide popularity. They have transcended the borders of "children's books", being produced for adult markets as well as for younger readers. They have also attracted an enthusiastic following of collectors and of patrons for library special collections that have holdings of pop-up books.[114, p. 21]

The movement and transformation of the customary flat page to a three-dimensional object provides the excitement that these books hold for readers of every age:

> Give a child (or an adult for that matter) a pop-up book and you will immediately hear oohs, aahs, and curious cries of "How does that work?" A child's natural curiosity and wonder are clearly evident as he or she interacts with

> these books...Pop-up books are always a highlight for story time in the library, especially since many librarians choose not to circulate them because of wear and tear.[1, p. 25]

What is a pop-up? Technically, a pop-up is some subset of possible devices that occur in movable books. Movable books are those books with pages containing devices that can be moved separately from the page itself either manually by the reader, or automatically when the book is opened to the page. Movable books also include books that can themselves be transformed in unusual ways, for instance by being folded into a different shape.[1] Individual movable books may or may not include true pop-ups and many modern pop-up books also contain devices that are not strictly pop-ups. A true pop-up is self-opening, being lifted by the action of the book itself, and is truly three-dimensional. Both pop-up and non-pop-up movable devices are present in the pop-ups made by the children in the user tests, and will be discussed in the analysis of pop-up devices in Chapter 4. Pop-up devices were developed much later than other movable book devices. Therefore, it is useful to understand how pop-ups differ from other movable devices, and how they developed from them.

This chapter begins by describing what pop-ups are, and how they came to assume their present form, through the evolution of movable books. It next explores the making of pop-ups as a representative craft for computational enhancement by situating the craft within the framework of knowledge, skills and appreciation described in Chapter 2. It concludes with an exploration of the value of creating pop-ups as a children's activity and provides a sampling of teacher accounts as illustration.

[1] Movable books are also called *movables*, *toy books* or *action books* and can also be placed in the general category of *novelty books*. Those movable books with only flaps for the reader to lift are also called *flap books*. Movable books can be called pop-up books even when they contain movable devices that are not true pop-ups, since modern books often contain a mix of movable devices. This work will use the terms *movable books* for books containing no true pop-up devices and *pop-up books* for those containing any true pop-up devices, even if mixed with movable non-popup devices.

3.1 A Brief History of Movable Books

A valuable way to introduce and define the pop-up and to distinguish it from other movable book devices is to look at the history of movable books. In addition, to appreciate the structure, craft, and uses of pop-ups, it is useful to examine the history of the movable book and how its craft tradition grew and changed over time. This exploration of the history of the craft will also consider the present design and manufacture of pop-up books, as it is in many ways still a craft since all pop-up books, even though printed on automated presses, are largely designed and assembled by hand.

The discussion in this section is based largely on materials in three areas. First, Hunt [54] and Darton [22] provide excellent general overviews of the history of children's books. Second, the development of the movable book before the advent of pop-ups is described and beautifully illustrated by Haining [42]. Finally, three general works on movable books and particularly on pop-ups are provided by Hiner [51], Montanaro [79], and Rubin [94].

The history of the development of movable books is centered on two qualities: movement and three-dimensionality. The non-movable book page is static and 2-dimensional. Movement creates animation of illustrations, as well as the presentation of alternatives: results of a calculation or display of additional data or pictures. For instance, anatomy books can use an overlapping flap arrangement to show the layering of parts of the body and the structures that lie underneath the currently displayed picture, adding depth to the illustration. It was a natural step to extend this motion and depth to picture books for children who appreciate the surprise of a moving, complex page.

This history of movable books is organized by the types of movable design devices that have been used. These devices represent particular ways of fabricating the paper to produce a desired effect, for instance to put certain parts of a picture behind others or introduce some movement to the page. The order in which devices are presented here is roughly chronological. Once a particular design device was used, of course, it continued in use for some time and might be

reused in conjunction with other, newer devices. During most of this history the movable book was a product of Europe, particularly England and Germany, and later of the United States, and this chapter will concentrate on these countries.

Pop-up books are often thought of as being intermediate between children's books and toys. The precursors of the earliest children's movable books were adult movable books. However, many current pop-up books are created with adults as their intended audience, this previous trend from adult books to children's books is now reversing, and many movable books, including pop-up books, are now being produced once more for adults. But from about 1820, and until very recently, movable books were produced almost entirely for children.

The children's movable book shares both publishers and audience with other children's books, especially those conceived for children's entertainment, and the history of children's literature, publishing of books for children, and movable books is closely intertwined. For instance, movable books for children increased greatly in numbers and formats after about 1850, coinciding with the more general explosion of children's books that appeared around that time. (Hans Christian Andersen's fairy tales appeared in English for the first time in 1846 and *Alice in Wonderland* was published in 1855.) The first golden age of children's movable books started around the last decade of the 1800s (a time of the flowering of children's books of every type) and ended in 1914 with the start of World War I when not just movable books, but the production of all children's books, declined due to paper shortages and the focus of manufacturing capacity on the war effort.

There are several factors that must be considered when discussing the history of movable books. First, children's books in general, aside from books for reading instruction or religious use, are a relatively modern idea. In earlier years (before the late 18th century) it was assumed that children should be engaged only in useful pursuits and that did not include reading books for entertainment. The books available to children then were ABCs, often containing some religious texts, and primers, perhaps containing Aesop's Fables, the most entertaining literature available to them. There were hornbooks, wooden paddles with a single page glued to the paddle and a layer of thin, transparent horn protecting the page. These were the equivalent of the cloth or

board books that are given to children today. The page of the hornbook would have the alphabet and a few religious texts, usually including the Lord's Prayer, printed on it. The hornbook was replaced by the battledore. This was a simple piece of folded cardboard with similar contents, and was often illustrated. There were also a small number of primers and school-books, often readers, spelling books, and Latin grammars. Children in those days went from primers directly to adult reading:

> ...how did children learn to read? The experiences of Adam Martindale, a Lancashire yeoman born in 1623, were probably the same as generations of children before his time and after. His godmother gave him an ABC when he was nearly 6, 'a gift in itself exceeding small and contemptible, but in respect of the designe and event, worth more than its weight in gold'. With the help of older siblings, and 'a young man that came to court my sister', he quickly mastered it, 'and the primmer also after it. Then of mine owne accord I fell to reading the Bible and any other English booke.' [54, p. 3]

It seems amazing to us, with the variety of children's books presently available, that there were no children's books for entertainment. Any entertainment from stories came from oral storytelling. Yet children still learned to read, and to enjoy reading, and were expected to do so. Much of the reason for this was due to religion, and to the concept of childhood prevalent at the time. Children were expected to learn to read the Bible for themselves, with England and its colonies being at the time Protestant. So while a child needed to read to understand the Bible, reading for entertainment was considered a waste of time as was, in fact, most play. Work was considered the proper way for children to occupy their time as soon as they were able. A child's mind was considered a *tabula rasa*, a blank slate, on which anything might be written. Therefore, a child's experiences were very important in fixing his character. However, the doctrine of original sin was also held; a child naturally tended to vice rather than virtue. It was obvious that a child had to be carefully led to virtue, and that any pernicious influence could easily take hold of him. Therefore, he had to be protected from vain pursuits, such as reading fiction, that is untrue, a lie, and therefore by definition sinful:

> Education...was less necessary than decency: and decency did not include

> reading for pleasure...The objection to light reading as a recreation was that it led to idleness and to false beliefs: that it was harmful as well as a waste of time. [22, pp. 42–43]

Another factor that discouraged light reading material was the high children's mortality rate. Educating children in virtue to prepare them for an early death was considered of vital importance; there was little time to waste.

These views of childhood, the empty slate, a leaning toward vice and the necessity of instilling virtue for rapidly approaching death, were only slowly overcome. They influenced children's literature heavily until the mid 19th century, and are still with us today in imprecations against comic books, popular music, and video games.

Even after the rise of children's books for amusement, the production of movable books for children was slowed by the fact that many movable devices require durable materials, meaning good quality paper. This is particularly true for the devices, such as pull-tabs, that must work without binding and have hidden mechanisms that cannot be mended easily once the book is assembled. As any parent knows, even modern pop-up books can be fragile. In addition, the manufacture of movable books was limited by the state of book illustration in general. Methods of producing clear line and bright color, while keeping the price of the book within the means of a family, were only gradually developed. Finally, those means and the ability to buy children's books were influenced by economic factors and in particular by the rise of an economically stable middle class.

3.1.1 The First Mechanisms (pre-1700): Wheels and Flaps

Since few books were made for children before the late 18th century, the earliest movable books were obviously made for adults and, with the scarcity of fiction, were non-fiction books. It is interesting to note that movable books predate printing. Two mechanisms were used in manuscripts: volvelles (wheels) and flaps. Both volvelles and flaps found their way from manuscripts into printed books soon after the introduction of printing, by 1476 in the case of

volvelles [103]. As is often the case with manuscripts and early printed books, use and time have destroyed or damaged a large number of examples, and it is likely that we have lost many early movable books, as movable books are even more susceptible to such damage than other types of books. Pages often survive only as *fugitive sheets*, or sheets that have been separated from the original book.

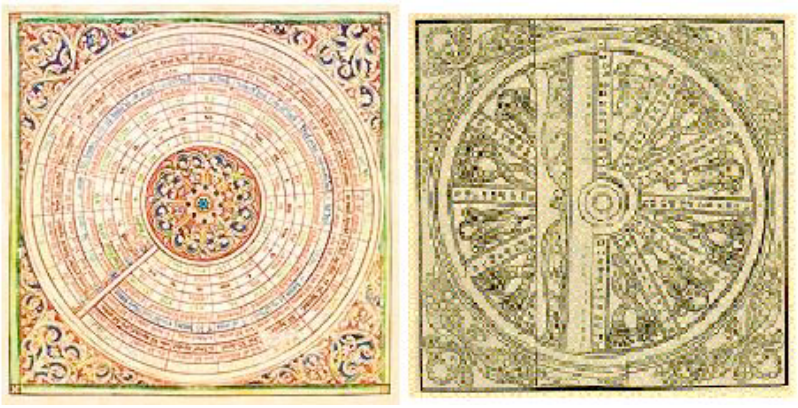

Figure 3.1: Various volvelles. On the left is a reproduction of a manuscript volvelle by Matthew Paris, used for calculating the dates of holidays. Photo courtesy Robert Sabuda [101]. On the right is a printed volvelle designed by Gabriel de Collange, in *Polygraphique et Vniverselle Escriture Cabalistique* by Johannes Trithemius, an edition of 1561. Photo courtesy Washington University of St. Louis Libraries [125].

The first movable mechanism used in manuscripts was the volvelle (from the French, meaning *to turn*) or wheel. Attached through its center to the page with a knotted linen string or a rivet, the volvelle could rotate independent of the page. There could be one or many wheels, each of which turned independently, and that could be lined up with each other and with marks on the page. The volvelle could also be a moving pointer instead of a full wheel.

Volvelles are particularly useful for doing calculations or presenting dense information in a compact form. For calendars or other tabular data, it is often easier to read a table by rotating a wheel than by following a row or column. Volvelles are used for computation by using nested wheels and quite complicated operations, such as astronomical calculations, can be performed

in this manner.[2] Another common use of volvelles was cryptography. On the right in Figure 3.1 is an example of a French volvelle used to read and write ciphers. Volvelles can provide rotating architectural diagrams that allow views from several angles [99]. Wheels were even used in fortune-telling books and the *Looßbuch* by Paul Pambst (1546) used both wheels and dice for this purpose [103].

There are three notable names in the history of volvelles. The first was Matthew Paris (1236-1253), a Benedictine monk. He was the author of the first known movable manuscript, *Chronica Majorca*, that used a volvelle to calculate the dates of holidays. It was common at that time to have tables of holidays in circular form, but so far as we know Paris was the first to realize that it was easier to turn a paper circle on the book than to turn the heavy book itself. A reproduction of this volvelle is shown on the left in Figure 3.1 [94, 101]

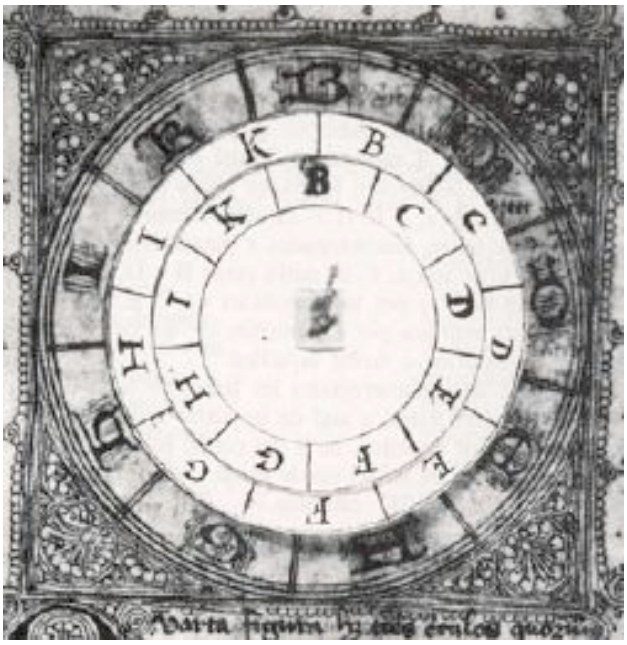

Figure 3.2: Lullian Circle. A figure from *Ars Brevis*, a work by Ramon Llull in manuscript form. This volvelle allows the reader to find all three-letter combinations of nine letters. Photo courtesy Centre de documentaciò Ramon Llull [16].

[2] The ultimate calculation volvelle is the circular slide rule. Although more accurate than a straight slide rule, as a long rule can be curved into a smaller space, it was never as popular as it did not fit into a shirt pocket.

The second important name in early volvelles was Ramon Llull, also known as Ramond Lully (c.1232-1315), a theologian and philosopher. His volvelles are sometimes referred to as Lullian circles and were used to illustrate his ideas about the *Ars Magna* (*Great Art*).

> ...a complex system, using semi-mechanical techniques combined with symbolic notation and combinatory diagrams, which was to be the basis of his apologetics in addition to being applicable to all fields of knowledge. [68, p. 1]

His desire was to encompass all knowledge in a single machine, with which one could prove or disprove any assertion (particularly in the area of theology.) In actual fact, his use of wheels was a system of combinatorics. For example, in one of his volvelles (Figure 3.2), two rotating wheels were positioned within a non-rotating circle. Each wheel, and the circle at the rim, was divided into nine areas, each labeled with a letter. The outer rim remained stationary, and all three-letter combinations could be produced by rotating the inner wheels that move independently.

> When properly used, the triple layer of combinations of nine letters–which, as in the Cabala, signified the names of God–answered questions about all creation and even the future, as well as inquiries intended to settle religious disputes. [103, p. 1]

Finally, Petrus Apianus or Peter Apian (born Peter Bienowitz), a German humanist, produced *Cosmographica Liber* in 1524. This best-selling book was translated from the original Latin into several languages, was produced in 47 editions, and was reworked and reissued by at least one later author, Gemma Frisius. Covering cartography and geography with maps of the world, and in later editions incorporating a surveyor's handbook, it contained volvelles allowing astronomical calculations. Large, beautifully colored copies as well as small, easy to carry editions made it available to, and usable by, not only the rich, but the student and the sailor as well [118, 101]. Apian also wrote another book on astronomy, *Astronomicon Caesareum*, using volvelles as well, in which he was the first to note that the tails of comets pointed away from the sun. Figure 3.3 shows volvelles from both of these works.

Figure 3.3: Volvelles in books by Peter Apian. On the left, a volvelle from *Astronomicon Caesareum* published in 1540. Image courtesy of Swiss Federal Institute of Technology Library [112]. On the right, a calendar volvelle from *Cosmographica Liber*, the 1545 edition. Image courtesy of the Museum of the History of Science, University of Oxford [82]

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Flaps were probably introduced to manuscripts after volvelles, at least the surviving examples appear later. Flaps are made by adding an additional piece of paper to the book, either by gluing it over the sheet, or folding the sheet to provide extra layers and cutting away the upper layers to allow the reader to open the flap to expose the lower layers. The flap can be lifted to see underneath it, and then replaced. The flap was the first attempt to add three-dimensional illustration to books and was the beginning of attempts over the next four centuries or so to give book illustrations more depth. In addition, flaps allow for movement of sorts by providing a way for an illustration or text to be changed by lifting the flap.

The flap was used to greatest effect in anatomical books to allow layers of the illustration to be peeled away. An example can be seen in Figure 3.4. In many cases, the anatomical drawings were a “do it yourself” activity:

Figure 3.4: Examples of Flaps. On the left is an anatomical plate with movable flaps from *Ristretto Anotomico*, 1790, by Daniel Ricco, photo courtesy of the Library of Congress [67]. On the right, a later revision of *Beginning and Progress of Man* adapted for children and renamed *Metamorphosis, or, A transformation of pictures, with poetical explanations, for the amusement of young persons*, printed in 1814 in America, photo courtesy of the University of Delaware Libraries [120].

> From 1538 onwards it is possible to trace a whole series of so-called anatomical fugitive sheets, depicting the parts of the body on a single sheet, or, often, as a pair of sheets, one male, one female. Sometime these were provided with the organs of the body arranged down the side of the sheet, so that they could be cut out and then stuck down (not always, alas, in the correct order) on a card beneath the figure. By lifting up the flap representing the trunk, one could then see how the internal organs of the body lay in relation to one another. They were often accompanied by a text describing the particular parts of the body. [83]

Some anatomical flap figures could be quite complex, such as:

> ...the famous Georg Bartisch *Augendienst* text on optometry printed in Dresden in 1583, in which the viewer can dissect an eyeball into five flaps, and then lift five more layers of a skull to view the optic nerves from above. [102, p. 12]

Other uses for flaps took advantage of their transformative, rather than their layering, prop-

erties. For instance in 1654, Benjamin Sand's *Beginning and Progress of Man* used a half-page flap to create a changeable picture. The illustrations taking up half of the page could be changed by covering or uncovering them with the flap [63]. The popularity of this book can be seen in the number of reprints including one adapted for children 160 years later and shown in Figure 3.4. Religious pamphlets used flaps to show the transformation of the Pope into a Devil, for the edification of Protestants. More prurient uses of a flap were quickly discovered and included such items as:

> ...a late 18th century watercolor of a lady, equipped with both another liftable skirt and considerable anatomical correctness. Liftable-skirt engravings were extremely popular in the late 16th century from the north to the south: one stereotypical Venetian courtesan found immense fame through the guise of ambiguously gendered undergarments and ludicrously tall shoes. [102, p. 12]

In addition to flaps and volvelles, some other forms that could be cut out and assembled from the pages of the book were developed in the Renaissance, such as games and astronomical instruments. Sundials were popular and were often meant to be cut out and pasted onto a wooden block.

> Peter Apian included sheets for this purpose in several of his books, but like toys today, they often came "batteries not included." While the sun powered the dial, it was missing components such as compasses to orient the dial for the correct time, and tiny pointers, or *gnomons* to catch the sun's shadow. Printed sundials and other paper instruments were also sold singly... [102, pp. 12–13]

But these were adult novelties and children's movable books had yet to be produced, largely because children's publishers did not yet exist. It was only in the 1700s that factors were right for the development of a separate children's literature.

3.1.2 The First Movable Books for Children (1700-1820): Harlequinades and Toilet Books

The idea of the children's book that entertains was born in the last half of the 18th century. Before that time, children read what adults read, with the exception of school texts or hornbooks for beginners. By 1820, there was a small body of what we would consider entertaining children's literature, influenced by the desire to guide children in the ways of rectitude–although that purpose was beginning to serve as a gloss to overcome the hesitancy of parents to allow their children pleasurable reading. Three primary changes led to the introduction of more playful children's books: the rise of the middle-class child, changes in adult views of childhood, and a flood of new stories arising in this period.

First, there were more children, and even more important, more children whose parents could afford to educate them. Families were large and life for the middle class child was much less apt to be cut short by disease. Jenner's first use of smallpox vaccination occurred in 1796, and medical advances were to continue through the 19th century. Better food was more generally available, leading to better nutritional health. With the rise of the British Empire, England had enough people who were well-off enough to give their children toys and books.[3] Publishers were happy to fill this demand, and did well for themselves by doing so. They were helped by changes in the law that eliminated censorship and established copyright.

Second, there were changes in the way children were viewed in society that allowed parents to think that giving children more toys and books was a good idea. Puritanism, with its belief that life was simply preparation for death, was weakened by the general prosperity. The rise of Romanticism promoted the view that the child was closer to nature than the adult, and since the child was so newly come from heaven, closer to God. The view of the child as naturally evil began to be replaced with the view of the child as innocent; children were seen as possessing a natural

[3] Poverty was horrendous at the time and throughout the Victorian period following, as any Dickens reader knows. But the fact that there were so many poor children, whose lives were nasty, brutish and bookless, does not preclude the rise of a middle class that was larger than ever before.

simplicity, and what would culminate in the Victorian sentimentality toward children began to develop. In addition, children were allowed to be children longer. School years were extended for middle-class children, and the child who might have been placed in apprenticeship at the age of seven instead went to a village school or academy, and possibly on to college. In addition, there began to be a realization that children had different needs based on age, for instance the perception that a teenager was neither an adult nor child, but something else. Not coincidentally, the early 18th century saw the rise of the child-care manual, in which appropriate ages for various activities were defined for the first time [54].

Finally, there were new stories that began to enter the market, both from the oral tradition and from adult books. In both Europe and America, a large body of potential children's literature had existed in oral form. When this was put into print, it produced a flood of stories. Mother Goose, a compendium of rhymes from "barrack room and alehouse songs, bawdy ballads and ribald love songs, political squibs, stage plays, street cries, ancient rituals, proverbs, riddles" [54, p. 63] became wildly popular in a variety of forms in the late 1700's. The fairy tale began to be published for children at about the same time. The tales of Charles Perrault, a French author, for instance, had been on the market since 1697, but in 1772 "were issued simply for children's delight, without the French alongside the English to serve as a token lesson book" [54, p. 71] and subsequently were reprinted in a multitude of editions. The most enduring of those stories were Cinderella, Little Red Riding Hood, and Sleeping Beauty, and are still loved by children, now in Disney productions. Other fairy stories followed, often to condemnation by the moralists, who saw them as dangerous for the young mind. But the young mind loved them, and doting parents bought them.

In addition, it must be remembered that novels for adults were a new development at that time as well, and that some of these novels were able to make the transition to a child's library. In particular, two publications intended for adults in the early part of the 18th century, *Robinson Crusoe* (1719) and *Gulliver's Travels* (1726), became staples of children's reading and were quickly adapted in an easier form for young children. "The novel-reading habit reached the

nursery almost before grown-ups had acquired it."[42, p. 8]

For most youngsters in England, the medium for these adaptations, fairy tales, and children's literature in general was the chapbook. Starting from about the mid-17th century, the chapbook was the mass market paperback of the time. Inexpensive, produced in large numbers, and appealing to children since they contained illustrations, chapbooks could be purchased from peddlers in any part of the country. They were so widely distributed that in the early 19th century, one publisher "was reputed to be able to sell two and a half million copies of *Of Rush's Murder*."[54, pp. 40–41] Made from cheap, durable cardboard, usually with 16 pages and often costing a mere halfpenny (about 50 cents in present United States currency), chapbooks recounted for adults the latest murder or hanging and were popular literature. Chapbook publishers realized the potential children's market early and began printing ABC books alongside adult titles when the format first arose, and they soon became the vehicle for fairy tales, nursery rhymes and historical romances.

This market for children's books made openings for publishers operating at the upper end of the price scale as well. John Newbery, the first publisher to produce children's books exclusively, opened for business in about 1744. Newbery recognized the profit to be made from children's books and developed ways of marketing that are still being used, such as aggressive advertising and including small toys with book purchases. His books were of far better quality in both printing and binding than the chapbooks, and appealed to children with their use of higher quality illustrations and brightly colored end-papers.

Even with the rise in popularity of children's books, it took some time for movable books to become important in the children's market. Movable devices are a form of illustration, and the state of illustration was still quite crude around 1800. The modern world takes high quality color printing in children's books for granted, but the necessary technology was not invented until the last part of the 19th century. Woodblock printing, that lacked the ability to render fine detail, was the rule for most books for children during the 18th century, although copperplate was sometimes employed for more expensive volumes. [4] Since they were expensive to produce,

[4] Both woodblocks and copperplates were hand-engraved and therefore labor-intensive. Copper gave a finer line,

illustrations were often reused. For instance, if a publisher happened to have a woodblock of a dog, it might be inserted at any point in any book in which a dog was mentioned, or a wolf, or for random use of space even if no dog was written about at all. A giant move forward in illustration quality came when lithography was invented in 1798. Lithography could produce much finer lines and detail and was used increasingly throughout the 19th century, although not completely replacing wood blocks and copperplate until the 20th century. These advances in producing fine illustrations were still limited to a single ink color, usually black. All coloring was done by hand. Around 1800:

> The colour was put on by droves of children working together; so many put on the red patch, so many the blue, and the prints were passed on thus till the final gay thing was completed. Most of the colour-work thus done was not comparable in finish or delicacy with the very similar hand-colored aquatints of a few years later. But it was surprisingly good in the better-class volumes, and the method continued long in use; my father saw it being employed by his father–that is, about 1855-60. [22, p. 202]

Hand-coloring had one major advantage: books were sold both with and without color and un-colored books were considerably cheaper, allowing a wider range of families to purchase them.

This period from 1700 to 1820 saw little in the advance of actual paper engineering. Wheels and flaps were still the only devices used. The primary development during this time was the migration of movable books into the hands of children in the form of the *harlequinade*. *Beginning and Progress of Man* had used a half-page flap and the harlequinade was an extension of that form. Introduced in about 1765 by Robert Sayer in England, the book's paper was doubled, and cuts were made both horizontally and vertically across the page through the upper layer. This produced a picture that could be viewed with any of the four flaps down or up. The text told the reader which flap to lift to reveal the next portion of the text and the accompanying altered illustration. Figure 3.5 shows one of these original books. These ingenious books are also called *turn-ups* or, in the United States, *metamorphoses*. The name harlequinade comes from

but the material was so much more expensive that, even given that the copper was reusable and less prone to wear, it could not be used for chapbooks. The woodblocks used for chapbooks were often done quickly by less skilled artists and used until well-worn as well.

the fact that the earliest examples featured a hero called Harlequin. (Harlequin was a common theater character of the time, and Sayer was a publisher of theatrical prints. Harlequinades were sometimes based on the plot of the latest play.) Early examples are extremely rare, as they were printed on poor-quality paper. While harlequinades were the first movable books published for children, many were aimed at adults as well. The making of harlequinades was a popular family activity, one of the few instances in history where movable bookmaking is mentioned as an activity in which children participated. The flaps are easy to make, so the paper engineering is easy. The trick is to make a picture in parts that create the desired effect for the story. Some of these handmade pages still exist [54].

Figure 3.5: An example of a harliquinade *Queen Mab or The Tricks of Harlequin, #6* by Robert Sayer, and published in 1771. Photo courtesy Ellen G.K. Rubin [94].

Harlequinades are a good example of the use of flaps to produce motion:

> Because the figure (usually Harlequin) lies over the break lifting the flaps creates an impression of a transformation being effected. The figure of Harlequin becomes animated, as in later cartoon illustration. The careful overlaying and underlaying of the figures in dramatic poses may suggest motion. [91, p. 9]

Harlequinades have never died out. They were still being produced in their original form

throughout the 1800's and survive today in the lift-the-flap books that are very popular with pre-school children. They have the advantages of being easily manipulated by little fingers, inexpensive to produce, and harder to damage than the more complex pop-up books. Harlequinades also survive in the *mix and match* books that allow children to pick parts of several characters and create a new picture by taking, for example, heads, bodies, and feet from the split images [107].

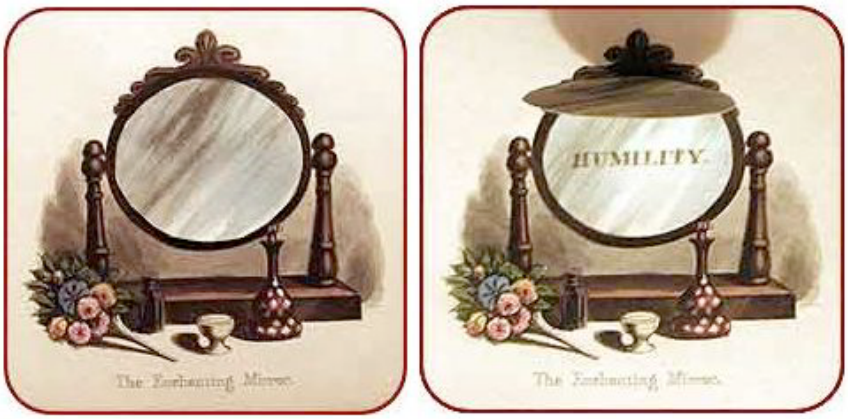

Figure 3.6: An example of a page from Grimaldi's toilet book, showing the operation of the flap. This is a later printing, from around 1840. Photo courtesy Philadelphia Rare Books and Manuscripts Company [88].

Movable devices also began finding their way into use in traditional book types. One popular non-movable early book form for children was the *emblem book*. In the emblem book, an animal or artifact was shown as a symbol for some moral quality. For instance, the bee might be pictured as an emblem of hard work, along with a suitable verse. The original book of this type was John Bunyan's *Divine Emblems, or Temporal Things Spiritualized* [22].

By adding flaps to an emblem book, the reader could change an illustration of the emblem into a picture or text of the virtue being illustrated. This created the first movable book to rise to "best seller" status, *The Toilet*, published by Grimaldi in the 1820's. Inspired by toilet items on a dressing table, this book extracted moral lessons from each item, with an accompanying illustration that, by lifting the flap containing it, changed the picture from the toilet item to an illustration of a virtue [42]. Figure 3.6 shows a page from a later reprint of the book, that used

text instead of the illustration of the virtue. (That the reprint was made 20 years after the original was published indicates the lasting popularity of the toilet book.)

3.1.3 Early 3-Dimensional Effects (1820-1850): Slots, Panoramas, and Peep-shows

Flaps were a beginning attempt to provide motion and depth in book illustration, and to merge toys and books for children by providing ways in which books could be manipulated to produce new effects. These were followed by several other early types of movable devices in children's books as well, that combined books with toys.

Paper doll books are one early example. These were developed around 1810. These books are still popular today but did not begin life as the "cut out a costume and place it on a doll" form currently found. Rather they consisted of either a series of scenes with the costume and a hole for the head, through which a head on the last page could be viewed, or a paper head that could be placed in a slot on a page that contained a costume and a scene. About 1830 these gave rise to the popular *slot books*. These took the form of paper figures that could be placed in a scene by putting them in slots cut in the page.

Figure 3.7: An example of a panorama book: a reproduction of Lothar Meggendorfer's 1887 *International Circus* [73]. For a closer view of one panel, see Figure 3.10.

While flaps, volvelles, and slots are devices that make a book movable or changeable, there are other kinds of movable books in which the form of the book itself can be changed. A few

examples developed during the early 19th century and still being produced will demonstrate the concept: panoramas, peep shows, and carousel books.

Figure 3.8: A modern example of a handmade carousel book *New York Dreams* by the artist Andrea Dezsö. Both the opening and the opened book are shown. Photo courtesy of the artist [25].

The *panorama* is a book that, rather than having the usual form of a cover and pages, can be unfolded into a long zig-zag form that can be many feet long. This actually an old form, re-invented for children. This form is ideal for telling stories that have long scenes that would not fit into a regular book, a battle-scene or a train for instance. The example in Figure 3.7 is a circus, and the panorama format allows the entire circus to be spread out at once. Panoramas sometimes employed slots and paper dolls that could be put in the slots. In this way an entire house of paper dolls could be moved about, or a set of cats dressed as people could be rearranged on the pages [45].

The form of the *carousel book* (sometimes called a *star book*) allows the book to be folded back on itself, creating a star-like shape. This is also a method for producing three-dimensional effects, since the heavy cardboard pages can have multiple shorter pages between them. These

books are sometimes made without the shorter pages, and fold into the form of a building for use with paper dolls.

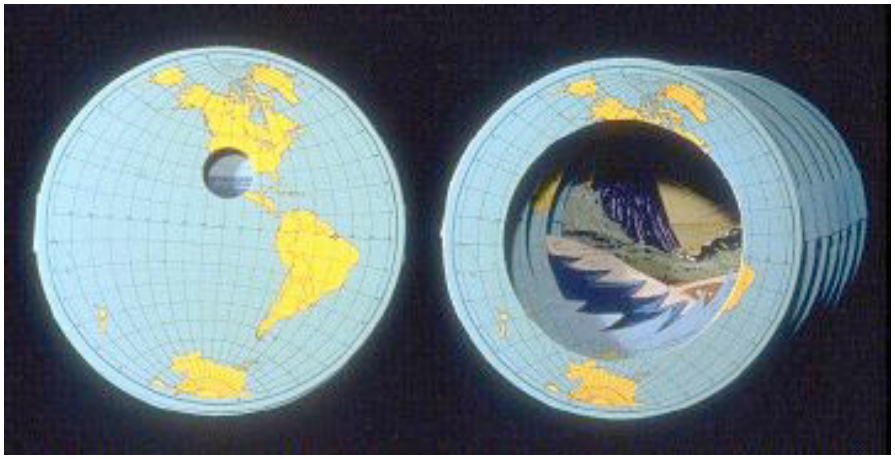

Figure 3.9: A modern example of a tunnel book, *Tunnel Map* by the artist Carol Barton showing both the outside of the book with the peep-hole, and the inside construction. This is an unusual circular form of the book type. Photo courtesy of Colophon Pages [19].

Still another type of 3-dimensional effect can be produced from an accordion-like method of attaching pages called a *peep-show*, also commonly known as a *tunnel book*. (Carousel books are sometimes called peep-shows as well, leading to confusion.) Each layer of the scene is attached to one of the folds, and a hole in the cover allows the scene to be viewed at the correct angle (see Figure 3.9). This book form grew out of the peep-shows that were a part of traveling carnivals:

> These were often quite elaborate constructions which depicted scenes from famous stories or legends or topical events, which it was hoped would appeal to provincial or rural populations. The showmen sometimes made the cardboard scenes and figures themselves, changed the tableaux to those which they thought would attract the biggest crowds, and then charged inquisitive patrons a penny or so to stare in at the scene through the peep-hole. [42, p. 22]

In the book form of a peep-show, the viewer looks at the scene through a hole in the cover (see Figure 3.9). Peep-shows can also be used as part of a page within a book, and pulled out for the full effect. The illusion of depth in a peep-show can be quite dramatic.

3.1.4 The Golden Age of Movable Books (1850-1914): Tabs, Scenes, and Transformations

A look at the books for (or read by, at any rate) children between 1850 and World War I reveals the amazing burst of creativity of the period: *Moby Dick* (1851), *Hiawatha* (1855), *Tom Brown's Schooldays* (1857), *The Water Babies* (1863), *Alice's Adventures in Wonderland* and *Hans Brinker; or, The Silver Skates* (1865), *Little Women* (1868), *The Adventures of Tom Sawyer* (1876), *Uncle Remus* (1880), *Treasure Island* (1883), *Heidi* (1884), *King Solomon's Mines* (1885), *The Blue Fairy Book* (1889), *Pinocchio* (1891), *The Jungle Book* (1894), *The Wonderful Wizard of Oz* (1900), *The Tale of Peter Rabbit* (1902), *Peter Pan* (1904), *The Wind in the Willows* (1908), *The Secret Garden* (1911), and *Tarzan of the Apes* (1914) [54]. As publishers and authors found they could make a living from children's books, the status of children's book authors in society was elevated, and the trade exploded. Most important:

> Fiction was now by a long way predominant over fact, magic was not rebuked but at large, nonsense was free. Children could go back to the enchantments of the Middle Ages without being told that they were really the work of the Devil; to Aesop and traveller's tales with the knowledge that such fables were not true but were thoroughly worthy of belief and love; to folk-lore with open rapture in the rogueries of the Booted Cat and the decapitation of ogres, without any warnings about superstition or ignorance or unreality; to fun, without being told not to be silly. [22, p. 290]

Attitudes were right for books that were pure fun, and movable books could supply that. Paper engineering had started to develop; children's movable books included paper doll books, books containing flaps (such as harlequinades), and books that were not in the standard format: panoramas for instance.

The next developments required for the advancement of movable books were enhanced printing techniques (including color printing) and good quality paper. Most movable books (if made in quantity) have to be printed well and carefully manufactured in order to allow more complex mechanisms to function correctly. Proper registration in printing is vital in order to allow two-sided printing, and die-cutting is valuable to keep hand-labor to a minimum. Color is

important for movable books as well, since with more life-like illustrations, animation and depth are shown at their best. For movable books, the paper must stand up to rough treatment. Some devices also require paper that is smooth enough to move easily when pieces connect or rub against each other, and stiff enough to stay straight when force is applied to create the motion. For more than the simplest movable devices, therefore, the manufacturing process is of great importance. These prerequisites were finally met in the Victorian era.

As in so many other areas, the industrial revolution drove changes in printing toward automation and powered machines:

> ...changes to books and book production took place at a rapid clip. Major innovations were introduced in every facet of the printing operation: typecasting, composition, inking, impression, and binding. By the end of the [19th] century, a web of integrated machines was producing books and other printed materials at rates that would have been unimaginable in the days of hand-composition and impression. [52, pp. 113–114]

This increase in the quantity of books produced was accompanied by a similar increase in the quality of the product. The development of lithography by Alois Senefelder in Germany in 1798 allowed better reproduction of images, and color lithography followed closely thereafter. Germany became the printing capital of Europe and much of the production of movable books shifted to Germany until World War I.

New advances in paper engineering began around 1855 [42], as publishers looked for new forms to capture children's attention, and the period between 1880 to 1915 is commonly called the Golden Age of Movable Books [94]. Because the technological advances had come in the form of printing techniques, color, and paper, the golden age was led primarily by publishers, although one artist stood out as an exception. The publishers were Dean & Sons, Raphael Tuck, and Ernest Nister; the artist was Lothar Meggendorfer of Germany, who was the first true paper engineer.

Dean & Sons of London was founded in the 18th century, began publishing movable books in the 1840's, and became one of the premiere producers of these books, publishing as many as 50 titles between 1860 and 1900, and having a special department in charge of this part of their

operation.

Also located in London was the publishing firm of Raphael Tuck (and later his sons). Tuck was born in Germany, but left for political reasons and moved to London where his books were designed although his printing was still done in Germany. His company produced movable books from about 1870 until 1952. Almost 100 movable books were published by Raphael Tuck & Sons during that time, about 30 of which were panoramas, of which they were the major producers [78].

The third publisher, Ernest Nister, was the son of a pastor. Being a businessman, he purchased a small Nuremberg printing shop in 1877:

> At the time of his sudden death on 26 May 1909, he was able to leave to his son of the same name, a firm which employed some 600 people. This printing business was capable of producing work by all the major processes of the time...[63, p. 73]

His firm published anything printable including cards, calendars, books, and hundreds of movable books, for the English, American, and German markets. Although he ran a large business, he helped design some of the movable books he produced.

The exception to publisher driven advancement was Munich artist Lothar Meggendorfer (1847-1925). His work was ingenious, comedic, and, above all, different from that produced by the large publishers. While the movable artists employed by publishers made standard Victorian scenes of children playing or illustrated the usual fairy tales, Meggendorfer created funny characters like the Dancing Master (Figure 3.12), an angler who catches a fish too big to pull in, or an ugly woman looking into a mirror. Meggendorfer is still revered in paper engineering circles, and the annual prize of the Movable Book Society is named the Meggendorfer prize in his honor.

The first important new movable book device to be created during this period was the *scenic*, sometimes called a *lift-up*. Figures and scenes are arranged in overlapping layers and can be pulled out to separate them in space to produce a three-dimensional effect, a peep-show book without the peep-hole and surround (see Figure 3.10.) All of the major publishers had their own

Figure 3.10: An example of two scenic books with different methods of opening the scene. On the left, *The International Circus* by Lothar Meggendorfer [73]. The entire book is a panorama (see Figure 3.7), and each panel is a scenic, opened by the reader. On the right is a Dean & Sons scenic from *Aladdin and his Wonderful Lamp*, in which the scene is opened by pulling a ribbon. Photo courtesy of Robert Sabuda [100].

versions of these scenic books, often distinguished only by the method of pulling the layers apart. Dean & Sons incorporated a ribbon to pull the layers, while in Tuck's scenics they were pulled apart by hand. Nister's were the most technically interesting, as they were attached to the facing page by a tab, and opened automatically as the page was opened, anticipating true pop-ups.

While scenic books anticipated the depth of pop-ups, there were also advances in producing motion as well. One of these was the *transformation*, the second significant new device in movable books first produced in 1860 by Dean & Sons. Transformations are illustrations that change from one picture into another. To produce this effect, two pictures are fitted together so that rotation or sliding of the picture sections can cover one and reveal the other. This can be done in several ways. In one, the first picture is cut on the diagonal through the center and the two pieces slide away into the corners to reveal the second picture underneath. Another features a dissolving picture in which the two pictures overlap each other in either vertical or horizontal

Figure 3.11: An example of a transformation; the summer scene turns to winter. Photo courtesy Adriaan Heino [45].

sections. Yet another is a circular revolving picture that is essentially two interlocking volvelles. Tabs can be installed so that the reader can simply pull the tab to cause the motion. Figure 3.11 illustrates the dissolving version of a transformation.

The third major design development was the pull-tab. This has been mentioned in connection with scenic books and transformations, but they could also be used with a clever combination of hidden levers to cause parts of the illustration to move. Meggendorfer used several mechanisms, but was most famous for his pull-tabs. A diagonal tab could produce many simultaneous, or even delayed effects in the picture. Many of his creations contain 5 or 6 motions produced by a single tab. Figure 3.12 shows one such Meggendorfer picture and the mechanism behind it.

3.1.5 True Pop-ups Emerge (1914-1979)

The First World War was the end of this first golden age of movable books. Not only did the cooperation between Germany's fine printing technology and the British market end, but the use of labor (making movable books requires considerable hand-labor) for what could be seen as peacetime pursuits became less tenable. In a world consumed by war, books for children suffered in general. Publishing picked back up after the war, but movable books languished, perhaps as the result of labor scarcity and the slow recovery of the German printing industry.

Figure 3.12: The Dancing Master. An example of a pull-tab book by Lothar Meggendorfer, also showing the type of mechanisms used by the artist. The terpsichorean fiddler plays his instrument and dances, all with one pull-tab. Photo courtesy The Wonderful World of Pop-up and Animated Books [127].

It was not until the end of the 1920's that the next metamorphosis in movable books occurred: true pop-ups. Pop-up books are a particular type of movable books that provide enhanced depth and motion. They use types of movable book devices that open automatically and that create three-dimensional objects that can be viewed from multiple angles. Flaps, transformations, pull-tabs, and volvelles must be manually operated, while pop-ups are operated by the opening of the book's page. The scenic can come close in three-dimensionality, and some scenics do open automatically. But scenics only look three-dimensional from one angle since they are composed of multiple flat layers that give the effect of depth. Pop-ups can be constructed so as to fold up into a true three-dimensional form.

True pop-ups appeared in 1929 with their first publisher, S. Louis Giraud. Giraud was English and employed by the *Daily Express* newspaper as a book publisher. The newspaper made extra money and enlarged its readership by offering special publications of various books, some of which were children's books, and Giraud was placed in charge of these publications. He began producing pop-ups, or as he called them *Bookano* (perhaps a combination of *book*

and *meccano*) or *living models*, in annual issues timed for the Christmas market. He produced 17 of these annuals, the last of which was published in 1949 after his death. They were priced for the average reader, and became extremely popular. It is a tribute to their popularity, and to Giraud's management skills, that the series lasted through World War II, in spite of paper and labor shortages.

What was the reason for this popularity? It certainly was not the quality of the Bookano production. Unfortunately,

> ...production standards had to be kept pretty basic–coarse absorbent paper; crude photolitho printing and colour reproduction; cheap covers and bindings which (sadly) have rarely endured the ravages of time unscathed. Undoubtedly in their day the books were enormously popular with children and received much rough handling; as a result, those that have survived invariably look shabby. [23, p. 220]

Their literary and artistic qualities were not of the best, either,

> ...his own prose style as a children's writer, and that of his other contributors, can at best be described as vapid; at worst, glutinously sentimental or trite. The verse is rarely more than doggerel and the pictures...are adequate rather than inspired. It is really only the pop-ups that distinguish these books from the morass of cut-price juvenilia that appeared in the penny bazaars... [24, p. 251]

This popularity then came down to those pop-ups, that exhibited almost all of the pop-up devices currently in use. (See Figure 3.13 for two examples.) It was an amazing technical leap.

> Whereas all the earlier movable books had been developed or refined from [scenics, pull-tabs, and transformations]...Giraud stumbled almost by accident upon a completely new way of devising three-dimensional effects–the first "true pop-ups" in fact...Unlike all previous movable books, the best of Giraud's popups stand four-square on the opened pages, truly three-dimensional, and so can be viewed from literally any angle. [23, page 220].

But it was not Giraud who invented the devices used in his pop-ups. A man about whom little is known named Theodore Brown brought him the idea, although Brown had little idea of what to do with it, other than advertising brochures or toys. Giraud, however, being a publisher,

Figure 3.13: Left: A replica of an early pop-up–one of Louis Giraud's Bookano pop-ups. The clown spins on a bar as the book opens. Photo courtesy Ellen G.K. Rubin[94]. Right: Pop-up from Bookano No. 9. This photo gives some idea of the depth of Bookano pop-ups. Photo courtesy University of North Texas Libraries[121].

knew the market for movable books and understood the attraction that pop-ups could provide. Together they patented the designs in 1929. Mr. Brown evidently helped with the first two books, then promptly vanished. (One of Giraud's assemblers said that he may have died at this time.) It was Giraud who wrote parts of the books, hired writers and illustrators, published the books, did the paper engineering, and set up the facilities for manufacture. Oddly enough, Giraud previously showed no interest in children's books for other than business reasons or even in telling bedtime stories to his own children, and was never seen "with scissors and paste striving to achieve new effects"[24, p. 256]. He was no illustrator, and hired illustration from outside, but his talents as a paper engineer in a new field were undeniable.

Pop-ups were instantly popular with children, and were copied by many publishers, patent or no, becoming a staple in children's books. Around 1932, one of these publishers, Blue Ribbon Books in the U.S., was responsible for calling these books *pop-ups*, the name by which they are now universally known.

Pop-ups produced between Giraud's death in 1949 and 1979 were common but fairly forgettable. However one Czech artist, Vojtěch Kubašta (1914-1992) made pop-ups an art form and inspired many modern paper engineers. Kubašta, an architect who became a book illustrator, was a talented artist in many media and was well-known in his own country. Czechoslovakia at

Figure 3.14: A 1961 pop-up by Vojtěch Kubašta. The pop-up castle is a fold-out of the back cover of the book containing the story. Two separate knights on horseback, not shown, can be made to joust in the foreground. Photo courtesy Ann Montanaro and Rutgers University Libraries[79].

the time was producing some of the best children's books in the world, "creating native and folk images with bold colors and lines."[93, p. 27] Beginning in the early 1950s with advertising cards, Kubašta developed a unique style of pop-ups, and began to work with Artia, the state publishing company, to produce children's pop-up books. Exactly how many books he created is not known:

> The sheer number of titles he designed continues to confound contemporary paper engineers. Today, a single pop-up book, from concept to publication, can require up to two years to completion...Kubašta illustrated and paper engineered over ninety books between 1955-1965, and collectors and scholars are still discovering titles that were not recorded. [93, p. 31]

One of his Artia pop-ups is shown in Figure 3.14, a castle rising from the back cover of a book about a medieval tournament.[5]

[5] I have a special love of this pop-up. I first saw it in the library, was able to open, hold and examine it, and what initially struck me was how complex it was. However, on closer inspection, I realized that it was made completely

While initially unknown outside Eastern Europe, Kubašta's later works were exported all over the world, and he illustrated pop-up books for Disney (although his name never appeared on them) that were manufactured by Artia. Without leaving Czechoslovakia he influenced a new generation of paper engineers.

> ...Robert Sabuda, the well known contemporary illustrator and pop-up artist, remembered receiving his first Kubašta pop-up book when he was ten years old, "It was *Cinderella* and I couldn't believe that a pop-up could have such beautiful artwork. My whole notion of what a pop-up book could be changed forever that day." [93, p. 38]

It was not only children who noticed Kubašta's work. Waldo Hunt, the owner of Graphics International, a company that did printing and brokered book sales, also discovered these books, and wanted to import large quantities–a million books. Unfortunately, Artia could not export in such quantity, as the Czechoslovakian Five Year Plan did not allow for it. Hunt began producing his own pop-up books, and in 1974, after Hallmark bought Graphics International, he started a new company named Intervisual Communications (ICI). This was not a publishing, but rather a packaging company. Most pop-up books are now produced by packaging companies, and ICI has been one of the largest having, for instance, introduced 40 new titles in 1990 alone [115, 105]. Packagers are used in pop-up production to bring together illustrators, authors, paper engineers, printers and assemblers, and to sell books to multiple publishers internationally. The process of creating a modern movable book is more complicated than most publishers wish to take on themselves.

> Most publishing houses do not have the expertise (nor the time) to design and execute a movable book from start to finish. It's bad enough that they have to spend so much time copy editing and color proofing their flat picture books. But correcting die moulds and overseeing assembly, too? Forget it! [95, p. 1]

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from v-folds and tents (see Chapter 5), with a few connecting structures, and well within the capabilities of the program produced for this study. The paper engineering in fact, is quite simple, but quite appropriate to the subject and perfectly done–it is the artistry of the thing that makes it look complex and dazzles the eye. Viewing this pop-up convinced me that the pop-up devices selected for inclusion in the program could be used to make very complex pop-ups.

Packagers have helped support the growth in complexity and popularity of modern pop-up books, as their special expertise allows the development of books that publishers are not equipped to handle, and they can aid the beginning paper engineer with the details that are hard to learn for oneself.[6]

3.1.6 The Modern Pop-up Book (1979-present)

Some have termed the years since 1979 the second golden age of movable books, because of the variety, complexity, and number of these books produced each year. There are several trends that distinguish modern pop-ups from those produced before about 1979. First, modern pop-ups contain a larger quantity of devices, and often mix in types of devices including those that predate pop-ups, such as volvelles, flaps, and transformations. In addition, there is an increased complexity of devices. Because of this, the term "pop-ups" is often used to mean all movable devices, not just those that are technically and narrowly considered pop-ups. Children think of all movable devices as pop-ups, and use a combination of them in their work, just as modern adult paper engineers do. Finally, the rise of the modern paper engineer and artist that started with Meggendorfer and Kubašta has led to true "stars" of the pop-up world.

The book that might be considered the first of the modern pop-ups was published in 1979. *The Haunted House* [85] was a collaboration between illustrator Jan Pieńkowski and paper engineer Tor Lokvig, and combined several devices on each page, including flaps, pop-ups, volvelles, and other devices. It was an immediate success, and won the Kate Greenaway Medal for illustration[7] in that year. A view of one page of this book can be seen in Figure 6.6. [8]

[6] Experienced and famous paper engineers/illustrators often deal with the publisher directly. The advantages of using a packaging company are that it has the experience to deal with the publisher and the details of production, and that it sells the entire printing at once, thereby giving the paper engineer her royalties in one large check. One disadvantage is that the check is smaller; like middlemen everywhere, the packaging companies take a cut of the book price [124, 95].

[7] The Kate Greenaway Medal is the annual British award for children's illustration, and the equivalent of the Caldecott medal given in the United States.

[8] I included this book in user testing and therefore viewed it with children ten times (two times with each child). I was still seeing new things in the illustrations or noticing connections between pictures, such as characters that show up repeatedly, at the end of testing.

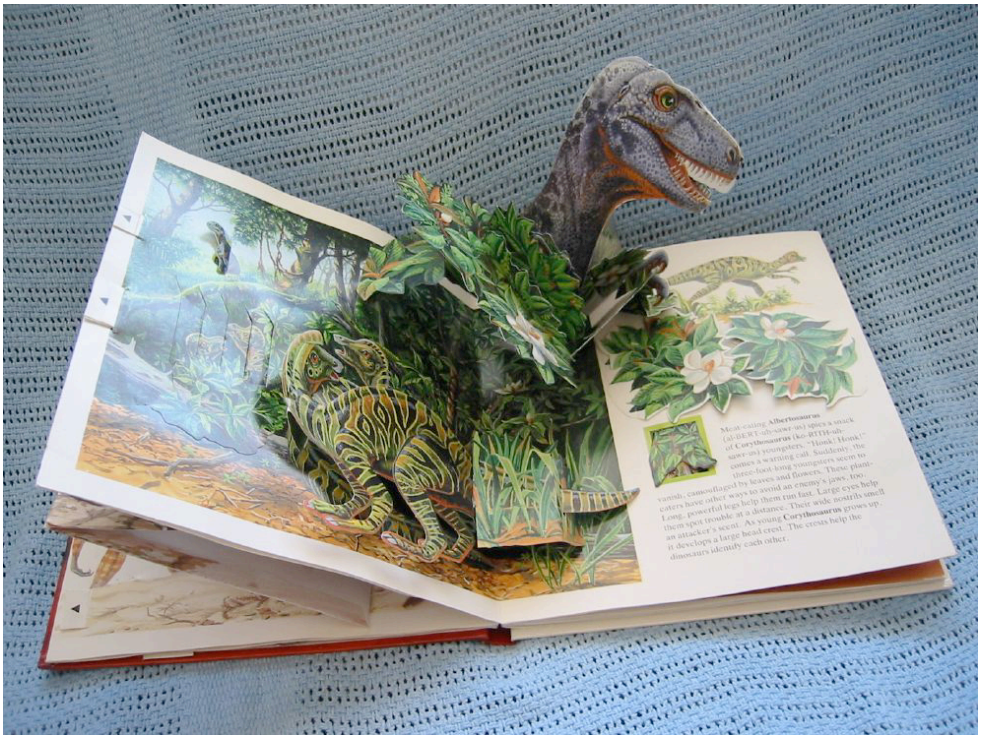

Figure 3.15: An example of a recent pop-up book page (*Dinosaur Babies* [62], that is an excellent example of both multiple and varied mechanisms on a single page. In addition to the large tyrannosaurus rex popup, the smaller duckbill dinosaur turns its head as the page is opened. A pull-tab on the left side controls the movement of a small dinosaur in the background. A second tab operates a transformation that reveals a hidden dinosaur. Several flaps show hidden pop-up dinosaurs on the right side.

The 1980's saw the rise of Ron Van der Meer, a trained artist who produced several groundbreaking works, including *The Art Pack*[32], a book aimed at adults interested in art history and theory, illustrating such concepts as perspective (with pop-ups) and color (with a wheel). This work includes not only pop-ups (one of Vermeer's studio for instance) but a pack of postcards of famous artworks, and an audio-tape.

In 1996, Robert Sabuda, probably the best-known modern pop-up artist, published his first work, *The Christmas Alphabet* [97]. Mark Hiner, another paper engineer, says of him, "I still don't understand how he managed to include mechanisms that printers have always told me were impossible to die-cut!" [51] Sabuda has continued to amaze with versions of *The Wizard of Oz*

[4] and *Alice in Wonderland* [13] among a growing body of work. Figure 6.8 shows a page from Sabuda's *Alice*.

The evolution of the pop-up book has returned it to the adult sphere where movable books originated. Books such as *The Pop-up Book of Phobias* [39] by Matthew Reinhart, another artist of note, *The Pop-up Book of Sex* [72], and *Graceland: An Interactive Pop-Up Tour* [81] are examples of this trend [126].[9]

In a world dominated by mass-production, it is important to note that even popular pop-up books are made by hand. The process begins with a hand-made design, often a collaboration between the paper engineer and illustrator. Usually the paper engineer works with paper, glue and scissors to produce the first designs. The paper engineer produces a *working white* sample of the design with all the pieces, in uncolored form, that is sent to the printer for pricing, since the pricing is largely determined by the number and size of pieces to be cut, and such details as the number of glue points, that is, the number of places where pieces will have to be glued in assembly. A final copy containing all the art-work and die-cutting instructions is produced by both illustrator and paper engineer for the printer; this step is often done on a computer. The paper engineer must produce not only the pieces to be die-cut, but directions on assembly [43]. The printers and assemblers often work near one another to minimize shipping time and costs, therefore locations to do the assembly are chosen that have the facilities to maintain very complex printing processes (since pop-up books are made from heavy card-stock and the printing and die-cutting are technically advanced), and a population of hand assemblers. The final die-cut pieces are put together by the assemblers, who work in an assembly-line fashion, each doing one folding or gluing task. This is often a village activity, and can employ more than 100 people. Columbia and Bolivia were important centers at one time, but most pop-up printing and assembly is now done in Singapore, China, and Malaysia. For a book like Maurice Sendack's *Mommy?* with a print run of 500,000 copies, and employing a writer, an illustrator, and a paper engineer, this process is

[9] Adults as much as children are attracted to pop-ups, I have noticed. There are many pop-up books in my office, and grown-ups are constantly looking at them. Moreover, many pop-ups are currently published specifically for adults, and even children's pop-ups are marketed primarily at Christmas, to attract the children's relatives.

elaborate [126]. However, as Robert Sabuda says, in some sense pop-up books are still handmade:

> Children always seem to get the impression that I actually make every single one of my books by hand. Obviously I don't...but I am always happy to tell them that someone else does. All pop-ups are indeed made by hand, so someone really does fold each piece, add a spot of glue, and carefully put it into the page. Maybe that's why I love making pop-up books. Each one goes from my hand creating it, to the pop-up assembler building it, to a young person's hand enjoying it. [96, p. 11]

As a complement to mass-produced pop-up books, there are also producers of *art books* who make the entire book by hand, sometimes in single volumes, sometimes with limited editions of a few hundred books. These can be movable books (often such forms as panoramas) or include movable devices. Figures 3.8 and 3.9 are examples of two such books. Such personal expressions are better examples of movable books as craft, if much less common.[10]

Paper engineering, then, can be considered a craft, both in its professional forms, and by those who practice it for artistic expression, including children. As a craft, it shares with other crafts previously discussed a tradition of knowledge, skill, and appreciation.

3.2 Pop-up Making as a Representative Craft

Chapter 2 presented a framework of craft learning and practice and examples from sample crafts were explored. This section examines paper engineering in terms of that framework. To do this, it is necessary to examine both how the paper engineer learns her craft and how she practices it. As there exist accounts of professional paper engineers, it is useful to look at these first in order to see the patterns that emerge.

Many paper engineers start as artists or illustrators and turn to movable illustrations or bookmaking in general when they find that static, flat pictures are not what they are interested in doing. This can happen at almost any age, but most pop-up makers start as adults. Carol Barton, a book artist and pop-up making teacher who began her career as a painter says that she

[10] And terribly expensive to buy, with books costing in the hundreds and even thousands of U.S. dollars.

was fascinated with "the mechanics and sculptural qualities of the pop-ups."[2]. Bruce Foster has been a paper engineer for several professional books but:

> ...missed out on pop-up books during his childhood. He went to the University of Tennessee, attended art school and worked for decades as a graphic designer before seeing his first one in the 1990's...Foster, who has always been fascinated by the three-dimensional, was instantly intrigued: "From the first time I saw it, I really wanted to do it. I thought it would be a great way to combine my three-dimensional skills with the skills I already had." [126]

Mary Beth Cryan, who makes pop-up greeting cards, is also a fine arts graduate and was drawn into the craft first through a review of geometry taken for graduate school and then when she found a book on paper engineering while looking for one on origami [64]. One of the few pop-up artists that did not come to the craft as an adult was Robert Sabuda.

> "I made my first pop-up book when I was 9, " he said. "It was 'The Wizard of Oz.' I spent weeks on it. I couldn't get the cyclone to spin around. My room was a mess of paper scraps, pipe cleaners, glue and drawings. I did the illustrations with a pencil." [44]

Sabuda used manila folders his mother brought him from work. (Paper engineering requires stiff paper.) He went to art school, and spent years learning about book illustration and publishing before beginning to produce professional pop-ups, but his interest started at a early age. The cyclone in his *Wonderful Wizard of Oz* published in 2000 does spin.

Sabuda, like most paper engineers, is self-taught.[11] Descriptions of the self-teaching process involve two main ways of mastering the craft. The first method is simply practice. Although simple pop-up devices can be learned easily, it takes a great deal of trial and error to learn to make pop-ups that are more complex and that satisfy the engineer's design and vision of the page. The second method of learning the craft is to collect and learn from professional pop-ups. These accounts tell us that almost every paper engineer has used other's pop-ups as a learning tool, often

[11] All published accounts of paper engineers I have found indicate they were self-taught.

through the use of reverse engineering. [12] Foster "taught himself by taking pop-up books apart. 'I destroyed a lot of them trying to figure out how they were done.' "[126] Anton Radevsky, a Bulgarian paper engineer, collected Kubašta, and "I used to destroy them to see how they worked." [33, p. 8] Mary Beth Cryan was the only person who made reference to learning from a 'how-to' book.

Although most paper engineers begin making pop-ups when they are adults, this is not because children are unable to make their own. Carol Barton, who teaches classes in pop-up making, emphasizes the ease with which children can pick up the craft:

> I can actually teach someone how to make a simple box or triangle pop-up in about three or four minutes, and I haven't had a failure yet. I can teach a class of 4th graders how to make four or five different kinds of pop-ups in a 50-minute session, and the kids have no problem coming up with drawings that turn those pop-ups into all manner of 3-D flowers, furniture, food, and talking animals. They invent stories, too, and string the pop-ups together into narrative books. Adults are a little slower with the visuals, so in an adult class I usually concentrate just on the mechanics. Because many adults are intimidated by long-forgotten geometry formulas, I teach adult classes without any math. And in a two-day workshop, we cover about 85% of the basic pop-up structures used in commercial books. [2]

Where most children acquire the craft of making pop-ups has not been studied. Some children gain their knowledge of pop-ups through the sort of crafts instruction that Barton describes. Of the sample of users in this study (five children), three had previously made pop-ups, but none had taken classes or used "how-to" books (see Chapter 6 for more information on the prior experience of the users) and it is probable that written instructional material plays little or no part in children's pop-up making despite the number of instructional books and kits available for children (see Appendix B). Instead, this ability may come from a combination of self-teaching and knowledge passed from person to person rather than from any organized knowledge base. As an example of a child's self-teaching, Robert Sabuda serves as an example of someone who used the trial and

[12] Considering the cost of many pop-up books, this can be an expensive way to learn. However, some pop-ups for small children are simple, yet well-engineered, and can often be found in bargain bins and thrift stores–although in a tattered condition in the latter–if the reader desires to follow this method of instruction.

error method as an extremely tenacious child. It is likely that most parents would not be pleased if their children took the reverse engineering approach seriously.

One account of the adoption of the pop-up form by children in a guided activity is given by Power [89] who studied pop-ups as a means to make observations about conventions in a first-grade writing class. In the writing class, time was spent writing whatever the students wanted and a sharing session, in which the students read their writing aloud and took questions from the rest of the class, followed. Illustrations were often included with the stories and it was there that pop-ups were introduced by one student. Pop-ups were then picked up by others, reaching a peak of popularity before dying out, most likely because the teacher made no attempt to help the children acquire the craft. The original student who introduced pop-ups to her writing was Megan:

> Megan's mother said that she first became interested in pop-ups when she was overseas at age four, and had been attempting to make them when she worked with paper and pens ever since...More than half the class attempted to include pop-ups with their stories in the week following Megan's sharing. [89, p. 61]

Power is not clear about the forms that the pop-ups took, although she does state that:

> Use of the pop-ups required two important skills; the ability to manipulate paper, tape, scissors and glue, and the ability to integrate a pop-up with the words and pictures on a page. Attempts at pop-ups during this experimental phase included balls and characters flying off the page, as well as cut-outs of characters and objects glued to the page...as the use of the convention continued, the pop-up became more defined. Pop-ups were used to show motion...Not all the children continued to do pop-ups. But those who did wrote and shared movement through the pop-ups...Even though [the teacher] had pop-up books displayed throughout the room which show a wide variety of uses for pop-ups (i.e. showing dimension), the class defined pop-ups as symbolizing motion. [89, p. 61-62]

Power uses these observations to discuss issues of literary convention and social behavior, a subject outside the area of this dissertation, but certainly the ease with which children picked up the craft on their own speaks to the lack of difficulty of this craft for children and their attraction to it.

These observations also provide two other interesting details. First, the children took ownership of the pop-up form by defining how it was to be used: as an indicator of motion. Second, the pop-ups changed over time to match this agreed-upon definition.

Change in the practice of craft over time occurs during the learning period as a matter of course, and not just in the case of the children in the writing class. Learning develops both skill and knowledge that influence the way a craftsman practices the craft, leading to more skill and knowledge. It is necessary to look not only at the way craft is learned, but the way that it is practiced in order to talk about the competencies in paper engineering.

Two examples illustrate some of the techniques paper engineers apply to their craft. Vojtěch Kubašta was an artist who was trained as an architect and this most certainly influenced how he approached his pop-ups. For instance:

> He once entertained in his studio a famous author who came to see how his pop-ups were made. According to the visitor, Kubašta seemed to have everything worked out in his head and knew how the pop-up would finally turn out even before he began the design process. The visitor did not realize that "each and every one of [Kubašta's] books demanded an extensive knowledge of descriptive geometry." Kubašta admitted, however, to hating math but loving geometry because it "made perfect sense."...Kubašta said his books were created in stages: 1) inspiration for the artistic solution of an idea; 2) pencil sketches; 3) calculations for the pop-up; 4) mock up of the actual size book. [93, pp. 30–31]

Robert Sabuda, on the other hand, with a background and training as an artist, uses a method of trial and error with multiple prototypes. As he describes his process:

> Before any work begins I must decide what I want the pop-up to be. Should it be a static, three-dimensional object, like a castle, or should it be more about movement, like birds flying?...Instead of using a pencil to draw on the paper, I use scissors to cut the paper. I work with broad, general shapes when I'm designing a pop-up. I know that the simple, white rectangle I'm cutting in the beginning will become a very colorful, detailed structure later on. The most important thing at this early stage is that the pieces I cut and attach to the page work properly when opened and closed...Eventually I will make up to eight or ten white mock-ups of the same pop-up, each one more detailed and refined than the last...and I never have to use a protractor! [96, pp. 9–10]

The difference in these approaches is obvious and it is likely that every paper engineer has a unique approach since pop-up makers are generally self-taught. Kubašta consciously employed mathematics in designing his pop-ups. He also had the pop-up planned before making a mock-up, while Sabuda employs successively more refined prototypes and eschews mathematics. As a result of the dissimilarity in design methods, the design tools employed, pencil vs. scissors, are also different. Kubašta used the pencil to design, so that the final mock-up was a verification of what he had already planned. Sabuda, on the other hand, uses successive mock-ups, each a bit closer to the final product.

Although they employ different design techniques, the pop-ups produced by Kubašta and Sabuda use a similar set of elements and that is not surprising. Pop-up devices are made up of simpler elements, of which there are a limited number (although capable of endless combination and variation.) Sabuda's combinations of elements are much more difficult to understand and it is harder to see what basic elements he has used, possibly because of his prototyping approach. But both paper engineers knew how elements can be combined, and both knew before they began what effect they wished to achieve. In both cases, the pop-up is designed to fit the situation being portrayed, the desired motion and depth are considered and the design is based on those qualities. It is some of these commonalities in technique that should be identified when examining children's pop-up progress. Children can also work in many styles, and the analysis of their work should reflect this. The assessment of the children who participated in the user tests is guided by the following sections, in which the competencies of Chapter 2 are applied to paper engineering.

It should be obvious that there are differences between children who make pop-ups and professional pop-up makers. The following sections on skill, knowledge and appreciation deal with the competencies that one expects of children. A professional pop-up designer must know what can be manufactured, must be able to produce instructions for the assemblers, and must be able to provide printer-ready art with die-cutting marks and instructions. This requires a knowledge of publishing and printing that is not necessary for a child making a single copy of a hand-made card or book. In this, children are more like the artist-craftsmen who make single or limited

edition books for the art market.

Once again, it is worth stressing that even the most complex pop-up devices are modular, being built up from a small, basic set of elements and their variations combined together into a more elaborate structure. This modularity is important in discussing competencies, but the details of element construction will be left to Chapter 4.

As discussed in Chapter 2, the competencies are interrelated. As examples, knowledge of what is possible allows practice to develop skill and appreciation of the work of others increases knowledge by showing the craftsman possiblities that she has not yet considered. This should be kept in mind in the following discussion of the competencies as they apply to paper engineering.

3.2.1 The Pop-up Maker's Knowledge Set

Assuming that a child can build up a systematic base of knowledge about pop-ups, what would this base include? The how-to books available provide a useful look at what could be learned and elements, the basic building blocks of pop-ups, provide a convenient starting point.

The three children in user testing who had previously made pop-ups each knew one element. While it is not necessary to know many elements (many professional pop-ups commonly use variations on three or four[13]), in general, the more elements that one can recognize and construct the better, as this leads to more interesting pop-ups and a greater range of possible motions.

Besides the basic form of an element, there commonly exist one or more variations. Elements are made of cuts, folds, and applied pieces, and it is important to know how the direction, length and shape of these affects the element. Folds come in two varieties, mountain folds and valley folds (pointing toward and away from the viewer respectively). This is important, as fold direction affects the element both visually and functionally. For instance, some elements can be placed on either a mountain or valley fold, and will look quite different when this is done. Applied pieces can be attached over folds, or over the seams where other applied pieces sit; once

[13] See Section 4.1.2 for an analysis of several representative pop-up books' use of elements.

again, the direction of the fold or the seam orientation is important to the function and look of the element. In addition, elements may be made symmetric or asymmetric, and rules exist for the constraints of both. In general, cuts may be made in any shape although folds, as a matter of course, are straight. Paper may be removed from an element so long as the element is not seriously weakened, and additional paper may be added so long as the addition does not collide with other elements. Although making variations on the elements is partly a matter of skill, these general rules about possible variations can be learned as part of the knowledge base.

At a more conceptual level, a child should develop some intuition and perhaps some quantitative knowledge about how elements function [8]. The motion produced by each type of element is also an important factor when used in selecting the element for a particular use in a design.

Once single elements are learned, there are certain facts about element combinations that become important. Most elements sit on folds and each element that is added creates more folds in the pop-up structure. Elements must be connected to a fold in order to move when the page is opened, and ultimately every series of associated folds must be connected to the center fold of the page itself. These requirements for fold connectedness commonly occur when designing pop-ups.

In addition to how folds can be connected, some knowledge of which elements can be combined is also important. For instance, some elements can sit on the folds created by gluing pieces together, and some cannot. In general, the motion created by a combination of elements can be hard to predict, but in designing a pop-up it is best to have some idea of what motion is likely, in order to reduce trial and error.

Another general area of craft knowledge concerns tools and materials. Children are, by and large, acquainted with the qualities of paper since they use it frequently both at home and at school. However, they may be presented with paper that they are less familiar with when doing paper engineering. Pop-ups usually work best, and sometimes require, heavier paper than notebook paper. Construction paper, despite its name, does not work well for pop-ups, as it

does not crease smoothly when folded. Pull-tabs may require doubling of the paper, and must be smooth and strong to work well. Understanding which papers work well is knowledge that children need to acquire. A similar problem exists when selecting glue. For example, familiar water-based glues often wrinkle paper, and glue-sticks are not strong enough for pop-up making. Such fasteners as tape and staples are not usually used in pop-up making, as they tend to bind.

There are only a few tools required for pop-up making, but knowing which is the correct tool is important. It is possible to use scissors on many elements, but a craft knife is needed for others[14] . Knowing about the use and care of craft knives becomes important and is made more difficult as children seldom have the opportunity to own or use them. A self-healing mat is important to facilitate good cutting, and not dull the knife blades. A metal ruler (not plastic) can be used to guide the blade. Since pop-ups are made with heavy paper, a tool is required to make good folds. This tool has a round, small, smooth end and is used to press along the fold and compress the paper fibers so that the paper folds correctly and easily. This tool can be a burnishing tool, an embossing stylus, or simply a pen that is out of ink. Again, this sort of tool for making creases is not something that children ordinarily encounter. Of even greater importance is the knowledge of how to use these tools safely.

Every craft has a vocabulary, and paper engineering is no exception. Unfortunately, the vocabulary of pop-ups is less standardized than many. The names of elements, for instance, vary widely and even the term *element* is not standard. It is common to find the terms: form, mechanism, structure, device, and even technique used to identify an element. This may be another effect of the prevalence of self-teaching in the craft. However, it is useful for children to learn or make up terms for the elements they make, the tools and materials they work with, and the techniques they use so that they can talk about their work.

Finally, the knowledge of what is possible given the elements available, and what is not possible grows over time. This can come with experience in designing one's own pop-ups, or by

[14] Children love using the knife, and will use it even when scissors are more appropriate and faster. One would hope that this changes with time, but the time of the user tests was inadequate for the glamor of the knife to wear off.

examining the pop-ups of others (through the growth of appreciation). It can also come through the experience of trial and error in making pop-ups (through the growth of skill). At some point, a young paper engineer should develop the knowledge that a particular element will or will not produce the effect desired, and have some idea of how to work around the problem if it will not.

3.2.2 The Pop-up Maker's Skill Set

The skills that a young paper engineer might be expected to develop come in two areas. First are the skills of actually constructing a pop-up. Cutting, folding and gluing skills are foremost in this area. Pieces are most easily (if the child is old enough) cut with a craft knife and it takes practice to be able to cut smoothly with a craft knife without producing "slivers" of paper that stick out and may impede motion.

Folds are most easily made in the paper if the paper is scored properly. Use of a stylus or empty pen takes practice in order to produce enough even, straight scoring to get a good fold, but not enough to tear the paper. The skill of folding also encompasses the skill of folding the paper in the correct direction, towards the viewer (mountain folds) or away from the viewer (valley folds.) This can be confusing, especially when several folds are combined in an element.

Gluing applied pieces onto the page requires using the proper amount of glue. Too much glue can cause pieces to stick together and prevent proper opening while too little will produce a page that comes apart. In addition, some gluing operations are best done by applying glue and then closing the page to allow the piece to come to its proper resting place.

Finally, putting several devices together compounds these problems. Multiple folds, applied pieces, and cuts on a page are best done in a regular order (from the largest, lowest elements to the smallest and topmost elements) and while this can be internalized as knowledge, it really can only be mastered as a skill. Small elements, and those that are not parallel to the fold they sit on are most difficult, and may require a pencil point or tip of a stylus to "poke" them into place.

The second skill area is in design and planning. There are two main qualities to consider in designing a pop-up: depth and motion. Understanding which elements can be put together is

something that needs to be tried to be learned. Different combinations produce different shapes and motion, and trial and error is the only way to really learn it. Likewise, it is difficult without practice designing pop-ups to know which elements are appropriate for which illustration. Certain elements make very good mouths, for instance, and others do not. Planning encompasses such skills as the ability to fit the design into the available page without pieces sticking out from the closed page and using available materials wisely (cutting paper in a way to avoid waste, for instance). And perhaps the hardest skill to acquire is the ability to visualize the final product that will result from the multiple pieces, cuts and folds. It takes a great deal of practice to make everything work together.

Skill is dependent on knowledge and appreciation. Knowledge of which elements are available is necessary in order to assign the best element to create a particular motion, and in order to visualize the results one must know what each element does. Appreciation allows the paper engineer to view pop-ups made by others and imagine new variations or applications of elements that she can already make.

3.2.3 Appreciation of Pop-ups

Children can learn to appreciate pop-ups by viewing the pop-ups of others, in particular professionally produced books, and by comparing their own efforts to these. The first step in this process is for them to be able to recognize which element is being used in a given pop-up that they look at. Being able to say “This is a v-fold” can be a major achievement when the pop-up involved is a complex one. This complexity can come from the presence of multiple elements that disguise or embellish each other, or from variations in the form of known elements. For instance, pieces can be added or parts of the element can be cut away to produce a different effect.

When several elements are combined in a single pop-up, appreciation may entail understanding how a given motion results. This goes beyond recognizing the individual elements to grasping the entire structure produced by the motions or form of the parts.

Another aspect of appreciation is the ability to recognize the appropriateness of the ele-

ments used. The child should be able to suggest some alternate element that might work as well or to recognize new elements and how they might be used in her own work.

Finally, a child can learn about pop-up styles and learn to recognize or compare pop-ups from different paper engineers, or to compare a professional pop-up with her own work.

> Children of all ages who discover, empirically, the joy of making their own pop-up books will approach the 'Children's Pop-Up Books' section of a book shop with a maturity and confidence, for they will be able to say 'I know how that pop-up was made because I've invented one like it!' [58, p. *xi*]

This can also contribute to knowledge, since seeing variations of known elements or even new ones can will increase her understanding of their function and use. Her design skills will be similarly enhanced as she applies this knowledge to her own work.

3.3 The Value of Paper Engineering for Children

Section 2.2 highlighted ways in which craft has value as an activity for children, primarily based on studies involving teachers who use crafts in the classroom. This section examines the craft of pop-up making and its particular values for children as well as some of the uses to which it has been put in the classroom.

Children typically experience pop-ups and other movable books in two ways: the use of professionally made movable books and by making pop-up cards and books for themselves. These are related, as professional books can serve as models for the pop-ups children make. Activities in the classroom can use both of these but this section focuses on the craft of making pop-ups and its value both as a craft and as a tool to teach subject content. The use of professional pop-ups is touched on only as it relates to the actual activity of children making their own pop-ups.

Paper engineering can be taught both on its own as a craft, or as a tool for teaching other subjects although sometimes these two uses intersect. Section 3.3.1 focuses on pop-up making as a craft, while Section 3.3.2 considers the use of pop-up making when introducing curricular subject matter.

3.3.1 The Value of Pop-ups as Craft

In discussing the value derived from having children make pop-ups, it is clear that the previously discussed qualities of craft (Section 2.2) apply here as well. Crafts teach personal values, such as hard work and patience. There are also lessons to be learned about the use of materials and tools, the ability to make aesthetic judgments, and the acquisition of problem-solving skills. All of the general values of craft that have been previously discussed can be applied to paper engineering. For example, a willingness to experiment is important in a craft that relies as this one often does on trial and error. Patience is developed in a craft that requires time for glue to dry before the result can be opened and closed. Imagination, expressive skills, and visual sensitivity are certainly in evidence when work in two dimensions is combined into three dimensional products that include both words and pictures[15] .

There are several basic reasons that paper engineering is a particularly good vehicle for children's craft-work. First, children are familiar with pop-ups, attracted to pop-up books, and enjoy pop-ups. However, pop-up books are often expensive and are easily damaged, so most children do not own many of them, giving them special possession status. There is real value, therefore, in teaching children to make their own pop-ups, and it is surprisingly easy to persuade them to do so. There is a built-in motivational factor, a familiarity that might not occur with other crafts, and the sense that a child is creating something special.

Second, the craft uses paper as its raw material. Paper is an excellent material for children to use. They are familiar with its properties, as they use it at home and at school from a young age. It is inexpensive and moderately durable, and has the advantage of coming in many textures, sizes, thicknesses, and colors. It is easy to transport and store the resulting craft objects if they fold flat, as pop-ups do. This seems like a minor point, but in working with children's art it is a quality to be appreciated as it "enables pop-ups from a class of thirty-five children to be stored in

[15] It is not the intent of the author to argue for the teaching of pop-up making in order to produce more paper engineers. As Robert Sabuda points out, "There may be 36 paper engineers on the planet. It is a small field." [44] It is more important that paper engineering offers many of the values of craft in a form that is easy for schools and parents to encourage.

no more space than that required for the same number of exercise books."[58, p. *vii*] In addition, the tools needed to work with paper are few in number, simple to use, inexpensive, and often already available (scissors and glue, for example) in the home and classroom.

Third, although almost all children have seen and read pop-ups, few have ever made them. Occasionally a teacher will show children how to make a ***beak*** (a simple triangular pop-up made with a single cut across the paper, and two folds as seen in Figure 5.11) and that is the extent of the exercise. Children can make much more complicated pop-ups, as a look at the web [98], or a perusal of Johnson's work [58] will show. It is a craft that is under-utilized in education, possibly because the craft is unfamiliar to teachers. Textbooks for the aspiring art teacher or studies of children's artistic development seldom mention pop-up making. For example, one textbook on art education, Hurwitz and Day [55], spends only two pages on bookmaking, with no mention of paper engineering. Because children rarely get to make pop-ups there is an element of excitement that comes when they create something that they usually consider a product to be purchased. One eleven year-old expressed this surprise:

> I used to think that pop-ups were very difficult to make but now that I've made them I think they are not so difficult and that anyone can make them. I think they're the best thing we've done at school this year. [58, p. 107]

Fourth, pop-ups are modular, being constructed from a combination of simpler elements. This makes them ideal for teaching design, as the design space is constrained to a few simple forms while simultaneously being capable of seemingly infinite variation on those forms. Interesting designs can emerge from knowledge of only one element allowing the beginning paper engineer to see results quickly. The teacher can introduce new forms gradually as the student needs them. And, in addition, basic principles of design can be taught without requiring too much complexity of construction.

Fifth, pop-ups have a mathematical basis, with constraints that must be met to allow them to pop up and fold down again. These constraints will be explored in more detail in Chapters 4 and 5, and involve such principles as parallel lines, equal distances between sets of lines, and

equal angles. There is a geometrical component to making a pop-up that is seldom encountered in making a flat drawing. Since pop-ups are both 2- and 3-dimensional, they require a level of topological visualization unnecessary in flat art.

Finally, pop-ups are often a part of books, with all that implies–reading, writing, and creating a love of books that can last a lifetime. It is a small step from making a simple pop-up card to joining that card with others to create a book. Children spend a great deal of their time in school, and one hopes at home, in contact with books. So there should be something special about making their own:

> When children plan and design a book of their own, integrate handwriting, lettering, illustration, layout, and binding as a vehicle for the communication of ideas, a superior kind of mental activity comes into play. [59, p. 13–14]

Since pop-up making is so well-suited as a children's craft, and combines verbal, mathematical, and artistic effort in one package, it seems natural to use it as a vehicle for curricular centered activities.

3.3.2 Pop-ups in the Classroom

This section examines some specific methods for using pop-ups in the classroom by looking at a sampling of the literature by and for teachers in specific subject areas. This discussion is not focused on instructional books about making pop-ups, although such material is included in some of the examples that will be covered. It focuses rather on reports by teachers of projects they have used, curricula they have developed through making pop-ups, and books and articles that aim to help teachers to integrate movable bookmaking into their classrooms. This section is not intended to be an exhaustive look at the literature on educational uses of paper engineering, and covers only a few important, inclusive, and interesting works in the subject areas of literacy, mathematics, and art.[16] These will demonstrate the pedagogical usefulness of paper engineering.

[16] The reader desiring a list of other publications dealing with pop-ups in education, including how-to books for teachers, reviews of pop-up books for use in the classroom and the library, and minor or esoteric sidelines such as pop-up polyhedra should consult Appendix B.

Making pop-ups can serve as a vehicle for practicing a variety of skills, such as measuring, group interaction, writing, and problem solving, or the finished product can serve as a manipulative or illustration of a principle being studied. Since pop-up books exist in the realms of writing and art, and incorporate principles of mathematics and design, their classroom uses are often cross-curricular and hard to classify by subject. In addition, authors often include details on the craft activity as well as the subject material. There is value in both for the student, so this analysis will examine both aspects. One purpose of this analysis is to look at the sample literature from the vantage point of the framework of Chapter 2 to establish how both the craft and subject matter are learned and integrated.

Movable books and pop-up making in particular have been most often employed in the teaching of reading and writing. Pop-up books as literature have sometimes been maligned by educators and reviewers and consigned to the category of *novelty books*. They have suffered such reviews as this (penned in 1979, the year considered by many to be the start of a second golden age of movable books):

> It is now difficult to go into a bookshop without being assailed by books whose pages flap and slide and rotate and creak, a tribute to designer's ingenuity, printer's sophistication, publisher's business acumen–and book-buyer's gullibility...apart from the subliminal message to children that things shaped as books can be fun, they have nothing whatever to do with the magic of the word. [80, p. 6]

Of course "things shaped as books can be fun" is not a bad message to send to children. Children who are lucky enough to have parents who read to them and who discover books at a young age might not need this message, but other children do. Another reviewer notes:

> As delighted as I was, I couldn't help but wonder how soon these books would cease to surprise and amuse. A good book enriches the reader with each new reading. A book is not a book when it is a toy. [60]

Both of these reviews illustrate that one reason pop-up books are criticized is that they often have minimal or even no text. However, some teachers have found a way to turn this seeming drawback into a boon in the teaching of literacy.

One of the most complete descriptions of a literacy unit built around both making and reading pop-up books is described in Shannon and Samuels [106]. The authors' concern is with building literacy, which they define as children having the ability to express themselves. They use pop-up book reading and production for this purpose, finding them "useful tools with which children can develop and practice their literacy and begin to understand its nature–the production of meaning."[106, pp. 213] They describe a four-step process. The first step consists of the teacher reading pop-up books to the children and asking questions to elicit ideas from the children about how the pop-ups work, and how the story is constructed. As they say:

> The goal of step one is to familiarize children with the structures of pop-up books to the point where they can articulate hypothetical but real reasons for author's use of text and illustrator's reasons for movable pictures... It is important that most children in a group can articulate explicitly some of the uses of movable illustrations and hypothesize about the construction of these movable forms...[106, pp. 214–215]

Second, small groups of children convert a non-movable story book into a pop-up book using pop-ups they create along with the original book's text. This introduces the children to the mechanisms without involving them in story construction. Third, the children write or rewrite the text for pop-up books. This allows them to concentrate on the textual aspects of making a book. This is one place where the paucity of text and the non-verbal complexity of professional pop-ups become important, as there is often more story in the books than is made explicit in the text and the pop-ups serve as springboards for the imagination. Finally, working in groups again, the children make an original pop-up book, writing the story, designing the illustrations and making the movable parts. Unfortunately, the authors do not indicate the age groups with which they have worked, provide examples of the children's work, or discuss the results observed. To assist teachers who may want to use their methods, they provide directions for making some simple pop-up elements, descriptions of the teacher's role at each step of the process, and indications of when the children are ready for each new step.

Shannon and Samuels stress the subject matter over any details of the craft of paper engi-

neering in their account. They take their own advice and emphasize "the process rather than the outcome"[106, p. 215]. However, it is clear that the craft and subject matter are well-integrated in their approach, and that the craft is very important to it, "providing stimuli for oral, artistic and written expression." [106, p. 218] Although they do not discuss details of the children's pop-ups, applying the framework makes it possible to understand what is happening at each step of the process. The authors' first step focuses on appreciation by exposing the children to pop-up books and asking them to analyze and think about how the pop-ups are made and how they relate to the story being told. This provides a base for the acquisition of knowledge (that is hypothetical at step one) and skill during steps two (making the pop-ups for a story) and four (creating a complete book). The acquisition of these competencies is simplified by first having the children observe pop-ups without having to make them, and second by removing the process of story-making from the task of making a book. As has been noted, simplification by removal of some of the complexity of the task is one way of aiding the beginner.

Rather than focusing on pop-ups alone, Johnson [59] concentrates on children making panorama books (called *concertina books* by the author) and variations on them that he calls *origami books*, along with limited types of pop-ups. His main concern is the integration of visual (illustration) and linguistic modes of communication though book design. His is a holistic approach, in both curriculum and assessment, stressing the whole: design, writing, and art. Johnson presents a variety of work by children, examples of the works in progress, dialogues with individual children, and ways of encouraging both group and individual design methods. He does not present an organized step-by-step process as Shannon and Samuels do, but rather presents a large assortment of techniques for working with both paper and children that he tailors to individual students. This may, however, make it more difficult for teachers to pick up and use his methods. Pop-ups take a secondary role to the panorama movables here, but they appear to be a very useful tool for the encouragement of young writers.

The use of panorama books and their variants is an interesting activity for children for several reasons. First, it is a book form more easily made by children than regular bound books

and this represents another method of simplification for learning. This simplification allows the development of the competencies of knowledge and skill in bookmaking, by integrating words and pictures in a book form that is easily constructed by children. Second, as he constructs it, with one large piece of paper folded to produce four pages with separate backs and fronts, each book is always of a standard length and structure. His argument is that children will work to fill the book and will naturally develop a narrative rather than writing only a sentence or two. Third, the book form can also be varied in interesting ways by changes to the folding and cutting, and the addition of pop-ups. These variations on a simple form may be more instructive and easier for children to pick up than exploring multiple ways of making pop-ups. Johnson, by encouraging group work and using a holistic approach, also allows for the growth of appreciation of the book form. He stresses skill in areas such as using cutting tools (the tops and sides of panoramas may be cut to vary the shape). The subject areas explored here are the creation of a movable book form, and the integration of illustration and writing for self-expression, making the subject and the craft tightly integrated.

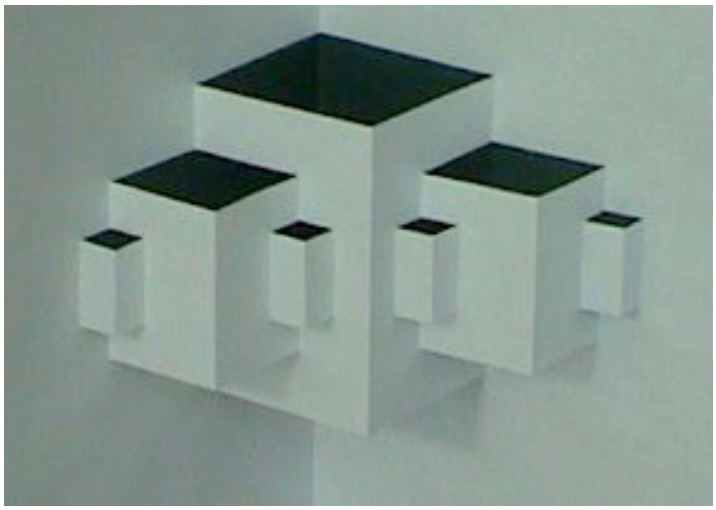

Figure 3.16: A fractal pop-up of the type used by Simmt and Davis [108] as a manipulative to study fractals and other mathematical concepts. The boxes are self-similar, and could theoretically be repeated forever, if the paper allowed it. This pop-up was made with Popup Workshop.

An extremely different approach in a different subject, mathematics, is provided by Simmt and Davis [108]. They work with simple pop-up cards produced using a single sheet of paper by means of cuts and folds. The major inspiration behind these cards is Uribe's *Fractal Cuts* [122] that explores pop-up elements that may be repeated in a fractal pattern. Their approach is oriented toward classroom use, and could be used in middle school as well as in high school. They describe their use of several cards of this type[17] in the study of fractals, limits, series, and growth patterns. Each pattern is built from self-similar elements and represents a manipulative of a fractal design and is limited only by the size of element that can be cut from the paper. Simmt and Davis describe several exercises that can be used with cards of this type. For instance, students can learn about growth patterns by studying the number of boxes or number of cuts, explore the concept of a limit by measuring the area occupied by the boxes as their numbers increase, or investigate the length of the line segments running across the card. This paper does not present actual classroom studies, but there are many ideas here for incorporating these simple pop-ups into a mathematics class.

Simmt and Davis are concerned almost entirely with the subject matter, and the pop-ups they use are clearly present as manipulatives only, but they offer an interesting study in how the craft of pop-up making can be used to explore these manipulatives. In terms of the subject matter, they contend that the pop-up cards are helpful for several reasons. They "tend to capture people's interest and attention" [108, p. 102], involve a wide range of mathematical possibilities, and are usable over a wide range of ages and abilities. They provide an easy to make manipulative for investigations of fractals that can be hard to visualize otherwise. The authors express the opinion that making the cards by repetitive folding and cutting before opening the card, itself has value, in that:

> The increased resistance encountered with each repetition of the process, coupled with such other changes as the decreasing dimensions of the shapes... provides learners with hints about the nature of the object...When students

[17] All of the cards described could be made with Popup Workshop. See Figure 3.16 for an example of the sort of pop-up used in this paper.

> open up their cards...their most common reaction is one of pleasant surprise: the cells are sometimes unexpectedly arranged...the relatively large number of cells generated often seems to be out of line with the few cuts and folds made; and the completed image is generally far more complicated and attractive than students would predict...The aesthetic dimension of the activity cannot be overstated. [108, p. 104]

From this statement, it can be seen that it is also possible to separate out some of the actual craft learning that occurs. The student's reaction to the often unexpected relationship between the cuts and the resulting pop-up and the aesthetic dimension is clearly due to a change in appreciation. In addition, although only one type of element is used, the activity nonetheless introduces some craft knowledge about element construction and positioning and exercises the skill required to effectively lay out and cut the pop-ups. The authors also encourage students to develop their own variations on the card, thus allowing more opportunity for the development of these competencies.

Another use of pop-ups in mathematics classes is illustrated in *Be a Paper Engineer* [110], one of the series called *Numeracy Through Problem Solving*. The basic approach is the teaching of mathematics through design, and therefore it is more oriented toward the craft of paper engineering and less oriented toward pure mathematics than the work of Simmt and Davis. Aimed at young people ages 13-16, it not only presents a range of projects, but lays out the mathematics behind the projects and provides assessment methods for the teacher. The course is divided into four stages. In the first stage, students make several examples of pop-up cards and paper boxes that illustrate various techniques and elements. They also practice classifying the assortment of items they have made by technique and look at professionally made paper products. The second stage consists of explorations of the previous techniques in more depth through a series of worksheets. In the third stage, students design and make a prototype of a "product" that they would like to develop, a paper box or pop-up card, and make a cut-out version of the product on a single sheet. Stage four is production. Using the cut-out from stage three, the students write directions for assembling the product and package it as a kit that can be duplicated and sold.

These four stages present numerous opportunities for learning the subject matter of mathematics and design. Drawing to scale and in perspective, classifying the techniques, creating flow charts, brainstorming, algebraic descriptions of geometry, and some trigonometry are used in the process of making the final product. This subject matter knowledge is integrated well with the craft. Knowledge of notation is introduced in stage one with the first examples that the students make, and by making a variety of objects using different techniques and elements that knowledge is extended to several types of individual elements. Skill is enhanced by having the students build a range of objects and practice folding, cutting and gluing. The use of standard examples in stage one allows the separation of the learning of skill and knowledge around making the object from the activity of design, simplifying the process. In the second stage, elements are combined, and the students use several elements to produce designs of their own, building both skill and knowledge. Perhaps the most interesting difference between this course and any of the other literature in this section is the emphasis on mathematical constraints. The teacher is encouraged to help students discover the constraints on various elements and designs. This is an important part of pop-up design that is usually neglected in classroom literature, although it is given its proper importance in how-to books on the subject, and is an important mathematical tool. During stages one and two, the course emphasizes bringing in examples of paper products and finding some similarities between them, providing the opportunity to compare various products and build appreciation. The final project in stages three and four allows the students to put what they have learned to use in building the kit for others to make, working with all three competencies.

Taking a different tack, Johnson's *Pop-Up Paper Engineering: Cross-Curricular Activities in Design Engineering Technology, English and Art* [58] also uses paper engineering to teach design, but its emphasis is more on writing and artistic creativity than on the mathematics involved. A large collection of movable book elements is covered in detail. For instance, pull-tab mechanisms are included although these are seldom part of paper engineering learning for children due to the difficulty inherent in making them. While writing skills are discussed and used in assessment, the primary emphasis is on making the pop-ups themselves. Numerous examples of the students'

work are described along with assessment criteria, and a structured curriculum is mapped out.

Johnson's approach touches all the competencies. The knowledge of various pop-up elements is introduced systematically, each is practiced to teach skill, and the use of group work encourages appreciation. It is useful to take one of the elements he introduces and examine his approach in detail. For this purpose, his first element, the basic box is appropriate as it is the same element used by Simmt and Davis for their mathematical manipulatives.

The section on the basic box is divided into two parts. In the first section, the basics of making the box are described. Constraints are mentioned, but not always made explicit. For instance, the lengths of the cuts necessary to keep the box from extending beyond the page when closed is detailed, but the necessity of the folds being parallel to allow the box to fold flat is not. The second section presents activities using the basic box. First, the children practice making some basic boxes to develop the necessary knowledge and skill. Next, since the box may be oriented vertically or horizontally, the children talk about the differences, and what pictures might go with each orientation. Artwork is then added to the boxes and a story is created around that picture and added to the page to produce the finished pop-up. Additional activities can involve adding doors and windows in the box or varying the cutting patterns. The section ends with evaluation methods (that include self-evaluation for the teacher, as well as evaluation of the student's progress) and a list of key points for the teacher to remember, in this case revolving around the appropriateness of the artwork to the pop-up form.

The sections for each pop-up element differ in their specific curricular activities but the formats are similar. In particular, the evaluation methods, although they vary in detail depending on the activity, are always divided into four sections (conceptualization, manipulation, imaging, and visualizing), and are interesting to examine within the craft framework. Conceptualization is the assessment of the children's knowledge and the teacher's presentation of it. Manipulation is the assessment of the skill competency, in particular the student's use of tools. Imaging involves storytelling and writing, and therefore does not directly relate to the craft. Visualizing assesses the relationship of the pop-up and the story, and the artwork itself and relates to the children's

appreciation of the craft.

Johnson here, as in his book on panoramas, tightly integrates the craft and the subject matter, to the point where it is impossible to separate them.

> At a time when every subject has to justify itself in the curriculum, there can be no other area of technology and design which addresses itself to so many adaptable skills and cross-curricular areas as pop-up work... The opportunities for technological inventiveness are endless. Integrated with the visually aesthetic and scientific dimension of pop-up work is the rich kingdom of the literary imagination...The greatest danger of this book is that the techniques it demonstrates will be 'lifted' out of the context of an interrelated programme of study and given to children as one-off novelties. [58, pp. *vii–viii*]

3.4 Summary

The craft of pop-up making, also referred to as paper engineering, arose before the advent of printing, and continued with the advent of printed books, with its goals to provide better access to data, motion, and depth. The first elements to be used for this purpose were volvelles (wheels) and flaps. Although originally produced for adults, movable books made the transition to children's literature as that genre became prevalent in the mid-nineteenth century. Movable books reached their first golden age in the latter part of the 19th century, with the introduction of such elements as pull-tabs and scenics. True pop-ups, as opposed to other forms of movable books, exhibit true three-dimensional forms that rise from the page automatically when it is opened. Pop-ups are a later development and were not produced until 1929, but they quickly became popular with children. Today they are a common part of children's culture and have entered a second golden age. Current pop-up books are produced for adults as well as children and are more complex and striking than ever before, often using many types of movable elements in addition to pop-ups. Mass-produced pop-up books are, in spite of the high technology involved in their printing, designed and assembled largely by hand. By contrast, they are also made by artists and children as a personal craft.

Since it is practiced as a craft, paper engineering can be studied as a representative craft and the framework established in Chapter 2 can be applied to it. By focusing on the modularity of pop-ups, the knowledge of the various elements, their combinations and possible variations, the skill of making them, and the ability to appreciate the way the elements are used in the pop-ups of others can be seen to lie at the heart of the craft.

Engaging in paper engineering also exhibits the established values of craft, in that it provides personal and cognitive benefits for children practicing it. As a children's activity paper engineering benefits from using a well-known material (paper) and simple tools to create a product with which children are familiar and that combines mathematical content, both 2- and 3-dimensional artwork and written text. These attributes have been recognized by educators who apply pop-up making to classroom programs in literacy, mathematics, and design. In spite of this, paper engineering is under-utilized by teachers, who seldom know about these possible uses of the craft.

The discussion of pop-up construction begun here continues in Chapter 4 with a more detailed look at what pop-up elements are, how they are classified, how they are combined, and how they work. Methods for integrating computation into the making of pop-ups will be examined through a review of the literature surrounding the mathematics and simulation of pop-ups, and software systems previously developed to aid in their design. This knowledge of pop-up composition and previous research, combined with the discussion of the requirements for computer enhancement of craft learning described in Section 2.4, supports the development of general requirements for a system to aid children in learning paper engineering.