Chapter 5
Print to Pixel: Foundations of an E-Book Instructional Model in Early Literacy

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Introduction

For students of all ages, the electronic book is a rapidly growing alternative to the traditional book; how this new age tool will impact reading and learning to read at school, however, remains unclear. Equally uncertain is the role of the e-book in beginning reading instruction and early reading experiences as the technology spreads more widely into early childhood settings. Publishers, such as Scholastic and TumbleBooks, for example, offer an increasing array of e-books for young children on a subscription basis—even iTunes now carries an e-book collection downloadable to the iPod/iPad (Mobi). As the technology of the book (as we know it) shifts from largely hard/paperbound to electronic-enabled, our research interest is in not only *what this means* for early literacy development and learning but also *what it might look like* in preschool settings. Formative studies of e-book applications in preschools are particularly appropriate at this early point in this line of research for at least two reasons. One, we have no articulated models of early literacy instruction with e-books. And two, we lack information about e-book pedagogies, that is, approaches and techniques that hold promise for equipping young children for reading in the twenty-first-century literacy. Our chapter describes a four-component e-book instructional model that we are currently implementing in preschool classrooms and observing both in terms of design functionality and usability.

Design has to function at every juncture of the object—Elizabeth Diller

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Foundations of the Model and Preliminary Research

At an early phase in a design process, we conceptualized an e-book instructional model that was purposefully underspecified to allow a wide-angle view of what it takes and what happens when e-book technology is introduced into preschool literacy instruction. The model consists of four components grounded in studies of e-book pedagogy in classrooms (e.g., McKenna and Zucker 2009; Moody et al. 2010) and the knowledge base on early literacy instruction with young children (Dickinson and Neuman 2006; NELP 2008).

- The e-book and its qualities in terms of design and content
- The physical environment of e-book reading in the classroom
- Engagement in e-book reading for small groups and individuals
- Explicit early literacy instruction using e-books

We used a formative research approach, creating a prototype model for implementation in a small sample of Early Reading First classrooms (Midwest, Southwest) and testing it using a convenience sample (4 teachers, 12 children) to observe, define the salient attributes, and rate, in situ, the functioning of each component toward the goal of framing a model for replication and further testing (Collins et al. 2004; Zaritsky et al. 2003). Data were analyzed qualitatively using Carney's ladder of abstraction method (Carney 1990) to formatively assess the functionality of the model in the preschool learning environment and to gauge its potential usability in early literacy practice. Adapting a typological analytic strategy (Lofland 1971), observational data were summarized in the form of ratings based on a rudimentary 0–3 rating scale to represent evidence of presence (0 = no presence, 1 = low presence, 2 = moderate presence, 3 = high presence) of critical attributes in each component. In the following sections, we discuss each component in turn, describing its research foundations and early research results to date.

E-Book Quality

Few studies have directly examined the internal instructional design of the e-book as a literacy learning resource for young children (Roskos and Brueck 2009), although studies focused on literacy development have peripherally observed design problems. Labbo and Kuhn (2000), for example, commented on the need for better designed digital conventions (e.g., pop-ups) to produce more considerate texts that support comprehension. Examining e-books as educational resources in kindergarten, Shamir and Korat (2009) identified several high-level design features beneficial for young learners, such as (a) an oral reading with text highlights that illuminate the nature of print (e.g., word boundaries), (b) a 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.

More specifically, de Jong and Bus (2003) developed a three-part framework for examining e-book construction: (a) book processing; (b) multimedia design, that is, the assembly of digital assets such as audio, video, graphics, and print; and (c) interactivity design, that is, the interface that allows choice, control, and engagement. Within these categories, they specified 15 characteristics that describe overall e-book quality. For example, the interactivity of illustrations is described as (1) no interactivity, (2) in games and/or songs and/or hotspots, (3) in games and/or songs, or (4) in hotspots. None of these features, however, were scaled for purposes of critiquing quality. In addition, they examined two other categories—quality of print and of hotspots—creating scales for each. To judge quality of print, they developed a 5-point scale ranging from unclear to clear print size, color, position, and spacing; for quality of hotspots, they used a 3-point scale ranging from incongruent to congruent with the story content. The analytic framework was applied to a corpus of 55 Dutch e-books that were coded for the relative presence of these 15 characteristics. Notably, the corpus showed strengths in book processing, multimedia in pictures (e.g., dynamic visuals) and text (e.g., oral reading), and interactivity with the text (e.g., restarting a page), but moderate to weak evidence of interactivity with illustrations, including games, songs, or hotspots, and weak congruence between hotspots and story. A cross-corpus pattern analysis revealed three subtypes of e-books: (1) talking books with minimal multimedia additions, (2) living books with filmlike story representations, and (3) interactive books that combine multimedia with interactivity. Based on their analysis, de Jong and Bus (2003) tagged interactive e-books as "the most promising prototype" for stimulating and supporting early literacy experience (p. 158).

Through the lenses of two broad reading models (The Simple View, Gough and Tunmer 1986; Interactive-Compensatory, Stanovich 1980), McKenna and Zucker (2009) highlight overarching design features of the electronic reading environment that support code-related skills and comprehension processes in reading. 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.

Building on this early design work in a prior study (Roskos et al. 2009), we identified and tested several analytic tools on a corpus of 50 mixed genre e-books from popular online sites. We were interested in the technical adequacy and usability of these tools along three dimensions: multimedia design (how words and pictures are presented), interface design (conventions of use, format, and controls), and learning design (basic features of instruction or *the learn about loop* of purpose, content, and feedback).

Tool 1, derived from de Jong and Bus (2003), examined the design features of the e-book as a unit in four categories: book assistants, multimedia illustrations,

multimedia print, and interactivity. Easy to use, the tool analyzed multimedia design to a large extent, interface design to some extent, but learning design only minimally. Based on a set of instructional design principles (Clark and Mayer 2008), tool 2 probed the screen pages of an e-book. Its strengths included tapping features of multimedia and learning design (particularly cognitive demand), but it lacked power for analyzing interface design. Tool 3 focused on digital assets (audio, video, text) to identify screen-page assemblies that create the learning architecture of an e-book (Roskos and Brueck 2009). More difficult to use, the tool nonetheless revealed critical design features across all the major dimensions of design. Different analytic tools, we observed, revealed different design features of an e-book, and we concluded that to judge e-book quality may require a multipurpose tool that examines both the *e* (electronic features) and the *book* (text features) of an e-book.

Based on this line of research, we developed a prototype online e-book Quality Rating Tool consisting of three subscales (ease of use, multimedia, interaction) and a total of 20 items rated on a 5-point Likert scale (Roskos et al. 2011). Our early tests of this tool show strong reliability among external raters (researchers, non-educators) and teacher-users on two dimensions (ease of use, multimedia), but weaker reliability on the interaction dimension. Training for raters, we hypothesize, may not have offered enough examples or allowed sufficient practice for using the tool reliably in judging e-books.

E-Book Physical Environment

Environments have a profound effect on what children think, do, and feel as knowledge seekers and learners (Moore 2001; Weinstein 1979). It was the late Jim Greenman (2005) who argued, "An environment is a living, changing system. More than physical space, it includes the way time is structured and the roles we are expected to play. It conditions how we feel, think and behave…the environment either works for us or against us as we conduct our lives" (p. 5). In an electronic age, the goal is to weave e-book reading into already well-designed physical learning spaces of the classroom and not to isolate this way of reading from traditional book reading areas, such as the book corner or library center.

High-level design of the physical learning environment for young children is guided by several principles, primarily derived from studies in ecological psychology (Gump 1987) and related environmental research (e.g., Moore 2001): the allocation and arrangement of physical space, the complexity and organization of materials, sensory appeal and comfort (e.g., light, temperature, air quality), and the built environment created by children and teachers. At the smaller scale of activity area or center in the classroom, design involves (a) creating boundaries and entries; (b) establishing size, shape, and the illusion of height in an area; (c) combining colors, furnishings, surfaces, and light for mood and tone; (d) setting expectations and rules; and (e) aligning function with program goals (Prescott and Jones 1984). Well-constructed library corners (Morrow and Weinstein 1986), literacy-enriched play

areas (Roskos and Neuman 2001), and child-scaled technology niches (Olds 2001) have been found to increase book reading/browsing, literacy play, and engagement in computer-based activities.

Drawing on this knowledge base, we designed an *e-book nook* as a physical place in the classroom for shared and solo e-book browsing/reading that meets several criteria. The *e-book nook* should be a clearly defined place in the classroom with an entry and boundaries that plat the size, shape, and height of the area. It should be built to accommodate small group and solo e-book experiences and merge with traditional library or computer areas. The space should be identifiable with appropriate signage; it should be appealing with attractive color schemes, comfortable seating, mixed lighting (direct, indirect), and a twenty-first-century look and feel (e.g., a café-like setting for browsing and sharing). The general acoustic level in the *e-book nook* should be lower than other areas of the classroom, limiting background noise and eliminating disturbing noises (e.g., HVAC systems) yet supporting the aural potentials of e-book features. E-book devices (touch screen, mobile devices) should be within reach of children; the space should support access to network connectivity and power supplies readily and safely.

To test the feasibility of the physical design of the *e-book nook* in the early childhood classroom, we introduced the *e-book nook* concept over two iterations in Early Reading First classrooms (time 1: 4 classrooms, time 2: 8 classrooms) and observed its arrangement in the classroom environment. Following the initial level of abstraction during year 1, physical design criteria of location, signage, space allocation, acoustics, and access to e-books were used to examine video/photo samples of the *e-book nook* as a physical place in the classroom. In year 2, a survey of the five criteria with operationalized definitions across a 4-point Likert-style rating was developed and used twice, initially to determine baseline and individual classroom needs and 30 days later to measure change in each classroom's physical environment. Four photos of each classroom were taken from "clockface" perspectives of 12:00, 3:00, 6:00, and 9:00 and were individually rated by the five researchers, who then shared their findings, which resulted in a series of recommendations for each classroom. Follow-up observations were conducted 30 days later to determine changes in each classroom. Teachers were informally surveyed on their comfort and satisfaction with changes and provided anecdotal information on their change process. In addition to the information for teachers, year 2 reliability between researchers was analyzed on each of the five criteria of the survey.

Based on post observations, all eight classrooms in the second iteration improved on each of the five criteria and approached a ceiling rating of 3.0 on their presence in the environment. Results indicated that the location of each e-book nook was defined for both teacher and children; all classrooms had adequate signage that included block letters identifying the e-book nook at the child's eye level. Although different in décor, each classroom's e-book nook included space for at least four children and teacher and comfortable seating (e.g., beanbag chairs). Touch screens were at an appropriate height to accommodate interaction; Wi-Fi bandwidth and proper wiring were improved. Generally, acoustics were above average in all the classrooms; all had soft-scapes to dampen the ambient noise of early childhood classrooms.

These changes provided enhanced spaces in which children and teachers could maximize e-book experiences embedded in the ongoing operations of busy classrooms. As they made classroom e-book modifications, teachers indicated willingness to test new strategies and an excitement to share this technology with young children.

E-Book Engagement

In early literacy research, indices of engagement range from physiological (e.g., eye tracking) to behavioral (e.g., self-regulation). Visual eye tracking and skin conductance registers, for example, measure focal visual attention (picture/print) (Evans and Saint-Aubin 2010) and arousal levels as indicators of engagement with printed stories (Verhallen et al. 2006). Inhibitory control measures (e.g., *Head-Toes-Knees-Shoulders*, Ponitz et al. 2009) yield behavioral evidence of attention and distractibility. In a study of electronic versus traditional storybooks, Moody et al. (2010) described reading engagement as "children's attentiveness to a storybook and their ability to sustain attention over time" (p 297) and reported significantly higher levels of child persistence, defined as the ability to complete and maintain participation in shared reading, in e-book over traditional storybook reading conditions. Their results corroborated extant research that shows the benefits of certain digital elements (e.g., animations, graphics) for garnering children's attention in book reading.

Although less precise than physiological evidence, systematic observations of global indicators of engagement, such as persistence (pointing, page turning, question asking), enthusiasm (facial expressions; commenting), and sustained attention (willingness to listen), can provide useful data on child engagement with e-books. At this early point in developing e-book pedagogy in fact, this level of observation is probably more appropriate for assessing the functionality and usability of shared book practices, reserving more precise (and more costly) measures for use when e-book shared reading techniques are more stabilized (Zaritsky et al. 2003). Evidence of engagement in shared e-book reading, for example, may include observations of teacher-child motor behaviors *at the screen*, such as pointing, touching, and gesturing; child attention *to the screen*, such as staring, watching, and nodding; and children's expressions *about the screen content*, such as smiling, frowning, puzzling, and commenting. The frequency of these broad indicators can provide baseline evidence of engagement and inform how it appears to function in the e-book shared reading context, which lays the groundwork for design changes in instructional techniques, as well as experimental research on the benefits of particular techniques over others.

Our observations at the this point are focused on developing analytic tools for observing young children's at-the-screen engagement during shared e-book reading sessions with teachers and with mobile devices. Research objectives include (1) generating an analytic framework for observing at-the-screen engagement in

shared book reading, (2) applying qualitative tools and strategies for purposes of grounded description, and (3) developing a systematic procedure for observing at-the-screen engagement in subsequent research.

Preliminary analyses indicate four primary behavioral clusters: (1) teacher-child motor behaviors at the touch screen (e.g., pointing), (2) children's facial expressions during e-book reading (e.g., smiling), (3) teacher-child control of the e-book at the screen, and (4) children's attention to the screen as indicated by eye gaze. Early results show that children repeatedly smiled, gazed, and contemplated the screen during e-book reading sessions, suggesting that they were interested in the e-book stories. Children's motor behaviors also demonstrated strong evidence of engagement on the part of participants. Children's positive motor behaviors (e.g., pointing, acting, touching) were high, while their negative motor behaviors (e.g., wiggling, shifting) were low. Incidences of pointing and sitting predominated over those of wiggling and shifting about "as if" uninterested. Children's focal attention to teacher and screen also provided evidence of moderate-to-high engagement in the e-book reading across sites.

Shared control of the e-book screen, however, emerged as weaker evidence of engagement. This indicator of engagement did not appear well organized or managed at this point. Several teachers reported that asking children to manipulate the controls at the touch screen proved disruptive, diverting children's attention from the story line. However, this represents a negative design feature in this dimension of shared e-book reading at the screen. Children's interactive participation, such as finger-tracking print, pointing to words, and page turning, is a staple of the shared book instructional routine (Mason et al. 1989) because it has been found to develop children's knowledge of print conventions which are foundational in the learn-to-read process (Morris 1992). Shared control of the e-book reading screen, therefore, is a critical design factor that needs to be addressed in the model.

E-Book Instruction

By design, the model limits instruction to science-based techniques that support the development of essential early literacy skills (NELP 2008). The number of scientifically tested instructional techniques is steadily growing, offering practitioners an ever-richer store of effective practices (e.g., U.S. Department of Education Institute of Education Sciences (IES) (n.d.), What Works Clearinghouse, 2011). A critical design feature of the instructional component, therefore, is fidelity to scientifically proven and promising instructional procedures and sequences.

Extant research supports systematic, sequential instruction in early literacy concepts and skills (Pianta and Hamre 2009). Structurally, reading research converges on a before-during-after framework (BDA) of shared book reading where children are primed before reading, guided during reading, and involved in extension activities after reading. Effective instructional techniques, such as dialogic reading (Whitehurst et al. 1994), provide teaching protocols or guidelines that support effective

instruction and boost learning opportunities in a BDA framework. Thus, the critical design criteria for the instruction component of the model are twofold: (1) selection of science-based techniques that develop knowledge and skills foundational for reading and writing ability and (2) fidelity of implementation to ensure learning outcomes.

The prototype model employs a direct vocabulary instruction technique referred to as say-tell-do to "test" the viability of the instruction component in the classroom sites (Roskos and Burstein 2009). The technique includes 12 teaching actions before, during, and after shared reading that guide instruction. In addition to evidence of fidelity to the instructional procedure (12 teaching actions), observational data on mean length of session, the percent of teacher explanations of target words during sessions and child use of target words during sessions were calculated and rated on a 0–3 scale of degree of presence to assess how well the instruction component functioned in the e-book shared reading sessions. Ratings on these indices showed considerable variability across sites in teacher implementation of the procedure, verbal explanations of target words, and session length—no surprise given the dynamics of instruction in preschool classrooms. Two patterns emerged in the results. In 3 out of 4 preschool sites, evidence of fidelity to the instructional protocol—the 12 teaching actions—was in the moderate to strong range on a 0–3 scale, which suggests the potential strength of an explicit procedure as a design feature. The generally weak presence of teacher language that supports word learning (explaining word meanings), ranging from 12 to 25% of total utterances, however, suggests that the instructional protocol, per se, is an insufficient design feature. Individual teacher knowledge and skill is a powerful factor and needs to be considered in the effectiveness of the design. More training and self-monitoring may need to be "built into" the design to improve the functionality and usability of this component. Still, it is worth noting the strong showing of child language in the functioning of this model component, ranging from 41 to 55% of total utterances, which provides further evidence of an explicit instructional protocol as a critical design feature of the model. Pre-/postresults on a curriculum-based measure also support this conjecture showing that children made vocabulary gains in either receptive or expressive vocabulary in the implementation sites (See Table 5.1).

Where We Are

Using a formative research approach, we examined the implementation of an e-book instructional model in a small sample of preschool classrooms for its functionality and usability. Salient indicators of each component were identified, observed, and assigned ratings to yield an assessment of design strengths and weaknesses as a basis for further model development. In brief, the design analysis revealed the need for better quality e-books, more precise design specifications for an *e-book nook* in the classroom setting, more explicit teacher guidance for child engagement during e-book reading sessions, and stronger teacher training on "how to" use instructional

Table 5.1 Child performance on a CBM of target vocabulary across classrooms

Classroom	Mean prereceptive assessment	Mean postreceptive assessment	Mean receptive gain/loss	Mean preexpressive assessment	Mean postexpressive assessment	Mean expressive gain/loss
1	13.33	16.33	3.00	7.00	14.67	7.60
2	14.00	16.67	2.67	9.33	8.00	–1.33
3	14.33	19.67	5.33	12.00	18.67	6.70
4	9.00	8.00	–1.00	6.33	9.67	3.30

procedures and skills in shared e-book reading. Several strengths of the model emerged as well. Functionality of the instruction component, for example, appeared to be enhanced by the inclusion of an explicit instructional procedure. Teacher-child motor behaviors at the screen and shared control of the screen, as well as children's generally positive affect in e-book reading sessions, revealed basic features of the engagement component. Usability was marked by a flexibility or "play" in the components that allowed teachers to make adaptations in terms of e-book selection, physical arrangements, and planning for and organizing sessions to facilitate engagement and instruction.

Considerable design research in each of the components is still needed to stabilize the model for more rigorous testing in early childhood classrooms. Not only high-quality sets of e-books for preschoolers but also online professional development materials for teachers need to be developed on the basics of effective e-book shared reading (e.g., pacing, pausing, science-based protocols). This is no small research task—daunting, in fact—but one that warrants our full attention. The e-book represents a technological advance in the book from a two-dimensional to a three-dimensional information tool, replacing the page with the screen and enlivening text with rich imagery, sound, and animation. Research on what this evolution means for early literacy learning is indeed young, but pioneer studies point to the potential of these new dynamic features for supporting children's emerging literacy skills and abilities (Segers et al. 2006; Shamir and Korat 2009; Verhallen et al. 2006). An important research task, however, is not only to understand how these new age tools impact early literacy development and learning processes but also to understand how to use them well in preschool early literacy education. Our e-book model is an instructional framework that moves in this direction—we are at the start-point and open to new possibilities.

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