

## Investigating Analytic Tools for e-Book Design in Early Literacy Learning

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### **Abstract**

*Toward the goal of better e-book design to support early literacy learning, this study investigates analytic tools for examining design qualities of e-books for young children. Three research-based analytic tools related to e-book design were applied to a mixed genre collection of 50 e-books from popular online sites. Tool performance varied across design categories (e.g., multimedia) and administration revealing comparative strengths and weaknesses. Results inform researchers and educators who are engaged in designing and evaluating e-books as material resources in early literacy teaching and learning.*

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Developing Analytic Tools for e-Book Design in Early Literacy Learning  
“How does function arrive?” Ricardo Scofidio, architect

### **Introduction**

In a recent book chapter we explored the e-book as a new kind of digital reading resource for young children (Roskos & Brueck, 2009). Increasing in popularity and availability, e-books show promise as a new kind of storybook reading for young children, piquing not only their interest in books, but also promoting their early literacy concepts and skills (Bus, de Jong, Verhallen & van der Kooy-Hofland, 2009; de Jong & Bus, 2002; Labbo & Kuhn, 2000; Korat & Shamir, 2007). Yet, we know relatively little about what makes e-books ‘tick’ for promoting early literacy learning. In this research we continue our study of analytic tools that might better inform the design of high quality e-book learning environments.

### *Why e-Books Matter*

We need to pay attention to the spread of e-books in early childhood for two compelling reasons. One is the e-book effect on traditional adult-child storybook reading in the everyday lives of young children. Online reading of an e-book is different from sitting near or in the lap of

mom or dad, and sharing a storybook together. Not only is it physically different, which is a major change in and of itself, but it is cognitively different because new media enliven old media in novel ways. Labbo (2009), for example, reports how multiple readings of an electronic story with her two-year old grandson transformed the conventional shared book experience, stimulating rich descriptive language and new literacies (e.g., strategic navigation of hotspots).

The other is the e-book effect on children's emerging literacy concepts and skills, and what it means for individual literacy development in a digital age. Consider two points here. First, 'reading' an e-book, even in a pretend way, involves new skills, as well as old ones, in order to negotiate the book environment (Hassett, 2006). Page-turning, for example, requires different sets of motor abilities (hold-point-click) than in a real book (grasp-lift-place). How e-books might support new basic skills for reading in an online world is of high interest. Second, e-books afford opportunities for lots of independent practice and exploration on one's own – far more than adults can supply, especially in pre-K-K classrooms. What e-books as *playgrounds* for early literacy exploration and discovery learning may mean for preschool literacy education is also of high interest.

### *What an e-Book Is/Is Not*

An e-book is like a traditional storybook in several ways (Anderson-Inman & Horney, 1997). It displays print; it has book parts, such as a table of contents, chapters, pages; it is organized around a theme or topic for purposes of communication. But it is also fundamentally different from what we know and love as 'the storybook' in one very powerful way: it uses multimedia to support or enhance text on the screen. The addition of visual features (e.g., special effects), auditory features (e.g., music) and animation (e.g., movement) make an e-book more film-like in presentation than traditional adult-child book-reading with profound implications for what constitutes early reading experience.

At the most fundamental level the e-book affords an opportunity for storybook reading without adult mediation. Multimedia, in essence, replaces the adult mediator, providing the supports that "read the story" to the young child. This has its benefits for early literacy development with respect to word learning (Segers & Vermeer, 2008) and comprehension (Verhallen, Bus & de Jong, 2006), especially for children at risk, but it also has its dark side. Multimedia can overload the cognitive processing of young children such that meaningful engagement with story and print is seriously reduced, and the literacy experience is superficial—sort of like play without purpose. It can induce cognitive confusion over clarity in emerging reading skills by focusing attention away from understanding the purposes and technical aspects of reading (Downing, 1979). It can send the wrong message about what reading involves and its benefits.

### *What We Know About e-Book Design*

Optimal design features of e-books are yet to be specified, although some progress has been made in articulating high level generalizations of e-book design and construction. In their pioneer study of e-book design quality, de Jong and Bus (2003), for example, identify several design categories that can serve as a macro-framework for evaluating e-book construction, including book processing; multimedia in pictures; multimedia in print; and interactivity. At the highest level, the categories can be collapsed into a two-part framework that describes (a)

multimedia design, i.e., the assembly of digital assets such as audio, video and text, and (b) interactivity design, i.e., the interface that allows choice, control and engagement. This is helpful as a start-point in examining the overall design of an e-book. They also developed rating scales for quality of print and congruence between story and hotspots, which may serve as design criteria when working with these elements.

Examining e-books as educational tools in kindergarten, Shamir and Korat (2009) elaborate on these basic categories, identifying several high level design features relevant to young learners, such as (a) oral reading with text highlights that illuminate the nature of print (e.g., word boundaries); (b) hotspot activation aligned with text; (c) a dictionary option that allows repeated action by the child; and (d) a game mode separate from text mode. Worked into eBook design, these features can help to reduce distractibility during book reading.

At a more fine-grained level, Bus, et al (2009) advanced the understanding of e-book design for early literacy learning in a series of studies focused on children with language deficits (second language learners from low educated families). Working from the basic premises of Paivio's dual coding theory, namely that audio and visual processing systems are separate, but mutually supportive information-processing tracks, they observed the benefits of repeated exposure (threshold of 4x) to media rich e-books for improving these children's language skills (Verhallen, Bus & de Jong, 2006). Noteworthy in design terms is the salience of redundancy in multi-media supports, which may be key to sustaining linguistically at risk children's mental effort in reading for comprehension in the e-book environment.

Using two models of reading (The Simple View, Gough & Tunmer, 1986; Interactive-Compensatory, Stanovich, 1980) as lenses on design, McKenna and Zucker (2009) highlight design features of the electronic reading environment that support code-related skills and comprehension processes. Research is mixed, for example, on the benefits of animations, hotspots and highlights as code-related supports for young readers. Helpful at times, these features also distract children from paying attention to print. Supportive sometimes, they also can be annoying, thus reducing engagement, especially for able readers. The research is quite clear, on the other hand, as to design features that support story comprehension. Animated illustrations are more robust than static ones, for example, and embedded vocabulary aids look promising, although such cues need to be relevant and child-friendly.

### *What We Have/What We Need*

So--what design information do we have and what do we still need to construct good e-books for young children? The research suggests three design domains for consideration: (1) multimedia design which focuses on how words (printed; spoken) and pictures (static; dynamic) are presented; (2) interface design which describes conventions of use, format, and controls; and (3) learning design which involves the basic features of instruction—the *learn about loop* of purpose, content and feedback. Each domain contains some high level generalizations or principles that can be used to examine e-book design. A few principles are specified to the level of design elements. For example, graphics (visuals) in the multimedia domain should display quality of print (e.g., appropriate font size) (de Jong & Bus, 2003). Still missing, however, is design information that pertains to the modes of instruction (e.g., receptive), types of knowledge (e.g., factual) and cognitive demand (e.g., understanding) embedded in the e-book architecture, as well as motivational features.

*Investigating Analytic Frameworks for e-Book Design*

The role of the e-book in early literacy teaching and learning can be examined through many different lenses – as children’s literature, as an instructional resource, as assistive technology, and so on. Our interest in e-books is less glamorous perhaps in that it focuses on the technical side of the e-book – its digital internal works, so to speak. We want to know and understand what makes an e-book ‘tick’ and from that position to develop analytic tools that guide the design of e-books for the important purpose of helping young children read and learn.

We mentioned our book chapter above, which was for us a starting point in our study of e-books as an early literacy learning resource. In that chapter we probed the e-book from a learning object perspective. That is, we explored primary learning objects as the digital building blocks of e-book construction. Although much debated as to what it is, a learning object or LO, in simplest terms, is an assembly of digital assets, such as images, audio files, video clips, texts, and flash animations (Downes, 2003).

LOs are hierarchical in nature, ranging in size from single units (one digital asset) to complex structures (multiple digital assets with logical structure and coherence). The design of quality LOs is complex, because it involves the fusion of content and object around the goal of active learning as defined by learner-centered principles and practices (APA, 1997). Lim (2007) discusses five challenges that confront good LO design: (1) standards; (2) de-contextualization; (3) coherence; (4) granularity; and (5) pedagogy.

To examine the primary LOs in e-books for young children, we developed two exploratory tools. One of them allowed us to observe several high level design features of LOs, such as graphic design, but this tool lacked criteria for judging the quality of an LO. The other tool—a blueprint key—provided a schematic of an LO which permitted closer inspection of its internal design. Schematics have the advantage of revealing the LO architecture shaping the e-book reading environment, and in turn children’s early literacy experience within it. Yet the practicality of this analytic tool for examining structurally more complex LOs still needs to be tested.

Our investigation here continues this technical work by expanding the repertoire of research-based analytic tools that may inform design at high level steps, as well in the details that lead to good, workable, instructive, enjoyable e-books for children.

## **Method**

Our main research objective was to apply and assess different analytic tools toward the goal of better e-book design for early literacy learning. We identified three analytic tools from the research knowledge base and applied them to a sample of mixed genre e-books from popular online web sites. Each tool was assessed for its technical adequacy and usability in revealing design features of the e-book sample. Technical adequacy was determined by design factors in three categories: multimedia design; interface design and learning design. Usability was examined around practical characteristics.

*Sample*

A sample of 50 mixed-genre e-books (31 narrative [N]; 19 informational [I]) was randomly selected from five popular online sources easily accessible to teachers and parents seeking e-books for young children on the internet or in CD ROM format. Descriptive information on the sample is summarized in Table 1.

Table 1

*Description of e-Book Sample*

| Source   | Description  | Sample |      |           |
|--|--|--------|------|-----------|
|  |  | Total  | Info | Narrative |
| Living Books<br><a href="http://www.riverdeep.net">www.riverdeep.net</a>     | CD versions of popular children's books that utilize a home page with an active character to guide the reader to the different activities and modes of interaction within the story; may be purchased and used on compatible computers | 4      | 0    | 4         |
| Raz Kids<br><a href="http://www.raz-kids.com">www.raz-kids.com</a>           | Designed for beginning, emerging, and challenged readers K-6; free samples; subscribing teachers provided additional tools to monitor students' reading activities   | 5      | 2    | 3         |
| Starfall<br><a href="http://www.starfall.com">www.starfall.com</a>           | Focuses on essential reading skills as defined by the National Reading Panel and the motivation to read  | 16     | 9    | 7         |
| Tumble Books<br><a href="http://www.tumblebooks.com">www.tumblebooks.com</a> | Displayed on a Tumble Pad frame that displays controls for the reader to navigate through the book manually or automatically   | 19     | 7    | 12        |
| Reading Is Fundamental<br><a href="http://www.rif.org">www.rif.org</a>       | Sing or read along to the animated stories   | 6      | 1    | 5         |

### *Procedure*

Each analytic tool was constructed based on frameworks and descriptions found in the knowledge base. Analytic Tool I was adapted from the coding categories of de Jong and Bus (2003) and focused primarily on multimedia/ interactivity design features. Analytic Tool II was derived from principles of instructional design described by Clark and Mayer (2008). (See Appendix A.) The design goal of these principles is focused on learning in the online environment.

Analytic Tool III was developed in our earlier work, referred to as the blueprint key, and allowed for mapping the architecture of LOs as assemblies of digital assets. For our purposes here, the blueprint key was applied to representative screens of each e-book genre to provide a schematic of the e-book learning architecture.

Drawing on instructional design theory and research (Merrill, 1999; Shredoff, 1994; Wiley, 2000), we developed a Technical Adequacy/Usability Checklist to probe the design performance of each analytic tool. (See Appendix B). We then applied the Tools to the sample, conducting three different analyses using the following procedures: (1) establish inter-rater reliability on the Tool; (2) apply the Tool; (3) summarize results; and (4) rate the Tool performance using the Checklist.

## **Assessment of Analytic Tools**

### *Analytic Tool I*

#### *Inter-rater Reliability and Application*

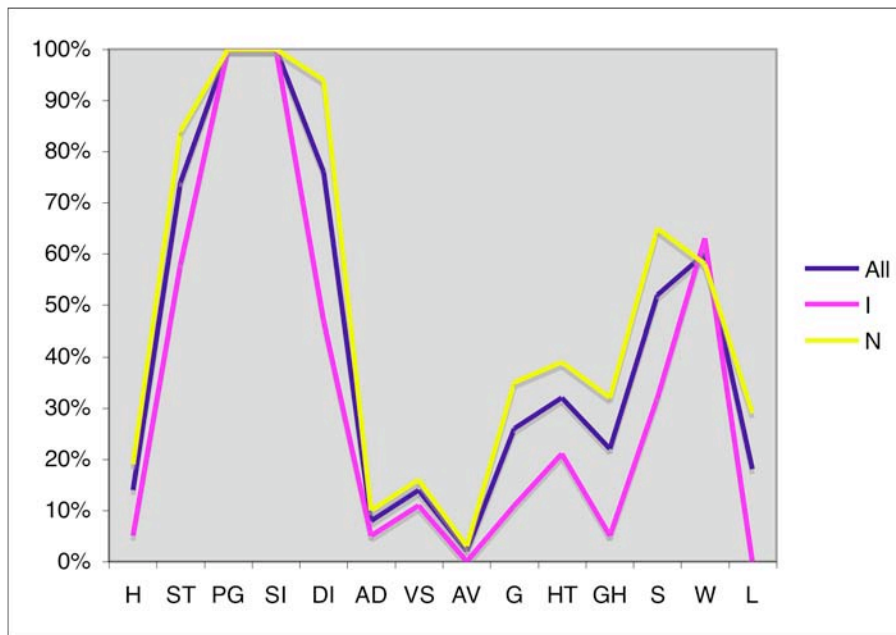
The Tool I application uses the entire e-book as the unit of analysis. It is organized into four categories—Book Assistants; Multimedia Illustrations; Multimedia Print; Interactivity—that reflect the major early literacy learning domains of Book Handling, Comprehension, Word Recognition and Cognitive Processing. The four categories include 14 elements that describe e-book design (e.g., presence of static and/or animated illustrations).

The initial round of coding on the e-book, *Maria Goes to School*, yielded a 76% inter-rater reliability across design categories and elements followed by a second round of discussion that achieved consensus. Each researcher then coded a sub-sample of the collection using online tools for accessing e-books and data recording.

### *Summary of Results*

Figure 1 summarizes the results from the application of Tool I to the sample as a whole as well as disaggregated by genre where the entire e-book serves as the unit of analysis.

Figure 1. Tool I results.



I: Informational e-books; N: Narrative e-books;

BOOK ASSISTANTS: H: home; ST: start-stop; PG: page; MULTIMEDIA ILLUSTRATIONS: SI: static illustrations; DI: dynamic illustrations; MULTIMEDIA PRINT: AD: oral reading; VIS: text highlights; AV: Aud+Vis; INTERACTIVITY G: games; HT: hotspots; GH: games + hotspots; S: sentence; W: word; L: letter

A survey of the analysis suggests a garden-variety design pattern that reflects the standard conventions of e-books for young children. Basics of book handling (Book Assists) are addressed across the sample in conventions of a home page (H), start-stop arrows (ST), and book-like pages (P). Although very few of the e-books in the sample included a distinct home page (12% All; 5% I; 19% N), most provided start-stop features at the screen page level (71% All; 58% I; 84% N). Navigation permits learner control primarily in page turning followed by starting and stopping the audio narration. Learner control is more prominent in narrative e-books as compared with informational e-books.

With respect to multimedia illustrations, nearly all illustrations in the narrative genre are animated in some way while this occurs in less than half of the informational books (100%; 47% respectively). Other than *reading aloud*, print is not supplemented by audio sounds and/or video very often in both genres (<20%). As a result, attention is directed to the gist of the written text, i.e., oral language comprehension, and not the print per se.

The emphasis on comprehension over print processing is also evident in the interactivity options. Nearly one-third of the narrative e-books include games/songs, hotspots or both to support comprehension (35%; 39%; 32%) although these devices are less prevalent in informational e-books (11%; 21%; 5%). Attention to print as an object of learning is primarily at the sentence level in narratives (65%) and the word level in informational texts (63%). Less than 30% of narratives moved to the letter level of print while informational texts in the sample did not reach this fine-grained of a level. All in all, the Tool I analysis reveals an e-book sample that reflects design features of traditional storybook reading implanted in the electronic environment.

Table 2

*Assessment of Tool I*

| <b>Technical Adequacy</b> |                            |                             |                           |                           |
|---------------------------|----------------------------|-----------------------------|---------------------------|---------------------------|
| Design Domain             | The Tool analyzes          | The Tool analyzes to a      |                           |                           |
|                           |                            | Large extent<br>>3 elements | Some extent<br>3 elements | Ltd extent<br><3 elements |
| Multimedia                | How words are presented    | +                           | -                         | -                         |
|                           | How pictures are presented | -                           | -                         | +                         |
| Interface                 | Choice                     | -                           | -                         | +                         |
|                           | Control                    | -                           | +                         | -                         |
|                           | Conventions                | -                           | +                         | -                         |
| Learning                  | Learning loop              | -                           | +                         | -                         |
|                           | Pedagogical assists        | -                           | -                         | +                         |
|                           | Knowledge types            | -                           | -                         | +                         |
|                           | Cognitive demand           | -                           | -                         | +                         |
| <b>Usability</b>          |                            |                             |                           |                           |
|                           | The Tool requires          | The Tool requires to a      |                           |                           |
|                           |                            | High degree                 | Some degree               | Ltd degree                |
| Administration            | User qualifications        | -                           | +                         | -                         |
|                           | Training                   | -                           | +                         | -                         |
|                           | Time Commitment            | -                           | +                         | -                         |
|                           | Technology supports        | -                           | -                         | +                         |

In brief, the assessment shows the strengths of the Tool in identifying a core element of multimedia for literacy learning—how words are presented as well as several elements of interface design that help young learners practice the conventions of print, such as orienting from left-to-right and page turning. It also reveals design elements that support a learning loop (purpose, content, feedback) in the e-book. The Tool appears less functional for tapping other critical elements that contribute to multimedia instruction, such as pedagogical assists, types of knowledge cultivated in the environment, and cognitive demand of the e-book as an early literacy learning experience. In terms of usability, Tool I appears relatively easy to use by those with some background knowledge in multimedia learning and instruction. Based on our experience, it took on average 10-15 minutes to apply the Tool to an e-book and code the evidence. Other than online access to the e-book, it required no other special technology to use the Tool.



### *Analytic Tool II*

#### *Inter-rater Reliability and Application.*

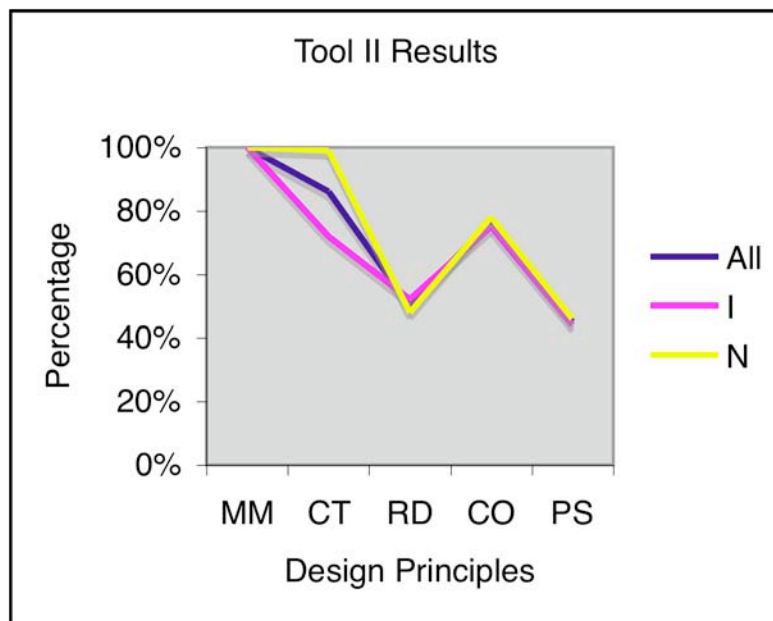
The Tool II application uses the screen page as the unit of analysis. The Tool is based on a set of instructional design principles for e-learning proposed by Clark And Mayer (2008) as described in Appendix A. It focuses on five principles--multimedia, contiguity, redundancy, coherence and personalization—and 12 design elements that further specify the set of principles. It also includes an analysis of five graphic types that are used in multimedia design: decorative, representational, organizational, relational, transformational and interpretive.

Of the 843 screen pages constituting the sample, 30% or 253 screen pages were randomly selected for analysis and equally distributed among the 50 e-books, yielding a five screen-page sub-sample for each e-book as determined by a random number generator. On our first pass on the *Maria Goes to School* sub-sample we achieved an inter-coder reliability of 78% across categories and elements of the Tool. Following discussion focused on clarifying definitions of the types of multimedia images, coherence, and personalization, we achieved consensus, and each researcher was assigned a set of e-books for application of the Tool to screen-pages.

#### *Summary of Results.*

Figure 2 displays the results of the Tool II application on the 253 screen-pages representative of the total e-book collection.

*Figure 2. Tool II results.*



MM: multimedia [words + pictures]; CT: contiguity; RD: redundancy; CO: coherence; PS: personalization

At a high level of generalization, the analysis generally corroborates the garden-variety pattern of the e-book collection as revealed by Tool I and shown here in the strengths in both the

multimedia (avg100%) and contiguity principles (avg97%), i.e., print near graphics (I: 94%; N: 99%) and synchronization of audio with print (I: 49%; N: 99%). Over and above Tool I, however, it reveals design strengths and weaknesses geared to early literacy instruction. A notable strength of the sample is shown in its design related to the coherence principle, demonstrating the avoidance of extraneous sounds (avg 78%), graphics (avg 69%) and words (avg 84%), thus focusing attention on the story line or content information. This advantage, though, may be offset by a general lack of redundancy (avg 50%). which is a critical design factor in e-books for young children given their nascent auditory processing skills (Bailey & Snowling, 2002). Coupled with weaker design related to the personalization principle—other than child-friendly voice—the analysis illuminates the instructional qualities of the sample for helping young children gain literacy concepts and skills in a read aloud context.

In addition the Tool II analysis yields detailed information about visuals. (See table 3.) While visuals are mostly representational, i.e., illustrating the written text, a sizeable amount are merely decorative (28% I; 35% N) and very few are interpretive (13% I; 6% N), or transformational, i.e., illustrating changes (1% I; 3% N)—design negatives especially troubling in the informational genre given the significance of content and vocabulary in reading comprehension (Hirsch, 2009; Stanovich, 1986).

Table 3

*Graphic Types by Genre*

| <b>Graphic Type</b> | <b>Informational</b> | <b>Narrative</b> |
|---------------------|----------------------|------------------|
| Decorative          | 28%                  | 35%              |
| Representational    | 57%                  | 55%              |
| Organizational      | 1%                   | 0%               |
| Transformational    | 1%                   | 3%               |
| Interpretive        | 13%                  | 6%               |

Note: Relational types were not coded because they summarize quantitative relationships and did not pertain to the sample.

Compared to the Tool I analysis, the Tool II analysis widens the lens on e-book design to reveal elements of multimedia instruction beyond the visible spectrum of multimedia presentation. It expands to include graphic types that contain information about types of knowledge available; it reveals extraneous uses of multimedia that can derail comprehension; it describes personalization elements that can motivate attention; and it describes pedagogical assists in more detail (e.g., redundancy).

*Assessment of Tool II*

Our assessment of Tool II is provided in Table 4. The strengths of this analytic tool are found in its abilities to identify multimedia and learning design elements. In this respect, it is more robust than Tool I, and perhaps more sensitive to the subtleties of design that engage the young learner in multimedia learning that promotes early literacy concept and skill development. Its primary weakness is in the lack of information about the interface design, which is serious because developing the young child's knowledge of print conventions is critical in the early stages of literacy development (Rathvon, 2000).

In terms of usability, this Tool is also relatively easy to use, and can be applied by those with a modest amount of background knowledge in multimedia approaches to early literacy learning. It requires a minimal amount of training, although the time required to apply the Tool is greater than that for Tool I.

Table 4

*Assessment of analytic Tool II.*

| <b>Technical Adequacy</b> |                            |                             |                           |                           |
|---------------------------|----------------------------|-----------------------------|---------------------------|---------------------------|
| Design Domain             | The Tool analyzes          | The Tool analyzes to a      |                           |                           |
|                           |                            | Large extent<br>>3 elements | Some extent<br>3 elements | Ltd extent<br><3 elements |
| Multimedia                | How words are presented    | +                           |                           |                           |
|                           | How pictures are presented | +                           |                           |                           |
| Interface                 | Choice                     | -                           | -                         | +                         |
|                           | Control                    | -                           | -                         | +                         |
|                           | Conventions                | -                           | -                         | +                         |
| Learning                  | Learning loop              | -                           | +                         | -                         |
|                           | Pedagogical assists        | -                           | +                         | -                         |
|                           | Knowledge types            | +                           | -                         | -                         |
|                           | Cognitive demand           | +                           | -                         | -                         |
| <b>Usability</b>          |                            |                             |                           |                           |
|                           | The Tool requires          | The Tool requires to a      |                           |                           |
|                           |                            | High degree                 | Some degree               | Ltd degree                |
| Administration            | User qualifications        | -                           | +                         | -                         |
|                           | Training                   | -                           | +                         | -                         |
|                           | Time Commitment            | +                           | -                         | -                         |
|                           | Technology supports        | -                           | +                         | -                         |

*Analytic Tool III  
Application*

Tool III--the blueprint key--focuses on digital assets (audio, video, text) as the unit of analysis in an effort to identify the learning-oriented assembly at the screen-page level and in turn patterns that reflect the learning architecture of an e-book construction. It also probes

navigation elements most often associated with a graphical user interface (GUI), the part of a computer program that sends messages to and receives instructions from the end user. Given the schematic approach of this Tool, inter-rater reliability is not central in its application, and thus was not conducted. Rather one of the researchers applied the key to screen-page samples taken from the beginning, middle and end of one narrative *My Family* and one screen page from the informational e-book *Crazy for Canada*.

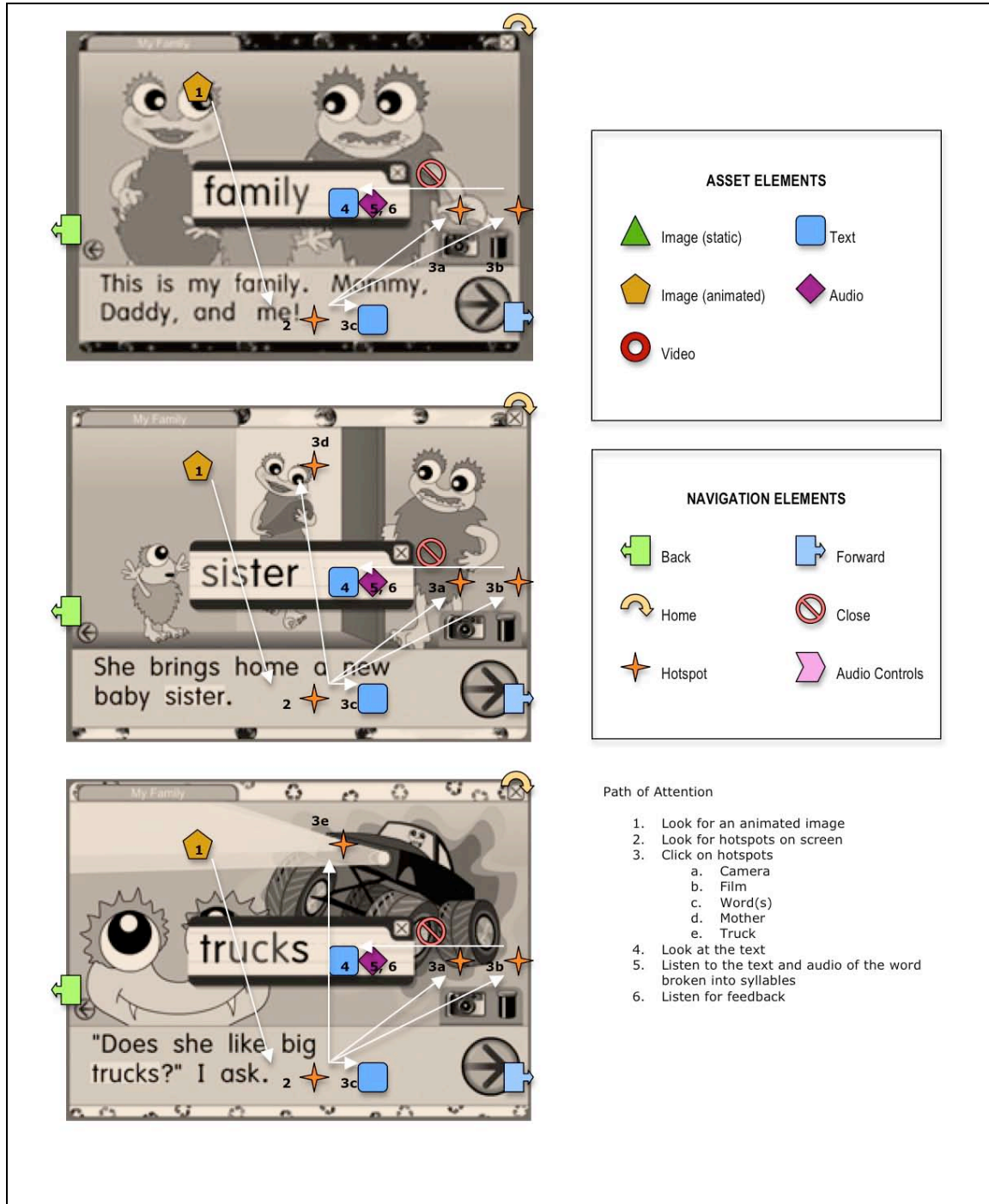
### *Summary of Results.*

What do the blueprint keys tell us about e-books? As stated earlier, the blueprint key provides a schematic of how digital assets (audio, video, text) and navigational tools (controls) form the learning architecture of an e-book. It displays the internal ‘works’ of an e-book at the screen-page level, and thus shows how the object functions as a learning environment. It reveals, as well, the learning pathways afforded the user in the e-book as a multi-modal literacy environment. Schematics of screen-pages rendered from a blueprint key illustrate the prevailing architecture of an e-book, and the learning patterns that it contains. Just as the architecture of a building shapes what people do there, so the architecture of the e-book shapes the learning of its users. The e-book, in architectural terms, gestures ‘literately’ to the child.

We applied the blueprint key (Tool III) to three screen pages taken from the beginning, middle and end of the narrative e-book, *My Family*, and one screen-page representative of the informational e-book, *Crazy for Canada*. Our goal was to examine their internal ‘works’ or assemblies for evidence of learning pathways at cognitive and motor processing levels that characterize the learning architecture of the e-book as a learning object.

Let’s inspect first the schematics of the sample screen-pages from *My Family* as illustrated in Figure 3. The purpose of the asset assembly is to break words (e.g., family) into syllable segments to ‘teach’ a decoding skill (use syllables to figure out an unknown word). As the audio plays, the correlating text segment is highlighted. After each syllable is played, the reader receives feedback. This is the learning loop where the purpose is decoding, the content is family-related words, and the feedback is audio confirmation of the decoded word.

Observe the *path of attention* established on each screen-page that guides cognitive activity in the loop: (1) **Look** for an animated image (on the illustration) > (2) **Look** for the hotspots > (3) **Click** on a hotspot (3a Camera, 3b Film or 3c Word(s)) > (4) **Look** at the text > (5) **Listen to and Look at** the syllable segmentation of the word > (6) **Listen** to the whole word.

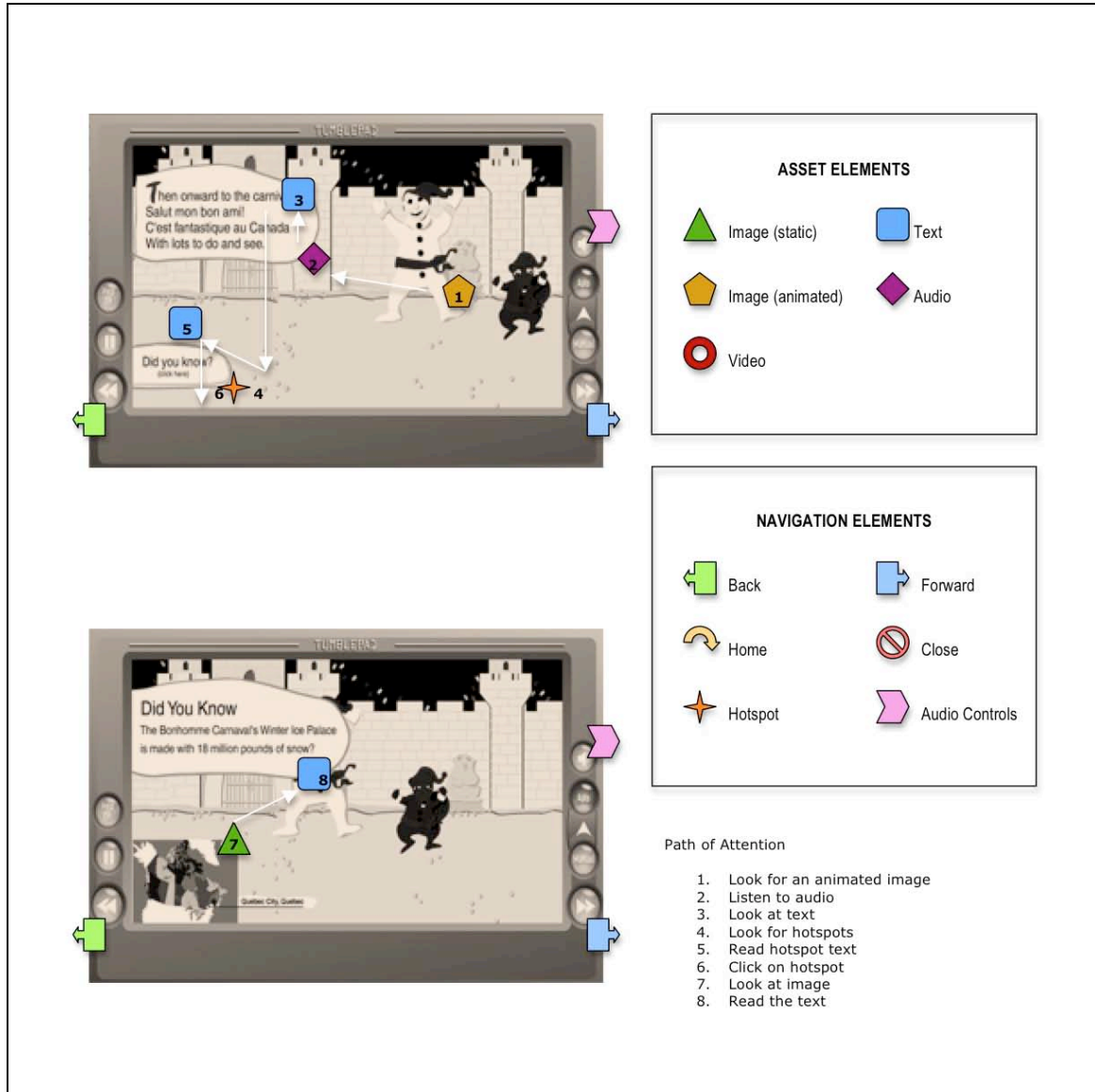
Figure 3. Blueprint key – *My Family*

In brief, the schematics show the scatter in attention that can occur at Stop 2 in the learning pathway where the young reader encounters diversions (3a; 3b; 3d; 3e) from the instructional goal (3c). Even as audio and text are in close proximity in the text option (3c), a strength in design terms, the animated image as the point of entry (1) followed by the hotspots (2) may derail attention from the 'get go' and make it harder to steer attention to the intended

goal (3c). Navigational elements reinforce the fractionating of attention by directing motor actions from animation (1) to hotspots (2). Once at Stop 3c, recouping attention may also pose challenges, although the considerable audio support probably helps. So: is this scatter-like learning pathway a problem? It is hard to say without more investigation, although considerable multimedia research describes the strain on cognitive systems due to embellishments (Mayer & Moreno, 2003). Other researchers suggest that repeated practice on a routine with digital supports, like the audio supports provided in 3c, might lead to dependence or a prosthetic effect such that the student cannot perform the skill without the digital supports (McKenna & Walpole, 2007).

Let's turn then to a schematic of a two-layered screen-page from the informational text, *Crazy For Canada*, shown in Figure 4. The purpose of the assembly is to 'teach' factual information about Canada. Consider the *path of attention* established in this learning loop: (1) **Look** for an animated image > (2) **Listen** to the audio > (3) **Look** at the text > (4) **Look** for hotspots > (5) **Read** the hotspot text > (6) **Click** on the hotspot > (7) **Look** at the image > (8) **Read** the text.

Figure 4. Blueprint key – Crazy For Canada



As above, the start-point of engagement is the animated image (1), which may or may not be related to the instructional goal, thus serving as an attention-getter. But at the very next stop, attention is drawn to text with audio supports (2,3) then followed up by hotspots (4, 6) that make reading demands (5, 8). The sequence of look-read-search-read organizes and focuses attention to the instructional goal of reading text for information. It offers, in short, a clear learning pathway with few diversions. Well-ordered navigation also offers more granular control of the spoken text. For example, the user can start and stop the audio with the PLAY/PAUSE button. They can also toggle between a manual and automatic mode. In automatic mode, the pages of the e-book turn themselves. If young readers desire to flip the pages themselves, then they can simply toggle to manual mode. This level of navigational control, when combined with the availability of an audio asset, can enhance a well-structured learning pathway. This would be most notable when using manual mode while having the audio is toggled OFF. These

navigational settings present the e-book reader an additional opportunity to encounter the text earlier in the pathway with feedback via audio assets *after* the reader has encountered the print. Tool III makes this value-added navigational feature apparent. Is this helpful in design terms? Probably because it illuminates what the learning environment has to offer in terms of challenge, feedback, and sense of control. According to Mihaly Csikszentmihalyi (1990)—the discoverer of *flow*--these are the essentials of enjoyment that fuel intrinsic motivation in reading and learning to read. This kind of technical information revealed by the schematics gets us closer to understanding the affective dimension of e-book design that influences the motivational effects of this curricular resource (Kamil, Intrator & Kim, 2000).

### *Assessment of Tool III.*

Results displayed in Table 5 show the overall strengths of Tool III as compared to Tools I and II. First it has the capacity to identify elements in all three of the design categories—multimedia, interface, learning--and at substantive levels in each. It describes the interface design, for example, to a large extent, and in a very visual way. Of the three Analytic Tools, it also has more capacity to demonstrate the learning function of the e-book environment in both cognitive and motor skill domains. Similar to the other Tools, it is limited, however, in locating evidence of knowledge types in the design architecture, although the schematic of the informational e-book screen-page, *Crazy for Canada*, did indicate how the assembly might facilitate the construction of factual knowledge. Still, the Tool's power for identifying design elements across categories may be at the expense of practicality. The Tool requires a high degree of multimedia learning knowledge to use it, not to mention lots of time to construct schematics and considerable technology to do the job right.



Table 5

*Assessment of Analytic Tool III*

| <b>Technical Adequacy</b> |                            |                             |                           |                           |
|---------------------------|----------------------------|-----------------------------|---------------------------|---------------------------|
| Design Domain             | The Tool analyzes          | The Tool analyzes to a      |                           |                           |
|                           |                            | Large extent<br>>3 elements | Some extent<br>3 elements | Ltd extent<br><3 elements |
| Multimedia                | How words are presented    | -                           | +                         | -                         |
|                           | How pictures are presented | -                           | +                         | -                         |
| Interface                 | Choice                     | +                           | -                         | -                         |
|                           | Control                    | +                           | -                         | -                         |
|                           | Conventions                | +                           | -                         | -                         |
| Learning                  | Learning loop              | +                           | -                         | -                         |
|                           | Pedagogical assists        | +                           | -                         | -                         |
|                           | Knowledge types            |                             |                           | +                         |
|                           | Cognitive demand           |                             | +                         |                           |
| <b>Usability</b>          |                            |                             |                           |                           |
|                           | The Tool requires          | The Tool requires to a      |                           |                           |
|                           |                            | High degree                 | Some degree               | Ltd degree                |
| Administration            | User qualifications        | +                           | -                         | -                         |
|                           | Training                   | +                           | -                         | -                         |
|                           | Time Commitment            | +                           | -                         | -                         |
|                           | Technology supports        | +                           | -                         | -                         |

**Conclusions**

There is a growing research base that informs e-book design for early literacy learning. It provides information for the development of analytic tools that can be used to examine e-book construction as a form of multimedia learning/instruction. The goal of instructional design is to facilitate learning and development and to obtain a product that helps people learn better (Reigeluth 1999). To achieve this goal, design has to function at every juncture in the construction of high quality multimedia curricular resources for young children. High-performing analytic tools can provide insights into effective multimedia designs that support early literacy learning.

We ‘tried out’ three research-based analytic tools that inspect design elements in early childhood e-books on a mixed-genre sample and assessed their technical adequacy and usability. Tool performance varied across design domains and administration revealing strengths and weaknesses of these analytic tools. The de Jong-Bus Tool, for example, revealed design strengths at the word level in a relatively straightforward way, but was less effective in describing the basic learning design of an e-book for supporting literacy skills. Stronger in this regard, the Clark-Mayer Tool yielded considerably more information on learning design providing an analytic focus on graphic types, extraneous media uses, cognitive demand and personalization elements (e.g., author presence). The added analytic power, however, comes at the price of greater time commitment and more expertise on the part of users. The Blueprint Key Tool is a power tool that goes to the level of LOs and illuminates the *path of attention* from the point of

engagement on the screen-page, thus making more visible the potential for literacy learning. In this respect it is more complex and more precise, and thus requires more knowledge and training to use it properly. Based on the longstanding practical advice of *pick the right tool for the job*, researchers and educators may find these distinguishing features among analytic tools helpful in activities related to e-book construction for purposes of influencing early literacy learning.

Our results point to a need for robust analytic tools that inform design in ways that lead to more careful, more thoughtful, more functional e-books that support early literacy learning cognitively and affectively. Different analytic tools reveal different design elements and patterns, and this design information is key to crafting e-book interactions for the benefit of the young learner. There is a need for multiple analytic tools that can examine *e* (electronic) and *book* (text) design elements more systematically, more specifically and more precisely for effects on emerging readers. These are the necessary tools that can advise and guide the fusion of content and object along that thin boundary between form and function.

## References

- Anderson, L., & Krathwohl, D. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Addison Wesley Longman.
- Anderson-Inman, L., & Horney, M. (1997). Electronic books for secondary students. *Journal of Adolescent & Adult Literacy*, 40(6), 486-491.
- American Psychological Association. (1997). Learner-centered psychological principles: A framework for school redesign and reform. Washington, DC: Author. Retrieved on June 1, 2007 from <http://www.apa.org/ed/lcp.html>
- Authors (2009). The eBook as a learning object in an online world. In A. Bus & S. Neuman (Eds.), *Multimedia and literacy development* (77-88). New York: Routledge.
- Bailey, P & Snowling, M (2002). Auditory processing and the development of language and literacy. *British Medical Bulletin*, 63, 135-146.
- Bus, A., de Jong, M., Verhallen, M., & van der Kooy-Hyland. (2009). How onscreen storybooks contribute to early literacy. In A. Bus & S. Neuman (Eds.), *Multimedia and literacy development* (pp. 153-167). New York: Routledge, Taylor & Francis.
- Clark, R., & Mayer, R. (2008). *E-Learning and the science of instruction*. San Francisco, CA: Pfeiffer.
- Csikszentmihalyi, M (1990). Literacy and intrinsic motivation. *Daedalus*, 119(2), 115-140.
- de Jong, M., & Bus, A. (2002). Quality of book-reading matters for emergent readers: An experiment with the same book in a regular or electronic format. *Journal of Educational Psychology*, 94(1), 145-155.
- de Jong, M., & Bus, A. (2003). How well suited are electronic books to supporting literacy? *Journal of Early Childhood Literacy*, 3(2), 147-164.
- Downes, S. (2003). Design and reusability of learning objects in an academic context: A new economy of education?, *USDLA Journal*, 17(1), 3-22. Retrieved May 1, 2006 from [http://www.usdla.org/html/journal/JAN03\\_Issue/ED\\_JAN03.pdf](http://www.usdla.org/html/journal/JAN03_Issue/ED_JAN03.pdf)
- Downing, J. (1979). *Reading and Reasoning*. Oxford: Chambers.
- Gough, P., & Tunmer, W. (1986). Decoding, reading, and reading disability. *Remedial and Special Education* 7(1), 6-10.
- Hassett, D. (2006). Signs of the times: The governance of alphabetic print over 'appropriate' and 'natural' reading development. *Journal of Early Childhood Literacy*, 6(10), 77-103.
- Hirsch, ED (2006). *The case for bringing content into the language arts block and for a knowledge-rich curriculum core for all children*. Retrieved on May 17, 2009 from <http://www.aft.org/pubs-reports/american-educator/issues/spring>
- Kamil, M., Intrator, S & Kim, H (2000). Effects of other technologies on literacy and learning. In ML Kamil, PB Mosenthal, PD Pearson & R Barr (Eds.), *Handbook of Reading Research*, V3 (771-788). Mahwah, NY: Erlbaum.
- Korat, O. & Shamir, A. (2007). Electronic books versus adult readers: Effects on children's emergent literacy as a function of social class. *Journal of Computer Assisted Learning*, 23 (3), 248-259.
- Labbo, L (2009). "Let's do the computer story again, Nana.": A case study of how a 2-year-old and his grandmother shared thinking spaces during multiple shared readings of an

- electronic story. In A. Bus & S. Neuman (Eds.), *Multimedia and literacy development* (pp. 196-210). New York: Routledge, Taylor & Francis
- Labbo, L., & Kuhn, M. (2000). Weaving chains of affect and cognition: A young child's understanding of CD-ROM talking books. *Journal of Literacy Research*, 32(2), 187-210.
- Lim, G. (2007). Instructional design and pedagogical consideration for the ins-and-outs of learning objects. In A. Koobang, & K. Harman (Eds.), *Learning objects and instructional design* (pp. 89-137). Santa Ross, CA: Informing Science Press.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38, 43-52.
- McKenna, M. & Walpole, S. (2007). Assistive technology in the reading clinic: Its emerging potential. *Reading Research Quarterly*, 42, 140-45.
- McKenna, M & Zucker, T. ( 2009). Use of electronic storybooks in reading instruction. In A Bus & SB Neuman (Eds). *Multimedia and literacy development* (254-272). New York: Routledge.
- Merrill, M.D. (1999). Instructional transaction theory: Instructional design based on knowledge objects. In C.M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (Vol. 2) (pp. 397-424). Mahwah, NJ: Lawrence Erlbaum Associates.
- Rathvon, N. (2000). *Early reading Assessment*. New York: Guilford Publications.
- Reigeluth, C. (1999). Knowledge building for use of the internet in education. *Instructional Science*, 31, 341-346.
- Segers, E., & Vermeer, A. (2008). Vocabulary learning by computer in kindergarten: The possibilities of interactive vocabulary books. In O. N. Saracho, & B. Spodek (Eds.), *Contemporary Perspectives on Science and Technology in Early Childhood Education* (pp. 149- 166). Greenwich: Information Age Publishing.
- Shamir, A & Korat, O ( 2009). The educational electronic book as a tool for supporting children's emergent literacy. In A Bus & SB Neuman (Eds). *Multimedia and literacy development* (168-181). New York: Routledge.
- Shredoff, N. (1994). Information interaction design: A unified field theory of design, 1-15. Retrieved June 1, 2003 from <http://www.nathan.com/thoughts/unified/unified.pdf>.
- Stanovich, K. (1980). Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly*, 16(1), 32-71.
- Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, 21(4), 360-407.
- Verhallen, M., Bus, A., & de Jong, M. (2006). The promise of multimedia stories for kindergarten children at risk. *Journal of Educational Psychology*, 98, 410-419.
- Wiley, D. A. (2000). *Learning object design and sequencing theory*. Unpublished doctoral dissertation, Brigham Young University. Retrieved May 1, 2006, <http://davidwiley.com/papers/dissertation/dissertation.pdf>

## Appendix A

## Instructional Design Principles for e-Learning

(Adapted from Clark, RC & Mayer, RE (2008). *E-Learning and the science of instruction*. San Francisco, CA: Pfeiffer).

| Principle  | Key Elements   | What To Look For   |
|------------|--|--|
| Multimedia | Include both words and graphics<br>Select graphics that support learning <sup>1</sup><br><br>Changing static to animated illustrations | Graphics & text present information<br>Graphics relevant to purpose, not decorative<br>Representative graphics illustrate facts and concepts<br>Animations are limited; used to illustrate content<br>Organizational graphics show relationships among ideas<br>Relational graphics show quantitative relationships<br>Transformational graphics show changes over time<br>Interpretive graphics explain or make visible phenomena<br>Graphics used as cases |
| Contiguity | Place printed words near corresponding graphics<br>Synchronize spoken words with corresponding graphics                                | Screens place print near graphic it describes<br>Feedback on same screen as question/answer<br>Directions on same screen as steps<br>Linked information does not obscure screen information<br>Text place next to/within graphics not below [information genre]<br>Legend call outs embedded in graphics<br>Narrated graphics in which corresponding words & graphics are presented simultaneously   |
| Redundancy | Do not add on screen text to narrated graphics<br><br>Consider adding on screen text to narration in special situations                | Graphics are described by words presented in the form of audio narration, not by concurrent narration & redundant text<br>On screen text can be narrated when screens do not include graphics<br>When language is challenging, words are presented as texts  |

|                 |  |   |
|-----------------|--|---|
| Coherence       | Avoid extraneous audio   | Lessons [pages] do not contain background sounds  |
|                 | Avoid extraneous graphics  | Lessons [pages] do not contain non-essential illustrations  |
|                 | Avoid extraneous words   | Lessons [pages] do not contain details non-essential to the purpose<br>Lessons [pages] present core content with sufficient words and graphics to help the learner understand the main points |
| Personalization | Use conversational rather than formal style [child-friendly voice] | Content presented in conversational language  |
|                 | Use effective on-screen coaches to promote learning                | Coaching is provided  |
|                 | Make the author visible to promote learning                        | Agents do not need to look realistic<br><br>Voice quality is natural<br>Agents serve an instructional purpose<br>Author expresses views or experiences relevant to instructional purpose      |

<sup>1</sup> Five types of graphics: decorative, representational, organizational, relational, transformational, interpretive

## Appendix B

## Technical Adequacy/Usability Checklist

| <b>Technical Adequacy</b> |   |                             |                           |                           |
|---------------------------|---|-----------------------------|---------------------------|---------------------------|
| Design Domain             | The Tool analyzes   | The Tool analyzes to a      |                           |                           |
|                           |   | Large extent<br>>3 elements | Some extent<br>3 elements | Ltd extent<br><3 elements |
| Multimedia <sup>2</sup>   | How words are presented<br>How pictures are presented                       |                             |                           |                           |
| Interface                 | Choice<br>Control<br>Conventions  |                             |                           |                           |
| Learning <sup>3</sup>     | Learning loop<br>Pedagogical assists<br>Knowledge types<br>Cognitive demand |                             |                           |                           |
| <b>Usability</b>          |   |                             |                           |                           |
|                           | The Tool requires   | The Tool requires to a      |                           |                           |
|                           |   | High degree                 | Some degree               | Ltd degree                |
| Administration            | User qualifications<br>Training<br>Time Commitment<br>Technology supports   |                             |                           |                           |

<sup>2</sup> Defined as words that can be printed and/or spoken + pictures that can be static and/or animated (Clark & Mayer, 2008).

<sup>3</sup> Defined as multimedia instruction (presenting words & pictures that are intended to foster learning (Mayer & Moreno, 2003) and information design defined as a) type of knowledge represented [factual, conceptual, procedural, meta cognitive]; and (b) level of cognitive demand [remembering; understanding; critical thinking] (Anderson & Krathwohl, 2001; Shredhoff, 1994)