Technology and Early Literacy:

The Impact of an Integrated Learning System on

High-Risk Kindergartners' Achievement

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Diane H. Tracey, Ed.D.
Kean University
Department of Communication Sciences (J-205d)
1000 Morris Ave.
Union, NJ 07083
dtracey@kean.edu
(908) 737-3944

John W. Young, Ph.D.
Rutgers University
Graduate School of Education
10 Seminary Place
New Brunswick, NJ 08903
jwyoung@rci.rutgers.edu

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Abstract

265 kindergarten children from a high-risk community participated in an evaluation of the effectiveness of the Waterford Early Reading Program, a software program designed to facilitate early literacy development. 151 students in eight experimental classrooms used the program for approximately 15 minutes per day. 114 students in seven non-intervention classrooms had varying amounts of access to older hardware and software that was not systematically utilized by their teachers. Students were individually pre- and post-tested using the TERA-2, the Lindamood Auditory Conceptualization Test, and the Waterford Inventory. Results indicated that students in the experimental classrooms performed significantly better than non-intervention students on the TERA-2 and the Waterford Inventory. Students in the experimental classrooms also outperformed non-intervention students on the Lindamood, although not to a significant degree.

Technology and Early Literacy Instruction:

Impact on High-Risk Kindergartner's Achievement

Virtually all educators share the goal of providing young children with early literacy instruction that leads to successful reading achievement. Extensive research documents the importance of children's early literacy achievements as foundational and essential for later academic success (Adams, 1990; Kamil, Mosenthal, Pearson, & Barr, 2000; Snow, Burns, & Griffin, 1998). In fact, the disturbing reality is that children who do not make adequate progress acquiring early literacy skills remain at-risk as learners throughout their schooling years (Shaywitz, 2004; Stanovich, 2000). Unfortunately, children from urban, low SES communities comprise the majority of this group (Kamil, Mosenthal, Pearson, & Barr, 2000; Snow, Burns, & Griffin, 1998).

Given the critical importance of developing early literacy proficiency, much attention has been directed to identifying optimal educational approaches for facilitating early reading success. While experts agree that there is no single " magic bullet" for creating an effective early literacy program, a high degree of consensus has been reached regarding instructional strategies that are associated with gains in early literacy development. These include: the establishment of a literacy-rich classroom environment containing a high-quality literacy center, the use of authentic children's literature as a central component of literacy instruction, opportunities for social collaboration among students, and extensive professional development for teachers (Morrow, Gambrell, & Pressley, 2003). Furthermore, explicit instruction followed by meaningful practice in the areas of phonics, phonemic awareness, vocabulary, fluency and comprehension have been found to be central in effective early literacy programs (National Institute of child Health and Human development, 2000).

Despite the consensus regarding many early literacy instructional practices, much controversy exists regarding the role of technology in this realm (Patterson, Henry, O'Quin, Ceprano, & Blue, 2003). Experts in the field of literacy education attribute much of this controversy to a lack of rigerous research investigating the relationships between students' technology use and subsequent academic achievement. For example, Labbo and Reinking (1999) write, "the research pertaining to the use of new digital technologies in literacy instruction is by any measure broad and shallow rather than focused and deep" (p. 480).

Furthermore, the research that exists regarding literacy and technology tends not to be published in prominent literacy journals (Labbo & Rerinking, 1999). Kamil and Lane's (1998) investigated the frequency of citations related to technology in the field of reading's four "mainstream" journals. The four journals selected by Kamil and Lane, based on frequency of citation rates, were: *Reading Research Quarterly*, *Journal of Reading Behavior* (now *Journal of Literacy Research*), *Research in the Teaching of English*, and *Written Communication*. Kamil and Lane examined the journals for the five-year period prior to the onset of their writing. Their work revealed that between 1991 and 1995 only 12 of 437 (2.7%) research articles published within the four major literacy journals focused on literacy and technology. Three of these focused on the relationship of technology to reading, the other nine on the relationship of technology to writing.

A current electronic review of the ERIC database, analogous to the one completed by Kamil and Lane in 1998, was done for the present article. The authors searched the ERIC database in the four journals cited above for a period of five years (1998-2002), and looked at the percentages of articles in the same journals examined by Kamil and Lane using the key word “technology”. *In Reading Research Quarterly*, five of the 102 articles published between 1998 and 2002 were generated as a result of a search using the key word “technology” (Reinking & Watkins, 2000; Cunningham, Many, Carver, Gunderson, & Mosenthal, 2000; Leu & Kinzer, 2000; Readence & Barone, 2000: Labbo & Reinking, 1999). It is important to note, however, that only one of these papers reported empirical research (Reinking & Watkins); the remaining four were of a theoretical nature. An additional empirical investigation related to technology in literacy education published in *Reading Research Quarterly* during this period was located by hand but not identified in the ERIC search (Karchmer, 2001). It is not apparent why this piece of work was not identified electronically with the key word “technology”, as it is an investigation of teachers’ reports of how the Internet influences literacy and literacy instruction in their classrooms. For the same period, one of the 81 articles published in *Journal of Literacy Research* was generated as a result of the same search (Baker, Rozendal & Whitenack, 2000). The search yielded nine of 75 articles in *Research in the Teaching of English*, and zero of 47 in *Written Communication.* In short, Kamil and Lane (1998) found 2.7% of the research articles published within the four major literacy journals focused on literacy and technology while the current search found that 4.9% of the research articles published within the four major literacy journals focused on literacy and technology. While this trend is in a positive direction, these numbers are still very low, especially considering the enormous expenditures currently being used by school systems for technology. For example, school districts in the United States spent 6.7 billion dollars on educational technology during the 1998-1999 school year, up from 5.4 billion in the 1997-1998 school year (Reading Today, 2000). This figure reflects the highest percentage growth recorded in a decade (Reading Today, 2000).

Despite the challenges that exist for researchers studying technology in literacy education, a number of recent studies have begun to provide specific areas of detail and definition to add depth in the field. In a high-quality study of young children's literacy development and technology use, Labbo (1996) investigated the ways in which young children make sense of the tools that the computer has to offer. Among the findings, Labbo determined that young children approached the computer screen with expectations that they will be able to write, draw, play, and create. These experiences then enabled them to engage in a variety of symbolic manipulations. The symbolic manipulations identified by Labbo included (a) depictive symbolism in which a picture of an object is used to represent a real object, (b) transformative symbolism in which a picture of an object is used to represent a real object other than the one pictured, and (c) typographic symbolism in which letters and other forms of typed print are used to express ideas.

Anderson-Inman and Horney (1998) summarized the work regarding the effects of electronically supported text (text that has been electronically modified so as to be more supportive of the reader) on at-risk readers' reading performance. In one high-quality study (MacArthur and Haynes, 1995), significantly higher reading comprehension scores were associated with the use of electronically supported texts. The modifications used in this study were: "(a) compensatory support to improve reading fluency (e.g.

glossary for definitions, speech synthesis for pronunciations, etc.), (b) strategic support to guide students' use of cognitive and metacognitive reading strategies, and (c) substantive support to enable modifications that enhance comprehension of content" (p. 18).

The effects of technology infusion of students' writing abilities is another area in which research regarding the role of technology in literacy education has made significant strides. In addition to the earlier, positive findings of Bangert-Drowns' (1993) meta-analysis in this area, Baker, Rozendal, and Whitenack (2000) examined students' audience awareness during composing in a technology rich elementary classroom in which each child had a personal computer on his or her desk. In this work the authors found that the students had more frequent opportunities to be part of an audience than students who were in traditional, non-technology infused classrooms due to the open nature of monitor screens in the classroom. These opportunities then led to greater interaction between students about their writing. The authors coined the term "interactive audience" to refer to the students in this technology-rich classroom who, "simultaneously participated as audience members while being authors and readers" (p. 409). This interactive audience then further affected student writing in the areas of topic selection, choice of sign system (modalities of presentations), and edits and revisions.

Despite the forays that have been made investigating the effects of technology in literacy education, much work remains to be done. One area in which high quality research has been lacking is that of determining the effectiveness of integrated learning systems on young learners literacy achievement (Patterson, Henry, O'Quin, Ceprano, & Blue, 2003). The term "integrated learning systems" (ILS) refers to a software package that includes content that is individualized to the child's learning needs, and an assessment system that provides information to the teacher regarding each child's progress with the program. An ILS is usually a large-scale, and frequently high cost, intervention adopted by a school district and used by many teachers and students. As Patterson et al. report, the research history on the effectiveness of ILS is sparse, with products of this type changing much since their inception in the 1970's. While Becker (1992) noted that some potential advantages of ILS's exist, such as their ability to provide activities to students at their individual level of need, and their ability to motivate increased student engagement, he concluded that convincing evidence regarding their effectiveness to promote student achievement was still lacking. Patterson et al. underscore the need for such research as a way to justify (or discourage) the large expenditures that are currently being allocated by thousands of school districts for the purchase of such systems.

In response to the need for high-quality research in this area, Patterson et al. (2003) designed a study on the effectiveness of the Waterford Early Reading Program, Level I, an ILS designed to promote early literacy acquisition, using the theoretical perspectives of social constructivism and emergent literacy theory to situate their work. They collected and analyzed both qualitative and quantitative data, using measures and interpretations generated from these perspectives. Their results showed no evidence for the support the use of ILS's as a way to promote early literacy development.

Current Investigation

The current investigation also sought to address the need for high quality research on the topic of ILS for young learners. However, this research used a different theoretical lens than did Patterson et al. (2003), and as such different research tools, methodologies, and data were generated. Specifically, the present research sought to examine the effectiveness of the Waterford Early Reading Program from a cognitive processing theoretical perspective. The research questions considered in the current investigation were:

(1) Did the Waterford Early Reading Program, Level I have a positive effect on children's literacy learning in the intervention classrooms?

(2) How can the results of this research extend the current knowledge base regarding the role of technology in young children's literacy education?

Theoretical Frame.

The current study is framed from a cognitive theoretical perspective. A cognitive theoretical perspective attempts to explain highly complex cognitive functioning by articulating the existence of unobservable mental events, meaning those events unobservable without the assistance of highly sophisticated brain imaging technology such as functional magnetic resonance imagery (fMRI's).

The cognitive perspective has generated a number of theories and models regarding learning in general, and the reading process specifically. One model of reading from the cognitive theoretical perspective that has received widespread attention is the Parallel Distributed Processing Model (Seidenberg & McClelland, 1989). Explained in great detail in Adam's (1990) work, *Beginning to Read*, this model suggests that there

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Insert Figure 1 about here

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are four primary processors that are central to the reading process: the orthographic processor, the phonological processor, the meaning processor, and context processor (see Figure 1). According to the model, the reading process begins in the orthographic processor where print recognition occurs. Here, highly rapid (automatic) letter recognition is needed to initiate the inter-letter associational unit system which activates letters which are likely to follow the initially identified letter, and suppresses letters unlikely to follow the initially identified letter, sequentially building rapid word identification skills in the reader. The inter-letter associational unit system will not be activated if letter recognition is slow, and this will lead to a greatly impaired reading experience. According to the Parallel Distributed Processing Model, following successful letter identification, the phonemic processor is activated, providing the sounds linked to the print. Like the orthographic processor, the phonemic processor is organized such that likely sounds are activated in sequential order, and unlikely sounds are suppressed, again to facilitate ease of reading. Adams (1990) describes additional functions provided by the phonological processor during the reading process. After the print and sound images are linked the word receives its meaning in the meaning processor. This processor, organized according to schema (Anderson and Pearson, 1984), also functions to enable likely word meanings to be activated as unlikely word meanings are suppressed. The final processor, the context processor is where the reader constructs and monitors the meanings of the phrases, sentences, paragraphs and full texts. In short, according to the Parallel Distributed Processing Model, successful reading is dependent on the readers' abilities in each of these areas: automatic letter recognition, accurate phonemic abilities, strong vocabulary knowledge, and the ability to construct meaningful messages during reading (Adams, 1990). Adams (1990) helped to design the Waterford early literacy software program to strengthen the key cognitive processors and abilities described above. As such, the application of the cognitive theoretical perspective, and in particular the Parallel Distributed Processing Model, as the theoretical framework to examine the effectiveness of the Waterford Early Reading Program seems appropriate.

Method

Participants

301 kindergarten students from a northeast, urban school district were pre-tested for participation in this study. The children resided in a community marked by multiple risk factors for early literacy failure including high rates of poverty, unemployment, teen and single parent families, crime, and drug usage. Eighty-five percent of the city residents are African American or Hispanic. 77% of the children and youth in the city qualify for federal free or reduced lunch programs. The high school graduation rate is 45%. The community was, in fact, recently ranked as the third worst city in the United States for raising children (Orr, 1997). As a result of these combined factors, all of the children participating in this study were classified as high-risk for reading failure.

All children from 15 kindergarten classrooms in the district participated in the study. There was one experimental classroom and one non-intervention classroom in each of eight schools, except for one school that only had an experimental classroom. Thus, there were eight experimental and seven non-intervention classrooms in the project. Class sizes in these rooms ranged from 10 to 28 students with an average of 20 students per room. There was not a significant difference in class size between the non-intervention and experimental groups.

265 of the original 301 children were post-tested for the study. 151 children were from experimental classrooms and 114 were from non-intervention classrooms. 36 children who took the pre-test moved out of the district during the academic year and were therefore excluded from the project. This attrition rate is approximately 13% and is typical of urban, inner-city communities.

Materials

Waterford Early Reading Program, Level I. . The Waterford Early Reading Program was created by the Waterford Institute, a non-profit educational research organization established in 1976 with the mission of promoting the effective use of technology in the field of education. The program is currently distributed by Pearson Digital Learning, a division of Pearson Education, which is the largest K-12 publisher of educational materials in the world. According to company statistics, at the close of the 2002 fiscal year, the Waterford Early Reading Program was in 5% of the elementary schools nationwide. During 2002, 2,700 schools, 12,570 classrooms, and approximately 326,000 children nationwide were using the Waterford Early Reading Program.

The Waterford Early Reading Program, Level I is a software-based interactive, early reading instructional program designed to help kindergarten children develop the emergent literacy skills they need to enter first grade ready to become successful readers. As stated earlier, the main emphases of the program are to facilitate young children's automatic letter recognition, phonemic awareness, vocabulary, and comprehension skills, all of which are essential to early literacy development, as suggested by the Parallel

Distributed Processing Model (Seidenberg & McClelland, 1989). The software package is extremely large. The Level I program offers 910 separate activities, enough for each child to complete the recommended 15 minutes of literacy activities per day without repetition for an entire school year. Sample computer-based activities targeting the above skills include: matching games, sorting games, fill-in-the-blank activities, and songs with accompanying tasks. The software individualizes each child's daily Waterford work, depending on his or her previous accomplishments and difficulties. Teachers monitor each child's progress via a management system that indicates those skills with which the child is proficient, and those skills with which he or she needs additional support. Paterson, Henry, O'Quin, Ceprano, and Blue (2003) present a full scope and sequence for Level I of the program.

In the current study, each of the eight experimental classrooms was outfitted with the software, hardware, and related print materials necessary for implementing the Waterford Early Reading Program, Level I. As is typically recommended for program implementation, the hardware for each experimental classroom included a network of three computers-all with an Intel Pentium 100 MHz CPUs, 16 MG RAM, CD-ROM drives, SoundBlaster sound cards, and other necessary accessories. Additionally, each computer was equipped with a 15-inch color monitor and a high speed, color laser printer. Supplemental Waterford Early Reading Program, Level I materials included a teacher's guide for each classroom describing the program and offering ideas for possible enrichment lessons. Each child in the experimental condition also received a set of four videotapes and 52 Early Reader books to take home and keep, which, again, are components of the recommended, standard Waterford set-up. The approximate retail cost of initially equipping the eight experimental classrooms with the Waterford Early Reading Program, Level I was $160,000.

The Waterford Early Reading program is designed as a supplement to, not a replacement for, an existing classroom literacy program. During the present study the core literacy program in the kindergarten classrooms was *Scholastic Literacy Place*. To implement this program, literacy instruction in the classrooms tended to be organized as whole class instruction, although children were often seated in groups. Practices in these classrooms were more consistent with a traditional "reading readiness" approach towards early instruction that focused on the development of isolated literacy skills, than with emergent literacy beliefs and methods that advocate a more integrated, authentic approach to literacy instruction. For example, instructional practices such as shared reading, interactive writing, modeled writing, and message time, were all introduced to the classroom teachers in this study in the year following the conclusion of this research project and were, for the most part, new to these classroom teachers at that time.

The non-intervention kindergarten classrooms in this study also used the *Scholastic Literacy Place* core program as the basis of their literacy program but were not equipped with the hardware, software, or supplemental Waterford materials provided to the experimental classrooms. Four of the seven non-intervention classrooms had older computers and a few varied (non-Waterford) pieces of computer software available for their students' use. The integration of these items into the literacy curriculum, however, was not systematic or intensive. The remaining three non-intervention classrooms did not have computers in their classroom. This design was judged to be ecologically valid as the non-intervention classrooms illustrated a realistic portrayal of many classrooms across the country which possess computers and some software for students' use, but which do not have intensive technology based literacy programs that are systematically applied.

Test of Early Reading Ability-2 (TERA 2). The Test of Early Reading Ability-2 (TERA 2) is a widely used, highly regarded standardized test of literacy achievement for children ages 3-9. The individually administered test takes approximately 15 minutes. The key skills assessed by the TERA-2 are: alphabet recitation, letter recognition (un-timed), book handling skills, print convention development, comprehension, word recognition, and reading comprehension. Alternate equivalent forms are used for testing and re-testing. The TERA-2 was found to have a reliability coefficient of .89 for both internal consistency and stability, and was evaluated as a "thoughtful and well constructed measure of skills related to early reading" (Hiltonsmith, 1992) in the Eleventh Mental Measurements Yearbook (Kramer & Conoly, 1992).

Lindamood Auditory Conceptualization Test. The Lindamood Auditory Conceptualization Test is a criterion-referenced instrument designed to gauge students' auditory processing abilities. Skills assessed include children's ability to isolate and manipulate phonemes and rhyming. The test is individually administered and takes approximately 15 minutes. The Lindamood Auditory Conceptualization Test was chosen for this study because it has been found to be the strongest predictor of reading recognition and decoding skills when compared with other measures of prediction (McGuinness, McGuinness, & Donohue, 1995).

The Waterford Reading Inventory. The Waterford Reading Inventory was designed and produced by Waterford Institute for the specific purpose of assessing the early literacy skills taught in the Waterford Early Reading Program, Level 1. The test, which is individually also administered, takes approximately 30 minutes to complete. The areas of early literacy development assessed by the Waterford Reading Inventory include: writing, alphabet recitation, letter recognition, phoneme isolation (the ability to hear sounds within words), rhyming, book handling, awareness of print conventions and word recognition.

Procedure

Project Design. Pearson Digital, the distributor of the Waterford Early Reading Program, contacted the authors and invited them to design an independent, large-scale evaluation of the Waterford Early Reading Program, Level I. Identification of the testing site and schools was made in conjunction with Pearson Digital. Selection of the appropriate assessment tools was completed by the researchers based on an in-depth review of relevant research articles in high quality professional journals. The Waterford Early Reading program, Level I was made available to the eight experimental classrooms, as previously described, without charge, in exchange for permission to pre-test and post-test all students involved with the project. The researchers received a flat fee for the design and evaluation of the research, but were/are not affiliated with the company, nor invested with the company, in any other way.

Pre-Testing. Four graduate students enrolled in a doctoral program in education conducted the project pre-testing. All pre-testing was individually administered and the order of the tests was rotated so as to avoid any order or group effects. In the pre-testing, 150 students received the TERA-2 and the Lindamood Auditory Conceptualization Test, and 151 students received the Waterford Reading Instrument. This spilt design was chosen so as to provide an opportunity to use three assessment tools while simultaneously keeping testing time (an important consideration for kindergarteners) to a minimum. During the pre-testing phase, student participation was maximized by having research assistants return to all schools a second time in order to test any students who were absent on the original testing date.

Program Implementation. Pearson Digital, the distributor of the Waterford Program, led the implementation phase of the project. Pearson Digital personnel were responsible for insuring that teachers and students used the program and materials in the intended fashion. As stated earlier, the objective of the program is to have each student use the software for 15 minutes a day during school. To accomplish this goal, Pearson Digital personnel made 4-6 visits to each site during the school year. In addition, teachers submitted monthly reports to Pearson Digital detailing their students' use of the materials that month. Teachers and students in the non-intervention classrooms were not monitored during this phase of the study.

Post-Testing. Post-testing was completed by the same graduate-level research assistants who conducted the pre-testing, and, again included individual administration of the Waterford Reading Inventory to 131 students, and the Lindamood and TERA-2 to 134 students. As in the pre-testing phase, student participation was maximized by having research assistants return to all schools a second time in order to post-test any students who were absent on the original post-test date.

Data Analysis. An analysis of variance (ANOVA) was computed for each of the assessment instruments comparing the pre-testing literacy abilities of the experimental and non-intervention group students. Following this, an ANOVA was computed for each of the assessment instruments comparing the year-long gains (gain score = post-test score minus pre-test score) made by the students in the experimental classrooms with those of the students in the non-intervention classrooms. Finally, performances on the TERA-2 by all students were converted to National Curve Equivalency scores (NCE's).

Results

Pre-Testing

Based on pre-tests administered prior to intervention, the children in the non-intervention and experimental classrooms did not differ significantly from each other in terms of their early literacy skills on two of the three assessments used, the Lindamood Auditory Conceptualization Test and the Waterford Reading Inventory. Significant pre-test differences favoring the non-intervention group were found, however, using the Test of Early Reading Ability-2 (TERA-2) ($F=4.28$, $p<.05$).

TERA-2: Gain Scores

When the gain scores of students in the experimental classrooms were compared with the gain scores of students in the non-intervention classrooms using the TERA-2, significant differences were found favoring of the experimental group ($F=6.82$, $p<.05$). The 60 students in the non-intervention classrooms had a mean gain score of 17.62 while the 74 students in the experimental classrooms had a mean gain score of 26.50. The results of the TERA-2 Gain Score comparisons are reported in Figure 2. The raw mean scores and standard deviations for the TERA-2 Gain Scores are reported in Appendix A.

Insert Figure 2 about here

Lindamood Auditory Conceptualization Test: Gain Scores

When the gain scores of students in the experimental classrooms were compared with the gain scores of students in the non-intervention classrooms using the Lindamood Auditory Conceptualization Test, non-significant differences favoring the students in the experimental classrooms were found ($F=.39$, $p<.53$). 59 students in the non-intervention classrooms had a mean gain score of 10.71 and 75 students in the experimental classrooms had a mean gain score of 11.63. The results of Lindamood Auditory Conceptualization Gain Score comparisons are reported in Figure 3. The raw mean scores and standard deviations for the TERA-2 Gain Scores are reported in Appendix B.

Insert Figure 3 about here

The Waterford Reading Inventory: Gain Scores

When the gain scores of students in the experimental classrooms were compared with the gain scores of students in the non-intervention classrooms using the Waterford Reading Inventory, significant differences were found in favor of the experimental group ($F=11.69$, $p<.001$). The 55 students in the non-intervention classrooms had a mean gain score of 47.68 while the 76 students in the experimental classrooms had a mean gain score of 59.13. The results of Waterford Gain Score comparisons are reported in Figure 4. The raw mean scores and standard deviations for the TERA-2 Gain Scores are reported in Appendix C.

Insert Figure 4 about here

National Curve Equivalency (NCE) Scores

Students' performances on the TERA-2 were converted into NCE scores and then compared. In the pre-test, 33% of the non-intervention students had NCE scores greater than 50%. In the post-test, 61% of the non-intervention students had NCE scores greater than 50%. In the pre-test, 15% of the treatment group had NCE scores above 50%. In the post-test, 74% of the treatment group had NCE scores above 50%.

Discussion

This report summarizes the results of an evaluation of a year-long implementation of an ILS, the Waterford Early Reading Program, Level I with 265 kindergarten children from an urban, high-risk, community. In brief, when comparing student gain scores, the evaluation showed that students in the intervention classrooms outperformed students in the non-intervention classrooms for all three of the assessment measures. Significant results favoring students in the experimental classrooms were found using the TERA-2 and the Waterford Reading Inventory. Non-significant differences favoring the experimental students were found using the Lindamood Auditory Conceptualization Test. Below, some possible explanations and implications regarding these findings are presented.

Achievement Results

The present research is framed from a cognitive processing theoretical perspective, specifically, the Parallel Distributed Processing Model (Seidenberg & McClelland, 1989). As stated earlier, this model suggests that there are four primary processors that are central to the reading process: the orthographic processor, the phonological processor, the meaning processor, and context processor. The Waterford Early Reading Program, Level I was based on the research findings related to this model of reading, and was constructed to closely align with it. As such, the Waterford Early Reading Program, Level I was designed to strengthen each of these processors in students who use this system.

Examination of the achievement patters results suggests that those measures which aligned most closely to the Parallel Distributed Processing Model yielded significant achievement results favoring the intervention group. For example, key elements in the TERA-2 include letter and print recognition (un-timed), vocabulary knowledge, and oral reading in connected text. Similarly, key elements of the Waterford Inventory are speed of letter recognition, phoneme isolation, rhyme generation, and word reading. In contrast, the Lindamood Auditory Conceptualization Test, on which the intervention group showed improved although not significant gains over the non-intervention group, assessed only children's ability to isolate, sequence, and manipulate sounds within words (i.e. phonemic processing). The Lindamood Auditory Conceptualization Test may also not have revealed significant differences between the intervention and non-intervention groups because it was extremely difficult for both sets of children. For example, on the pre-test 60% of students did not answer any questions correctly. Even on the post-test nearly 50% of the students received a score of 0. These data are consistent with a floor effect, that is, an inability to discriminate between students on the low end of the distribution because the test is too difficult. With this in mind, the data from the Lindamood Test appears to have accurately represented the progress of less than half of the students (i.e. the higher performing students). In short, while the Lindamood may be an excellent measure of early reading ability in some situations or for some students (McGuinness, McGuinness, & Donohue, 1995) it may not have been an appropriate assessment tool for the students in this study, given the unusually high risk of literacy failure faced by children in this community.

The findings above underscore the importance in research of selecting measures that closely align with the objectives and the population in which the researchers are most interested. In this work, the researchers were most interested in assessing the effects of the Early Waterford Reading Program, Level I on at-risk children's literacy growth, specifically in the areas of orthographic, phonemic, meaning, and context processing. Assessment measures that linked most closely to this objective, and which were most appropriate in difficulty level, were found to reveal significant academic advantages for those children in the intervention classrooms. In contrast, the use of alternate assessment measures chosen by Patterson et al. (2003) may account for the absence of a significant relationship between the use of the Waterford Early Reading Program and literacy gains in that study.

Research Questions

The present study sought to answer two research questions:

(1) Did the Waterford Early Reading Program, Level I have a positive effect on children's literacy learning in the intervention classrooms? and,

(2) How can the results of this research extend the current knowledge base regarding the role of technology in young children's literacy education?

With regard to the first question, the present study evaluated the effectiveness of the Waterford Early Reading Program on young children's early literacy skills and revealed strong, positive, statistically significant results associated with its use. With regard to the second question, the results of the present investigation have been situated within a larger framework of the current research base in technology and literacy education. Although this current research base is far from rich and remains disproportionate to current spending on educational technology, it has been demonstrated that the body of knowledge is growing both in terms of specific studies that add depth and detail to the field, and in terms of the percentage of articles that are now published in mainstream literacy journals.

Conclusions

Educators in urban school districts are frequently faced with the daunting task of determining how precious human and financial resources should be allocated to provide optimal educational experiences for their students. This responsibility becomes increasingly more difficult as the cost of any particular initiative increases. In the case of infusing technology into the curriculum, particularly with the use of large-scale, ILS's, the costs are often especially dramatic. Given the size of these expenditures, educators are entitled controlled research regarding the effectiveness of any product that they are considering purchasing. The current project sought to provide this information.

Additionally, a closer look at the ways in which young, at-risk children's literacy development can be fostered and evaluated has been presented.

The overall findings of this investigation showed that children who participated in Level I of the Waterford Early Reading Program, children at great risk for reading failure, had significantly greater achievement in the acquisition of early literacy skills than did students who did not have access to these materials. These results are encouraging and, we believe, support increased evaluation of this and many other technology interventions for young children. Although ILS's are only one kind of technological tool that teachers have available to them, their use should not be discouraged if the possibility exists, as the current study suggests, that their integration is associated with positive and significant literacy growth for at-risk children.

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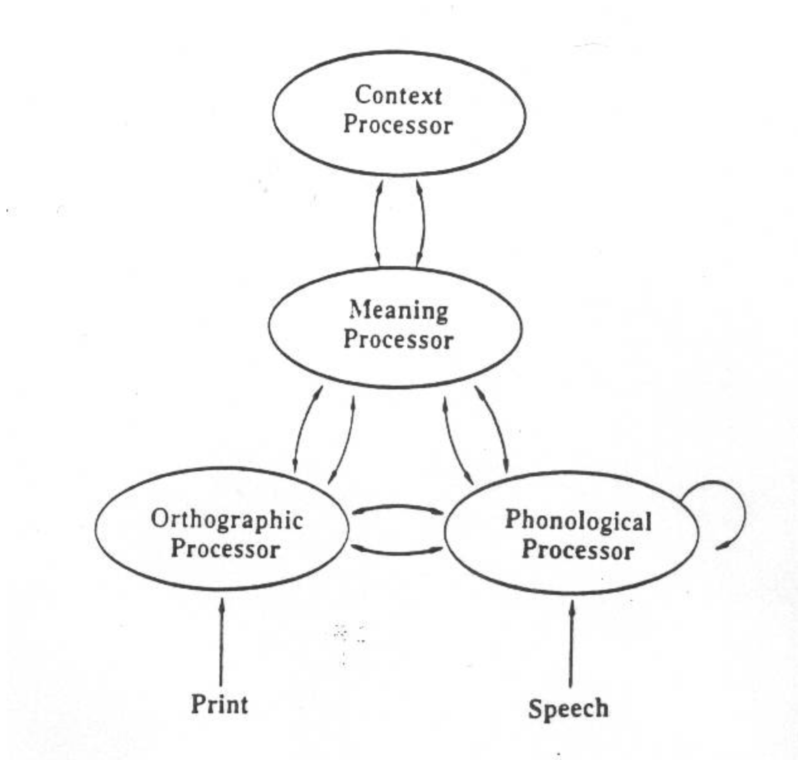
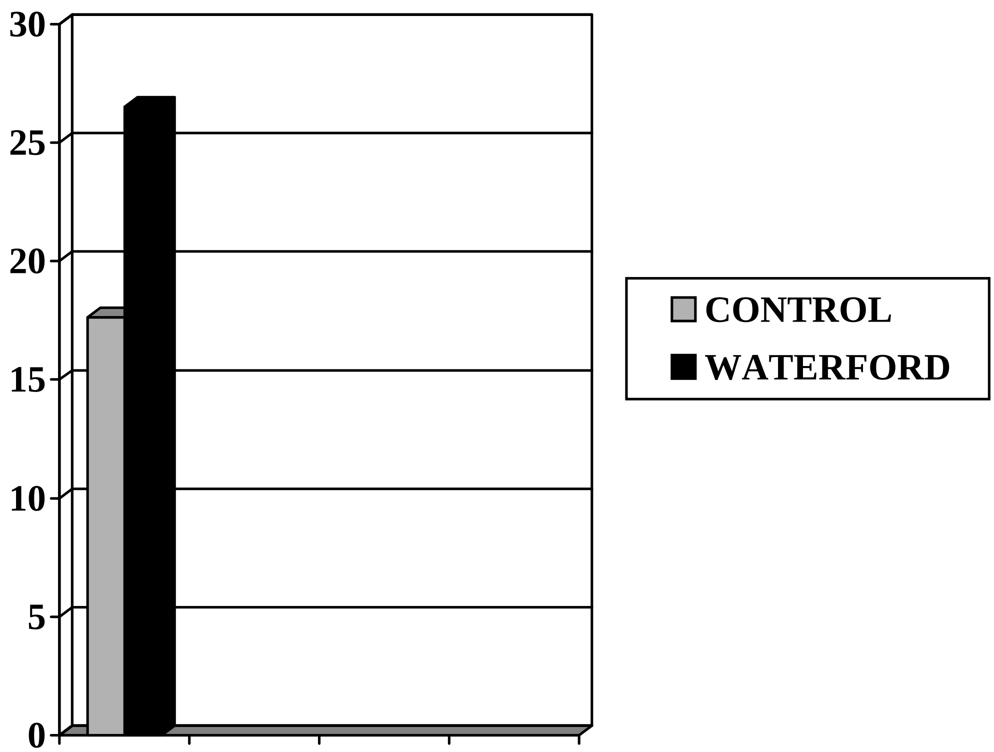
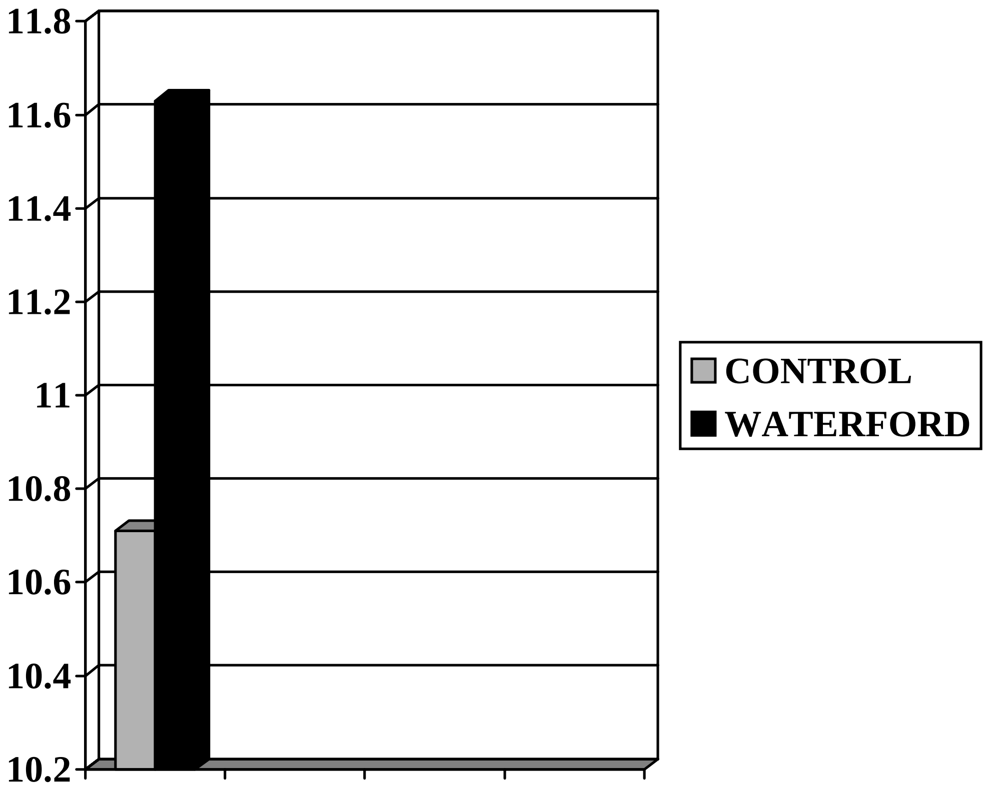


Figure 1. Parallel Distributed Procesing Model (Seidenberg, McClelland, & Rumelhart, 1989) as presented in Adams, 1990. Permission to publish is <u>not</u> yet granted.



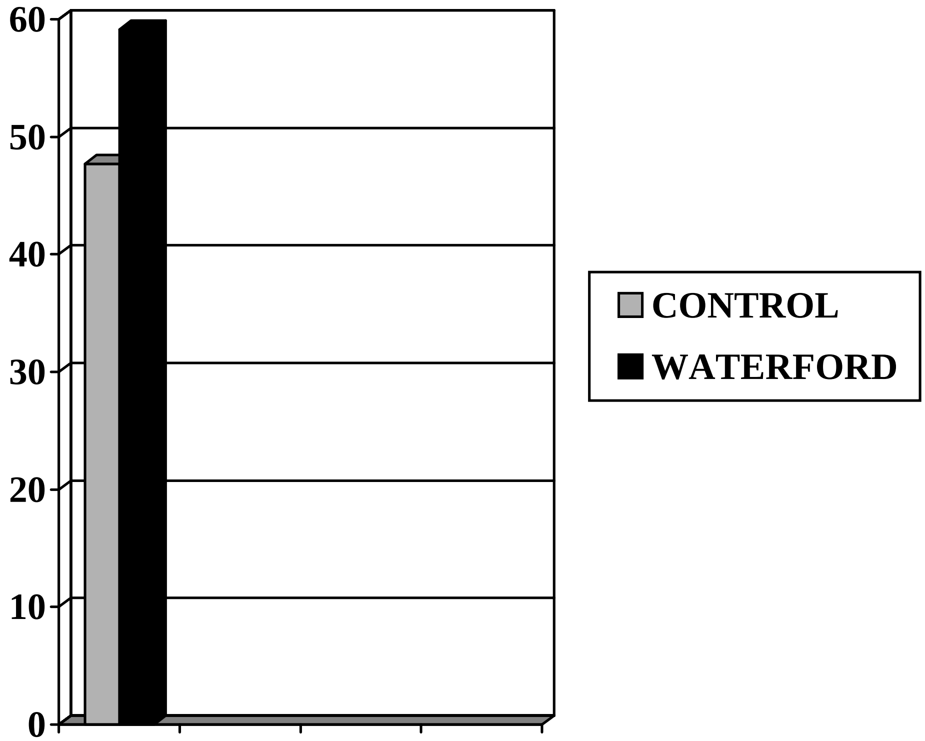
- **TERA-2 Mean Gain Scores**
- **Control=17.62**
- **Waterford=26.50**
- **f=6.82, p<.05**

Figure 2. TERA-2 Mean Gain Scores.



- **Lindamood Auditory Conceptualization Test Mean Gain Scores**
- **Control= 10.71**
- **Waterford= 11.63**
- **f=.39, p<.53**

Figure 3. Lindamood Auditory Conceptualization Test Mean Gain Scores.



- **Waterford Early Reading Inventory Mean Gain Scores**
- **Control=47.68**
- **Waterford=59.13**
- **f=11.69, p<.001**

Figure 4. Waterford Early Reading Inventory Mean Gain Scores.

Appendix A

<u>The TERA-2 Pre-Test and Post-Test Means</u>

School	Classroom	Pre-Test Mean (SD)	Post-Test Mean (SD)
Abington	Control	31.64 (20.96)	55.02 (13.34)
Abington	Experimental	10.91 (14.70)	47.64 (20.42)
Belmont-Runyon	Control	41.76 (30.23)	48.81 (18.32)
Belmont-Runyon	Experimental	28.64 (20.12)	43.14 (13.19)
Boylan	Control	40.40 (27.16)	52.77 (16.84)
Boylan	Experimental	48.55 (13.90)	65.93 (10.45)
Branch Brook	Experimental	38.45 (15.47)	52.41 (11.68)
Burnet	Control	36.61 (23.32)	58.03 (16.77)
Burnett	Experimental	34.00 (21.82)	44.21 (16.81)
Hawthorne	Control	40.13	50.62

		(16.91)	(13.25)
Hawthorne	Experimental	47.29	50.73
		(20.75)	(16.65)
Speedway	Control	22.19	50.60
		(22.17)	12.61)
Speedway	Experimental	38.34	59.13
		(19.22)	(8.30)
Wilson	Control	49.76	57.16
		(22.05)	(19.05)
Wilson	Experimental	24.30	52.18
		(17.44)	(3.80)

Appendix B

The Lindamood Auditory Conceptualization Test: Pre-Test and Post-Test Means-

School	Classroom	Pre-Test Mean (SD)	Post-Test Mean (SD)
Abington	Non-intervention	3.31 (4.64)	19.75 (21.64)
Abington	Experimental	0.46 (1.13)	7.92 (15.60)
Belmont-Runyon	Non-intervention	13.33 (18.19)	13.89 (16.94)
Belmont-Runyon	Experimental	6.40 (8.13)	16.57 (16.77)
Boylan	Non-intervention	6.70 (12.35)	21.78 (18.25)
Boylan	Experimental	7.89 (11.70)	21.38 (17.05)
Branch Brook	Experimental	0.50 (1.27)	2.90 (6.90)
Burnett	Non-intervention	4.56 (10.99)	11.25 (23.17)
Burnett	Experimental	0.45 (1.51)	8.27 (14.17)
Hawthorne	Non-intervention	1.33	10.80

		(1.75)	(22.49)
Hawthorne	Experimental	0.40	20.11
		(0.97)	(19.73)
Speedway	Non-intervention	4.55	16.78
		(7.87)	(16.63)
Speedway	Experimental	1.07	19.55
		(1.44)	(20.38)
Wilson	Non-Intervention	6.29	18.43
		(2.00)	(18.51)
Wilson	Experimental	7.14	25.00
		(3.77)	(38.82)

Appendix C

The Waterford Reading Inventory: Pre-Test and Post-Test Means-

School	Class	Pre-Test Mean (SD)	Post-Test Mean (SD)
Abington	Non-intervention	43.58	90.73
		(36.25)	(22.65)
Abington	Experimental	4.80	78.36
		(5.77)	(18.39)
Belmont-Runyon	Non-intervention	20.09	56.38
		(20.24)	(25.81)
Belmont-Runyon	Experimental	19.11	60.17
		(15.97)	(14.73)
Boylan	Non-intervention	19.09	61.40
		(16.18)	(19.00)
Boylan	Experimental	28.73	81.30
		(19.39)	(18.96)
Branch Brook	Experimental	35.18	86.55
		(23.56)	(15.14)
Burnett	Non-intervention	43.00	93.50
		(25.17)	(24.27)
Burnett	Experimental	19.40	74.75
		(20.21)	(26.17)
Hawthorne	Non-intervention	12.75	70.25

		(15.96)	(14.13)
Hawthorne	Experimental	19.93	72.63
		(16.94)	(10.93)
Speedway	Non-intervention	21.36	82.90
		(22.72)	(22.14)
Speedway	Experimental	25.72	84.14
		(21.86)	(22.14)
Wilson	Non-intervention	15.67	56.17
		(24.01)	(28.91)
Wilson	Experimental	12.00	108.00
		(11.90)	(5.96)
MEAN SCORE	Non-intervention	27.78	75.46
MEAN SCORE	Experimental	21.99	81.12