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Lighting The Fire:

The Effectiveness Of The **Hatch TeachSmart Learning System** In Improving Literacy & Mathematics Outcomes For Preschoolers

hatch

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The HATCH® Mission

For more than 25 years HATCH® has been committed to supporting the needs of the early childhood education community. The mission at HATCH® is to provide innovative classroom solutions that meet the goal of preparing children for school. HATCH® targets at-risk children with the deep understanding that the acquisition of essential skills in early childhood is proven to positively affect the outcomes of children in kindergarten and beyond. Our products are developmentally appropriate and use cutting-edge technology to present children with opportunities to develop these essential skills and provide teachers with the progress monitoring tools to create success in the classroom.

Relationship of the TeachSmart® Learning System with Literacy and Mathematics Outcomes for Preschoolers

Lilla Dale McManis, Ph.D., Mark H. McManis Ph.D., and Susan B. Gunnewig, M.Ed.

Executive Summary

Developing and properly using instructional technology hinges on many factors including the developmental appropriateness of the equipment itself and the content to which children are exposed.

The results of our recent study found that prekindergarten children in classrooms using the TeachSmart® Learning System—an interactive whiteboard with instructional activities designed for preschoolers—made significant gains from fall to spring in literacy and mathematics.

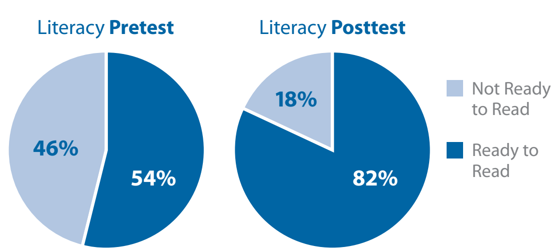
Participants

The study included 87 randomly selected children in school district preschools in the 2009-2010 school year. The children were tested on measures of literacy and mathematics near the beginning and again near the end of their prekindergarten year. There were two measures for literacy and one for math. The data were collected and analyzed by outside consultants.

Results for Literacy

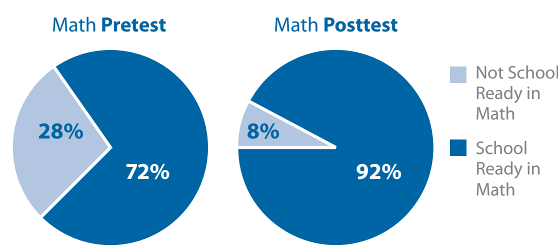
The Test of Preschool Early Literacy (TOPEL) measures print knowledge, phonological awareness, and vocabulary combined into an Early Literacy Index. The children had a significant increase in their Early Literacy Index over the course of the year, where they began well below average and ended as average.

The Get Ready to Read! (GRTR!) Literacy Screener also measures early literacy skills, including knowledge of letter and sounds, recognition of spoken words, and phonological knowledge. The children had a significant increase on the GRTR. The score calculated from the Screener provides an index of readiness to learn to read. At pretest, 46% of the children were Ready to Read, at posttest 82% were Ready to Read.



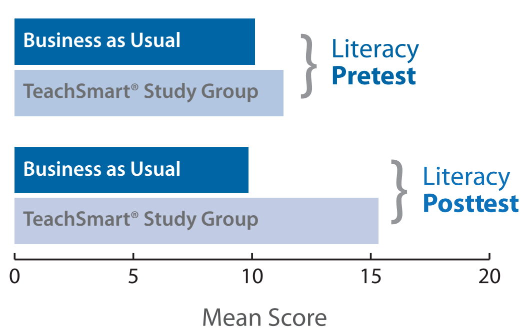
Results for Mathematics

The CPALLS+ Math Screener looks at the skills important for the development of math knowledge; including counting, shapes, operations, and number identification. Children in the study showed a significant increase from fall to spring. The Screener also gives an index of progress towards school readiness in mathematics. The results from the pretest show that 72% of children achieved a high enough score to be considered ready for math in school. At posttest, that number had increased to 92%.



Comparing with "Business as Usual"

Results for children in "Business as Usual" classrooms showed no gains on the Get Ready to Read! Literacy Screener. Children in the TeachSmart® classrooms made significant gains in literacy.



Conclusion

The importance of these findings is twofold:
(1) The literacy and math skills on which these at-risk preschool children increased are known to be predictors of success in school, both in the short-term in kindergarten and first grade, and beyond to have an impact on their entire schooling experience.
(2) The study supports that instructional technology, as both a vehicle for presenting educational information and as a vehicle for bringing strong content and skills, can be used successfully with young children in early childhood education settings.

Overview

This study of randomly selected public school prekindergarten children in classrooms using the TeachSmart® Learning System—an interactive whiteboard with instructional activities designed for preschoolers—found the children to have made significant gains from fall to spring in literacy (namely print knowledge, phonological awareness, and emergent writing), and in mathematics (namely counting, operations, and shapes).

A. Background and Significance

The landmark report "Eager to Learn: Educating our Preschoolers" highlights that young children are better able to learn than current practices sometimes allow[1]. An educational preschool experience with the goal of preparing children for kindergarten means including more academic areas such as letters and counting, as well as helping build traits like being inquisitive, persistent, and independent. It is possible to motivate young children to learn concepts on their level by building on their natural eagerness to learn. Combining child-directed discovery along with direct teacher instruction on basic pre-academic skills supports the most effective learning for young children[2].

Literacy

While it is becoming more accepted that literacy, simply put, the ability to read and write to a competent level, begins well before formal schooling; it is only fairly recently that research has determined which particular skills are critical predictors of children's success in these areas. The importance of this can be noted in that one in three children will experience significant difficulties in learning to read[3, 4]. As a result, they will lag far behind most children their age in reading and over time in content knowledge, vocabulary, and other language skills[5-7], often never catching up[8-11].

The encouraging news is that many problems in reading can be prevented through providing children who do not have the basic language skills with instruction before they are exposed to a formal reading setting. Many experts have concluded that oral language, print knowledge, and phonological awareness are important requisites for developing reading skills[12-15]. The groundbreaking study produced by the National Early Literacy Panel used a meta-analyses approach and focused on the predictive relationship between skills measured in preschool or kindergarten and conventional literacy outcomes for children learning to read[16]. Conventional literacy skills refer to such skills as decoding, oral reading fluency, reading comprehension, writing, and spelling, and are later developing expressions of reading and writing. This is contrasted with precursor, foundational, or emergent skills. More generally, early literacy skills can refer to both precursor skills and conventional literacy skills. The panel concluded the following:

- Alphabet knowledge and phonological awareness are consistently the strongest non-reading correlates for decoding, reading comprehension, and spelling.
- Oral language, when determined by measures of definitional vocabulary, had substantial correlations with both decoding and reading comprehension.

The panel also worked to identify the effectiveness of instructional strategies, programs, or practices in teaching either foundational or conventional literacy skills to children. Definitions of the five strategy areas identified are:

- Code-focused interventions: Designed to teach children skills related to cracking the alphabetic code. Most code-focused interventions included instruction in phonological awareness.
- Shared-reading interventions: Involving reading books to children. These interventions included simple, shared reading and those promoting various forms of reader-child interactions with the material being read.
- Preschool and kindergarten programs: Evaluations of aspects of a preschool or kindergarten program. Many studies in this category were on one particular intervention—the Abecedarian Project. Others evaluated effects of educational programs, curricula, or policies, such as extended-year experience, on kindergartners.
- Language-enhancement interventions: Studied the effectiveness of an instruction designed to improve language development.
- Parent and home programs: Interventions using parents as agents of change. These may have included teaching parents instructional techniques to use with their children at home to promote linguistic or cognitive development.

The panel found statistically significant moderate to large effects with code-focused interventions across a wide array of early literacy outcome. The authors note that "code-focused interventions consistently demonstrated positive effects directly on children's conventional literacy skills." Book-sharing interventions yielded statistically significant and moderate-sized effects on children's print knowledge and oral language skills. The home and parent programs provided statistically significant moderate to large effects on oral language skills and general cognitive abilities. Significant and moderate to large effects on spelling and reading readiness were produced by preschool and kindergarten programs. Interventions featuring language-enhancement succeeded at increasing children's oral language skills to a large and statistically significant degree. The report concludes that taken together, "there are many approaches that parents and preschools can implement to improve the literacy development of their young children and that different approaches influence the development of a different pattern of essential skills."

Mathematics

Attention to teaching mathematics to young children before they enter formal schooling is now in a similar place as literacy was a decade or so ago. Overall, Americans hold a generally negative attitude about mathematics, and believe that if content is going to be delivered to children in early childhood it should be language and literacy. A recent study found that parents feel it is more important for young children to have exposure to literacy and language than mathematics[17]. One other stumbling block is the discomfort many early childhood education teachers feel teaching mathematics, either because they feel unprepared or due to their own personal negative experiences with math[18-21].

The dilemma is that research finds that learning mathematics is crucial for children in their early years and for their later success in mathematics. Further, when children have intentional instruction in math they also show better overall outcomes in literacy, science, and technology[22, 23]. There are striking similarities in themes that are emerging between literacy and mathematics. Young children from disadvantaged backgrounds show lower levels of mathematics achievement than do middle-class and higher status children[24-27]. Likewise, if they do not receive more intensive mathematics teaching, children who are at risk because of life circumstances, such as poverty, will fall further behind their more affluent peers over the course of time in school[28].

Also similarly, preschool-age children are excited about learning and enjoy activities that develop their mathematical competencies[29-32]. Further as in literacy, the early childhood period is vital for the maintenance and enhancement of motivation to learn. This is especially the case for children from disadvantaged backgrounds, as giving them access to enriching early learning experiences can facilitate starting kindergarten on a more level playing field with their more advantaged peers.

Fortunately, interest has been growing for including instruction in mathematics for young children and doing so in developmentally appropriate ways. Research has picked up to the point where a number of robust findings are now known. For example, the National Research Council established the Committee on Early Childhood Mathematics in 2007, with the charge of pulling out key learning and teaching practices around mathematical development in young children[33]. Troubling, though, is that examination of current standards, curricula, and instruction in early childhood education revealed that many early childhood settings do not provide adequate learning experiences in mathematics. Many early childhood curricula that are widely used do not give adequate guidance on content or instructional techniques in mathematics. When early childhood classrooms do include mathematics activities, they are often integrated in other activities, making the teaching of mathematics secondary to the other learning goals. Emerging research shows this approach is less effective in promoting children's mathematics skills as compared to an approach that makes math a central and primary goal. Even though current research regarding how young children develop and learn key mathematics concepts has clear practice implications, they are not known widely nor implemented either by early childhood teachers, or those who prepare them for educating children.

The Committee used a meta-analyses approach and identified the foundational mathematics content that should be provided to young children. Two core areas: (1) number, which includes whole numbers, operations, and relations; and (2) geometry, spatial thinking, and measurement, are important for school and life, and children find them interesting and enjoy exploring them.

Instructional Technology

As discussed above, it is now well established that three and four year olds need a strong focus on cognitive development, along with attention to their social/emotional development, to be ready for kindergarten. Instructional technology is clearly emerging as having the capability to play a key role in this preparation[34, 35]. Experts confirm that preschool age children are developmentally ready and able to benefit from instruction with technology[36-38]. The use of educational technology is now emerging as having a major, positive impact on the social, emotional, language, and cognitive development of children[39,40]. It is recommended that many opportunities be given during the preschool years for exploration using technology tools in a playful, supportive environment[41]. Developmental appropriateness also involves connections made in a meaningful way to the curriculum and in support of creativity and critical thinking[42].

Researchers further agree that a number of technology applications have the potential to support and extend learning in the young child through their unique capacity to provide excellent instruction in these important developmental areas that are critical for educational success. For example, research has found that preschoolers who used computers with supporting activities for key learning goals, had more gains than children without such computer experiences. Among others, these included gains in knowledge, long-term memory, verbal skills, mathematics, problem solving, and manual dexterity[43]. A set of studies with low-income children found those who received a computer curriculum had increases in cognitive, motor, and language scores compared to similar children in a regular curriculum[44, 45]. Recent research published in the journal Pediatrics found that young children who had access to a computer compared to those who did not, performed better on measures of cognitive development and school readiness as measured by the Boehm Test of Basic Concepts and the Wechsler Preschool and Primary Scales of Intelligence. The lead author notes the findings suggest that "computer access before or during the preschool years is associated with the development of preschool concepts and cognition[46]."

A recent study of educators around the use of digital media concluded that observers, from educators and policymakers to parents and business people, overwhelmingly agree that technology is an essential component of education[47]. Federal and state governments, and school districts, have spent billions of dollars on technology equipment and Internet access for schools. Both teachers and administrators believe that technology helps them engage many different types of students, including high-achieving students, students with academic needs, and English language learners. The study found that teachers who use technology frequently (defined as spending 31 percent or more of their class time using technology to support learning) report greater benefits to student learning, engagement, and skills from technology than teachers who spend less time using technology to support learning. These users also put more emphasis on 21st century skills and report more pronounced effects on student learning of these skills. Among others, the skills identified are in accountability, collaboration, communication, creativity, critical thinking, innovation, leadership, problem solving, productivity, and self-direction. Educators who are frequent users also have more positive perceptions about technology's effects on student learning of these skills, and on student behaviors associated with them.

An ongoing PBS survey on media and technology use, with a sample selected to represent teachers in urban, suburban, and rural regions, and in districts of all sizes, did find that classroom use of digital media by prekindergarten teachers is less common than it is among K–12 teachers, with only one-third (33 percent) reporting use. Those prekindergarten teachers who do use digital media however, use it as much as K–12 teachers do. More than four in 10 (42 percent), in fact, use it two times a week or more[48].

Yet, many schools continue to struggle to integrate technology into instructional programs. Most teachers do not believe that their pre-service programs prepared them well in either technology or 21st century skills. The findings suggest that on-the-job technology training for teachers may focus on how to operate new equipment, but not on how to incorporate it effectively into instruction[49].

B. Purpose of the Study

Developing and properly using instructional technology hinges on many factors, including the developmental appropriateness of the equipment itself and the content to which children are exposed. The purpose of the present study was to determine if preschool children in classrooms using the TeachSmart® Learning System (TSLS) would make significant gains in literacy and mathematics.

The TeachSmart® Learning System was designed specifically for early childhood classrooms to promote a connection between learning and technology. The technology and instructional content combines the educational theories of Piaget and Vygotsky in particular. Using the Interactive Whiteboard component of the system, children construct knowledge while exploring on their own or with the guidance of a facilitator (Piaget)[50]. The teacher is engaged directly with the child for rich language, stimulation, and scaffolding to assist and strengthen the child's capabilities (Vygotsky)[51].

The content on the TeachSmart® Learning System is key to children gaining skills by providing the teacher with research-based strategies and activities. The strategies and activities are in the skill areas of literacy, language, math, social studies, and science; and are tied into national prekindergarten standards[52-56] and the findings of the National Early Literacy Panel[57] and the National Research Council Committee on Early Childhood Mathematics[58].

C. Methodology

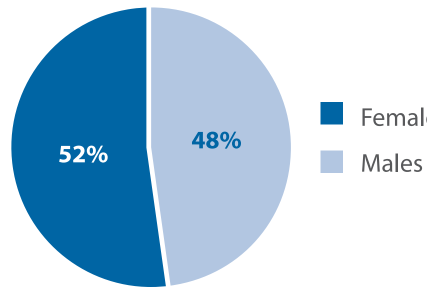
The study was conducted in eight public school district prekindergarten classrooms, across three schools, in three separate school districts in the 2009-2010 school year. The study used a repeated measures (pretest—posttest) design. The classrooms represented a convenience sample based on the following criteria: in a similar geographic region (West Tennessee) and location (rural), and using the TeachSmart® Learning System for approximately two years prior to the study in order to ensure that there was not a differential learning curve for the hardware and software. All teachers received a similar training when the TeachSmart® Learning System was installed in their classrooms.

Eleven children per classroom were randomly selected to be tested on measures of literacy and mathematics. There was a quasi-program group of six classrooms that used a multi-week scope and sequence in math and literacy TeachSmart® Learning System activities, and a quasi-control group consisting of the remaining two classrooms that used the TeachSmart® Learning System without the scope and sequence. All children were tested individually by trained external assessors. There was an average of six months between pretest and posttest. One school asked that all children be tested (four classrooms), in addition to the randomly selected children. This sample is referred to as the Study Plus. These results are reported following the results for the randomly selected children. As we used standardized assessments, the norming group averages comprised a (nonequivalent) control group.

Sample

Data for both pretest and posttest were available for 87 of the 88 randomly selected children. Girls made up 52 percent of the sample, and boys 48 percent (see Graph 1). The average age of children at pretest was four years and six months and at posttest was an even five years of age. The majority of the children were low-income.

Gender — Graph 1



Measures

There were three screening assessments used to measure children's school readiness skills:

- Test of Preschool Early Literacy (TOPEL)
- Get Ready to Read! Early Literacy Screening Tool (GRTR)
- C-PALLS+ Math Screener

All measures have good reliability and validity, and have been extensively used with preschool populations of various socioeconomic and ethnicity backgrounds, and early childhood education program types[59-61].

The Test of Preschool Early Literacy is a theoretically sound instrument designed to identify preschoolers aged three years to five years who are at risk for literacy problems. It provides valid and reliable raw scores, standard scores, and percentiles. The TOPEL has three principle uses: identification, documentation of progress, and research. The test has three subtests: print knowledge, definitional vocabulary, and phonological awareness. All results are combined to determine the composite score called the Early Learning Index that ultimately best represents a child's emergent literacy skills.

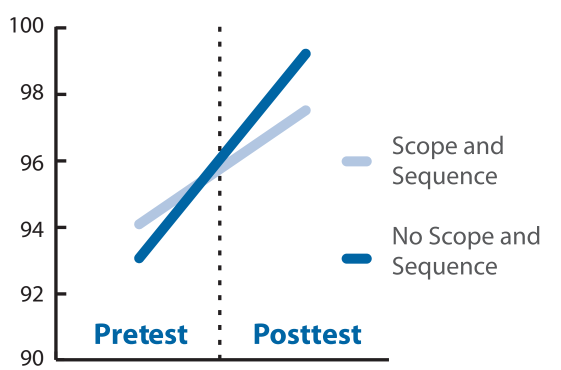
The Get Ready to Read! Early Literacy Screener is a 20-question tool that allows one to know how a child is progressing toward acquiring the knowledge and skills that lead to reading and writing. It is designed to explain how children learn to read and determine how far along a four year old is on the path to learning to read. The screening tool samples knowledge and skills in the three areas of print knowledge, emergent writing, and linguistic awareness. The screener gives a score that tells whether the child's skills are still very basic (step 1), beginning to develop (step 2), making progress (step 3), almost ready (step 4), or ready to learn to read and write (step 5). Children screened a year before kindergarten should be making good progress in acquiring the skills needed to learn to read and write, but not all are expected to be ready quite yet.

The C-PALLS Math Screener provides a good indication of what researchers typically think is important in early mathematical skills. The Math Screener evaluates child skills across multiple math content areas including counting (rote counting and counting sets), number identification, operations, shape naming, and shape discrimination. A cut score of ≤ 12 is used to conceptualize progress. Children scoring at or below 12 need more assistance/support in relation to early math skills. Children who score at or above 12 can be described as making adequate progress in relation to early mathematical development.

D. Results

Data were analyzed by an external statistician. There was no statistical difference between the children in classrooms using the scope and sequence (6) and children in classrooms that did not (2); therefore the classrooms were combined for analyses (see Graph 2).

Scope and Sequence — Graph 2



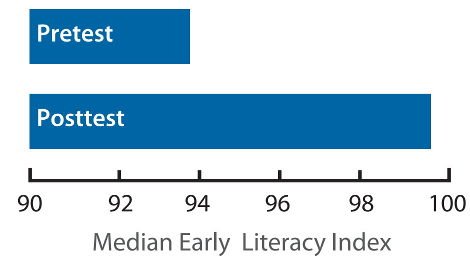
Literacy

Test of Preschool Literacy

The Test of Preschool Literacy assessment measures abilities related to early literacy. Raw scores are converted to age-corrected scale scores. The test has normative data that allow for comparisons to national standards. There are three subtests: Print Knowledge, Definitional Vocabulary, and Phonological Awareness. The subscales are combined to create an Early Literacy Index (ELI) which can be compared directly to the normative sample.

A comparison of the mean pretest ELI to the posttest ELI showed a significant increase in early literacy skills over the course of the year for the study children ($t(86) = 4.06$; $\underline{p} < .001$). The median ELI for all children at pretest was 94, which is in the 35th percentile of the normative sample. The median ELI for all children at posttest was 100, which is the 50th percentile of the normative sample (see Graph 3). This means the children began well below average and ended as average.

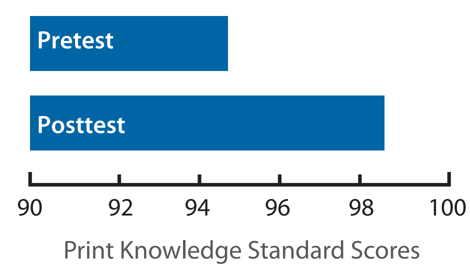
TOPEL Early Literacy Index — Graph 3



A closer look at performance on the TOPEL can be done by comparing the age-corrected standard scores of each subscale. Within the TOPEL there was a significant increase in Print Knowledge and Phonological Awareness. While the raw scores showed the children actually achieved a statistically significant gain in vocabulary (pretest mean 47.39; posttest mean 50.72, $\underline{p}<.0001$), using age-adjusted standard scores, there was a significant decrease in Vocabulary. However, the decrease in vocabulary did not bring the total Early Literacy Index down enough to make it non-significant.

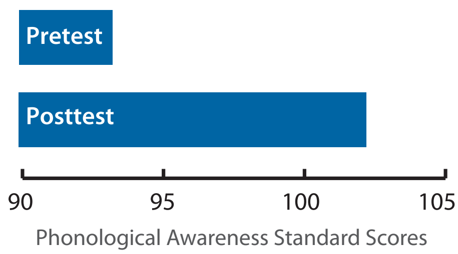
The Print Knowledge subscale measures alphabet knowledge, and identifying letters by sight and sound. A comparison of pretest Print Knowledge to posttest showed a very significant increase in Print Knowledge for the children ($t(86) = 7.42$; $\underline{p} < .001$) (see Graph 4).

TOPEL Print Knowledge — Graph 4



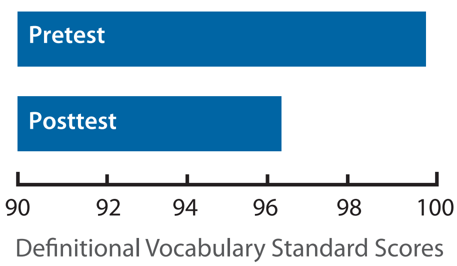
The Phonological Awareness subscale measures the child's sensitivity to letter sounds and oral language. A comparison between the pretest Phonological Awareness standard scores and posttest showed a significant improvement in Phonological Awareness skills across the school year ($t(86) = 2.50$; $p = .014$) (see Graph 5).

TOPEL Phonological Awareness—Graph 5



The Definitional Vocabulary subscale measures the child's one word vocabulary and ability to name objects in a picture. A comparison between the pretest Definitional Vocabulary and posttest age-adjusted standard scores shows a statistically significant decrease ($t(86) = 2.96$; $p = .004$) (see Graph 6).

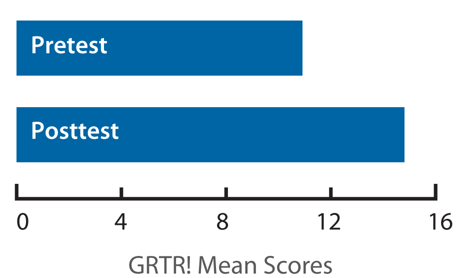
TOPEL Vocabulary—Graph 6



Get Ready to Read! Screener

The Get Ready to Read! (GRTR!) Screener measures early literacy skills, including knowledge of letter and sounds, recognition of spoken words, and phonological knowledge. A comparison between the pretest and posttest mean scores showed a very statistically significant increase over the course of the school year for the children ($t(86) = 12.22$; $p < .001$) (see Graph 7).

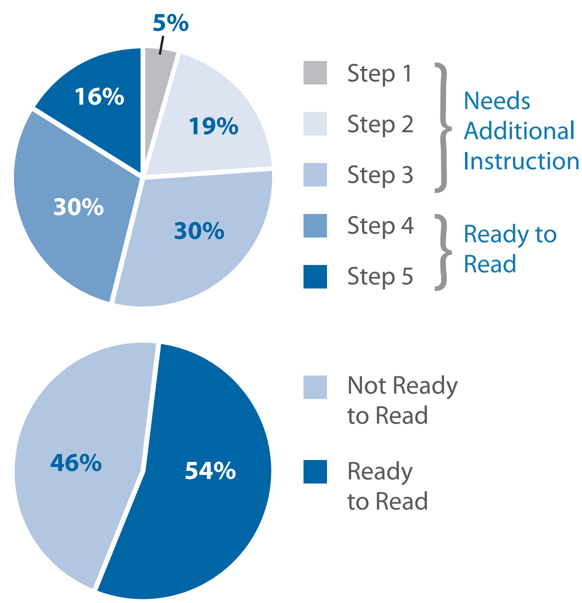
Get Ready to Read!—Graph 7



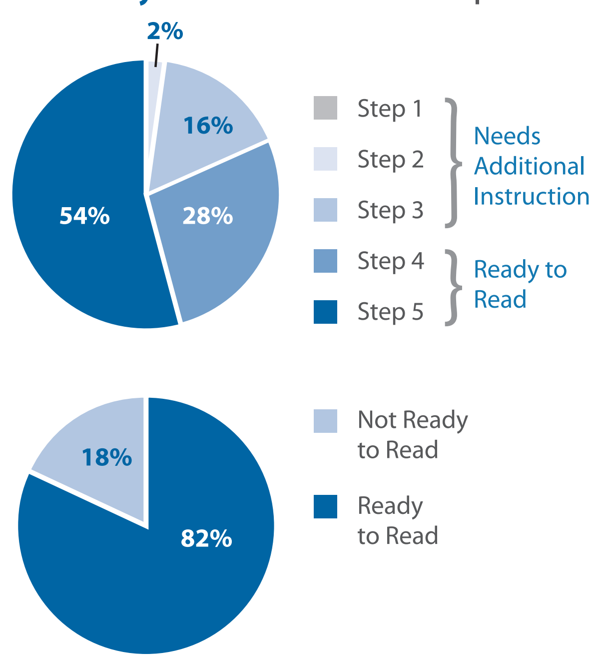
The score calculated from the Get Ready to Read! Screener also provides an index of the child's readiness to learn to read. The score is used to rank readiness into one of five steps. Children at steps one through three are considered to need additional readiness instruction while those at steps four or five are considered ready to learn to read.

At pretest, 54 percent of the study children were at step three or lower, needing additional instruction before being ready to read (see Graphs 8-9). At posttest, only 18% were at step three or lower (see Graphs 10-11). Conversely, at pretest, 46 percent of the children were Ready to Read, at posttest 82 percent were Ready to Read.

Get Ready to Read! Pretest—Graphs 8-9



Get Ready to Read! Posttest—Graphs 10-11



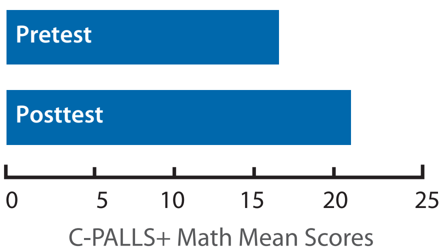
Mathematics

CPALLS+ Math Screener

The CPALLS+ Math Screener evaluates a child's skills across multiple content areas important for the development of math knowledge, including counting, number identification, operations, shape naming, and shape discrimination.

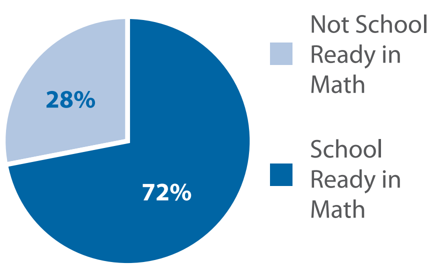
There was a very significant increase in the mean score on the C-PALLS+ Math Screener from pretest to posttest for the study children ($t(86) = 9.27$; $p <. 001$) (see Graph 12).

C-PALLS+ Math — Graph 12

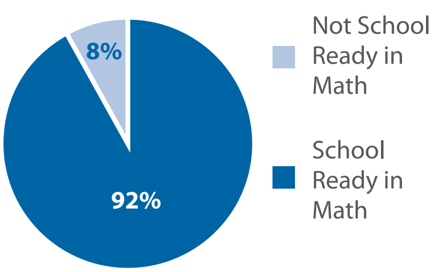


The score calculated from the screener also provides an index into the child's progress towards school readiness in mathematics. Specifically, a score greater than 12 at the preschool age represents adequate math knowledge for kindergarten. The results from the pretest show that 72 percent of children achieved a high enough score to be considered ready for math in school (see Graph 13). At posttest, that number had increased to 92 percent (see Graph 14). Conversely, at pretest, 28 percent were not School Ready in math. At posttest, only 8 percent were not School Ready in math.

C-PALLS+Math Pretest — Graph 13



C-PALLS+Math Posttest — Graph 14



Study Plus

By including test data on four of the eight classrooms in which all children were tested, there were a total of 109 children. Data on one subtest of the TOPEL was missing for one child, therefore the Phonological Awareness subscale and Emergent Literacy Index (ELI) were calculated on 108 children. The median age of the children at pretest was four years and six months of age. The median age at posttest was five years and zero months of age. There were 58 female and 51 male participants.

Results

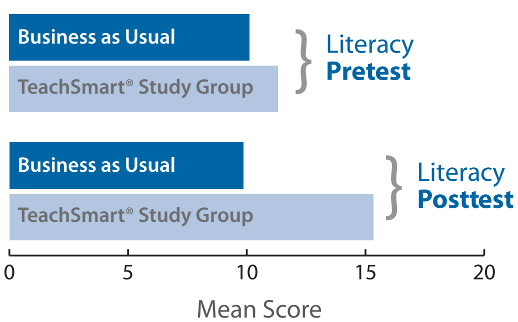
The pattern of findings was extremely similar to the sample of only randomly selected children.

- A comparison of the TOPEL mean pretest ELI to the posttest ELI showed a significant increase in early literacy skills over the course of the year ($t(107) = 4.89$; $p < .001$).
- A comparison of the TOPEL mean pretest Print Knowledge standard scores to posttest showed a significant increase ($t(108) = 8.44$; $p < 0.001$).
- A comparison between the TOPEL pretest Phonological Awareness standard scores to posttest showed a significant improvement in Phonological Awareness skills ($t(107) = 2.54$; $p = 0.013$).
- A comparison between the pretest Definitional Vocabulary and posttest age-adjusted standard scores showed a statistically significant decrease ($t(108) = 2.78$; $p = 0.006$).
- On the Get Ready to Read! Screener, there was a significant increase from fall to spring ($t(108) = 14.48$; $p < .001$).
- On the Get Ready to Read! Screener, at the pretest, 51 percent of the children were at step three or lower, needing additional instruction before being ready to read. At the posttest, only 16 percent of the children were at step three or lower.
- There was a significant increase in the mean score on the C-PALLS+ Math Screener ($t(108) = 10.49$; $p < 0.001$).
- The results from the pretest showed that 72 percent of children achieved a high enough score to be considered math ready. At posttest, that number had increased to 93 percent.

Comparing to "Business as Usual" Classrooms

The current study did not have a true control group, however we compared the norming group for a control group and thus demonstrated that our sample grew significantly within their group and when compared with the norming group on the standardized measures used. Further, for example, in a large reliability and validity study, the GRTR! baseline (right before children began their preschool year), showed the children's mean score as 10.12 and then at short-term follow up (three to seven months later) their mean score was 9.85. There was no intervention in this sample and it was composed of children from Head Start (41 percent), public prekindergarten (33 percent), and private preschool (25 percent)[62]. At pretest, our mean score for the randomly selected children (n=87) was 11.20 and six months later at posttest it was 15.18 (see Graph 15). Please see Appendix for more in-depth discussion.

"Business as Usual" — Graph 15



Discussion

The purpose of this study was to determine if preschool age children in classrooms using the TeachSmart® Learning System—an instructional technology tool with predesigned content delivered through an interactive touch screen whiteboard—would make significant gains in literacy and mathematics. The results strongly indicate this was the case. Over a six-month period, these low-income children increased overall in emergent literacy, and specifically in print knowledge, phonological awareness, and emergent writing. Their significant increase in math was represented by growth in counting, operations, and shape naming and discrimination. These results were true for a randomly selected group of children and for a larger sample including additional children who were not randomly selected.

The importance of this finding is twofold:

1) The literacy and math skills on which these at-risk preschool children increased are known to be predictors of success in school, both in the short-term in kindergarten and first grade, and beyond to have an impact on their entire schooling experience.
2) The study supports that instructional technology, as both a vehicle for presenting information and as a vehicle for presenting strong content, can be used successfully with young children in early childhood education settings.

The fact that the children did not gain in vocabulary when looking at age-adjusted scores is disappointing, but not unexpected. While it is known that vocabulary is related to later achievement[63, 64], there have not been many successful interventions in bringing word knowledge of low-income students up to the level of their middle-income peers[65], likely tied to findings that by age four, the average child from a family on welfare has 13 million fewer words of language experience than a child in a working class family (see Appendix for more in-depth discussion). Another connected reason could be that early childhood education teachers appear to have a somewhat difficult time promoting language and literacy skills in young children. The results of a recent meta-analysis found that the strongest effect sizes for vocabulary appeared not with classroom teachers, but rather in tightly controlled settings with trained examiners[66]. The researchers Neuman and Dwyer state that, "Together, this evidence suggests more intensive interventions might be needed to narrow the gap for less advantaged children[67]." These findings will generate recommendations for practice in using the TeachSmart® Learning System. Notable, however, is that even though there was not a significant increase in vocabulary, the overall Emergent Literacy Index (a composite score of print knowledge, phonological awareness, and definitional vocabulary from the Test of Preschool Early Literacy-TOPEL) is reported by the author of the measurement as ultimately the best representation of a child's emergent literacy skills[68], and was highly significant in the present study.

The study children also showed a strong increase on the Get Ready to Read! Screener. Recent research on the predictive validity of the GRTR looking both at concurrent and long-term relationships with reading related skills, found it once again to be a strong and valid measure of children's emerging literacy skills[69]. The authors note that "Results indicated that at intervals even greater than two years, children's performance on the screening measure was predictive of later reading-related abilities." The author of the GRTR reports that by the end of the pre-kindergarten year, two-thirds of the children have the early literacy skills they need to succeed in school (i.e., scores of 16+), while the other third will need additional focused educational intervention. Our study children began the year with 46% of the children having these skills and ended the year with 82% demonstrating they have the early literacy skills needed for school success.

The TeachSmart® Learning System includes very specific activities in areas known to robustly predict success in school. For example, it is well established that in order to be successful readers, children must be competent in phonological awareness because this increases their capability of breaking the alphabetic code—that is that the letters in print reflect the specific sounds in spoken words[70, 71]. Additionally, children must be able to comprehend how print is organized, so that they have strong print awareness in order to read successfully. For instance, knowledge of letter names prior to kindergarten has been found to be predictive of reading ability in the fifth and tenth grades[72]. As the meta-analyses conducted recently by the National Early Literacy Panel found, alphabet knowledge and phonological awareness are consistently the strongest non-reading correlates for decoding, reading comprehension, and spelling[73]. Spelling is strongly tied to writing, and the current study, in addition to phonological awareness and print knowledge, showed a significant increase for children using the TeachSmart® Learning System in emergent writing. At pretest, less than half (46 percent) of the study children were in the 'Ready to Read' category, while at posttest that percentage had increased to 82 percent of the children being considered 'Ready to Read.'

As the National Research Council on Mathematics in Early Childhood found, math is often given a lack of attention, and in particular even when taught, not done so independently of other subjects in preschool settings[74]. However, the Council found, and recommends, that direct and singular instruction in mathematics be the case in early childhood. The TeachSmart® Learning System has a large mathematics section and includes the key areas that the Council found need to be taught to young children in order for them to have success in mathematics when they enter formal schooling. These are (1) number, which includes whole numbers, operations, and relations; and (2) geometry, spatial thinking, and measurement. While our battery did not include measurement, the other areas were covered. The results of the present study showed significant increases for children using the TeachSmart® Learning System in these key areas. Most striking is that the percentage of children considered Math Ready increased by 20 percent, to a level in which 92 percent were considered Math Ready by spring.

Using the instructional technology appropriately and consistently is key to successfully bringing the content on the TeachSmart® Learning System to the children. As noted in the introduction, the findings of a large representative sample of teachers suggest that on-the-job technology training for teachers may focus on how to operate new equipment, but not on how to incorporate it effectively into instruction[75]. Knowing this, some of the features built into the TeachSmart® Learning System for each activity are: lesson plans, guidelines and standards, the research-basis, a look and listen feature which fully models the activities, digital portfolios that can capture children's efforts in real time, and progress monitoring. Upon first receiving the system, teachers are given a multi-hour, on-site training on the hardware and software, and have access to lifetime training.

Based on the large amount of research showing that as a whole, at-risk children due to poverty and challenging life circumstances, begin behind and stay behind their more affluent peers in school readiness and school achievement, the findings of this study support that with instructional technology combined with appropriate content, such children can make gains in their preschool year that put them on a more level playing field for beginning kindergarten.

There are limitations in the study warranting note. This study did not include a control group of children who were similar in background and school setting, so that even though they were randomly selected from among their classmates, the findings are worthy but need to be replicated under a more stringent design. The children attended school in only one geographic location in the country and the schools were located in towns, but would be considered rural. All were in school district prekindergarten and, while at-risk due to factors such as income, they were all taught by degreed teachers. Further research is recommended with children in a variety of geographic locations and early childhood settings.

In summary, based on a growing body of research around the importance of foundational skills in literacy and mathematics for preschool children, especially those considered at-risk for failure due to difficult life circumstances, and the confirmation that the use of technology is growing extremely rapidly even in early childhood education settings, the findings of this efficacy study are promising.

References

[1] National Research Council. (2001). *Eager to Learn: Educating our Preschoolers.* Committee on Early Childhood Pedagogy. B. T. Bowman, M. S. Donovan, & M. S. Burns (Eds.). Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

[2] Landry, S. (2005). *Effective Early Childhood Programs: Turning Knowledge into Action.* Houston, TX: Rice University.

[3] Adams, M. J. (1990). *Learning to Read: Thinking and Learning about Print.* Cambridge, MA: MIT Press.

[4] Donahue, P.L., Daane, M.C., and Jin, Y. (2005). *The Nation's Report Card: Reading 2003* (NCES 2005–453). U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

[5] Cunningham, A. E., & Stanovich, K. E. (1998). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology, 33,* 934-945.

[6] Echols, L. D., West, R. F., Stanovich, K. E., & Zehr, K. S. (1996). Using children's literacy activities to predict growth in verbal cognitive skills: A longitudinal investigation. *Journal of Educational Psychology, 88,* 296-304.

[7] Morrison, F. J., Smith, L., & Dow-Ehrensberger, M. (1995). Education and cognitive development: A natural experiment. *Developmental Psychology*, *31,* 789-799.

[8] Francis, D. J., Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Fletcher J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal individual growth curve analysis. *Journal of Educational Psychology, 88,* 3-17.

[9] Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80,* 437-447.

[10] Torgesen, J. K., & Burgess, S. R. (1998). Consistency of reading-related phonological processes throughout early childhood: Evidence from longitudinal-correlational and instructional studies. In J. L. Metsala & L. C. Ehri (Eds.), *Word Recognition in Beginning Literacy* (pp. 161-188). Mahwah, NJ: Erlbaum.

[11] Torgesen, J. K., Rashottte, C. A., & Alexander, A. (2001). Principles of fluency instruction in reading: Relationships with established empirical outcomes. In M. Wolf (Ed.), *Dyslexia, Fluency, and the Brain* (pp. 333-335). Parkton, MD: York Press.

[12] Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology, 30,* 73-87.

[13] Wagner, R. K., Torgesen, J. K., Rashotte, C. A., Hecht, S. A., Barker, T. A., Burgess, S. R., Donahue, J., & Garon, T. (1997). Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology, 33,* 468-479.

[14] Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development*, *69,* 848-872.

[15] National Early Literacy Panel. (2006). *Report on a Synthesis of Early Predictors of Reading*. Louisville, KY: National Center for Family Literacy.

[16] National Early Literacy Panel. (2008). *Developing Literacy: A Scientific Synthesis of Early Literacy Development and Implications for Intervention.* T. Shanahan, Chair. Louisville, KY: National Center for Family Literacy.

[17] Cannon, J., & Ginsburg, H. P. (2008). "Doing the math": Maternal beliefs about early mathematics versus language learning. *Early Education and Development*, *19,* 238-260.

[18] Clements, D. H., & Sarama, J. (2007). Early childhood mathematics learning. In F. K. Lester, Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 461-555). New York: Information Age.

[19] Copley, J. V. (2004). The early childhood collaborative: A professional development model to communicate and implement the standards. In D. H. Clements, J. Sarama, & A. M. DiBiase (Eds.), *Engaging Young Children in Mathematics* (pp. 401-414). Mahwah, NJ: Erlbaum.

[20] Ginsburg, H. P., Goldberg-Kaplan, R., Cannon J., Cordero, M. I., Eisenband, J. G., Galanter, M., & Morgenlander, M. (2006). Helping early childhood educators to teach mathematics. In M. Zaslow & I. Martinez-Beck (Eds.), *Critical Issues in Early Childhood Professional Development* (pp. 171-202). Baltimore, MD: Paul H. Brookes.

[21] Lee, J. S., & Ginsburg, H. P. (2007). Preschool teachers' beliefs about appropriate early literacy and mathematics education for low- and middle-socioeconomic status children. *Early Education and Development*, *18,* 111-143.

[22] Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanove, P., Pagini, L. S., Feinstein, I., Engel, M., Brooks-Gunn, J., Sexton, H., & Duckworth, K. (2007). School readiness and later achievement. *Developmental Psychology, 43,* 1428-1446.

[23] National Association for the Education of Young Children & National Council of Teachers of Mathematics. (2002). *Early Childhood Mathematics: Promoting Good Beginnings-A Joint Position Statement*. Online at: www.naeyc.org/about/positions/pdf/psmath

[24] Clements, D. H., & Sarama, J. (2007). Early childhood mathematics learning. In F. K. Lester, Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 461-555). New York: Information Age.

[25] Ginsburg, H. P., & Russell, R. L. (1981). Social class and racial influences on early mathematical thinking. *Monographs of the Society for Research in Child Development, 46,* 1-68.

[26] Starkey, P., & Klein, A. (2000). Fostering parental support for children's mathematical development: An intervention with Head Start parents. *Early Education and Development, 11,* 659-680.

[27] Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a prekindergarten mathematics intervention. *Early Childhood Research Quarterly*, *19,* 99-120.

[28] Starkey, P., & Klein, A. (2000). Fostering parental support for children's mathematical development: An intervention with Head Start parents. *Early Education and Development*, *11,* 659-680.

[29] Gelman, R. (1980). What young children know about numbers. *Educational Psychologist*, *15,* 5468.

[30] Ginsburg, H. P., Goldberg-Kaplan, R., Cannon J., Cordero, M. I., Eisenband, J. G., Galanter, M., & Morgenlander, M. (2006). Helping early childhood educators to teach mathematics. In M. Zaslow & I. Martinez-Beck (Eds.), *Critical Issues in Early Childhood Professional Development* (pp. 171-202). Baltimore, MD: Paul H. Brookes.

[31] National Research Council. (2001). *Eager to Learn: Educating our Preschoolers.* Committee on Early Childhood Pedagogy. B. T. Bowman, M. S. Donovan, & M. S. Burns (Eds.), Commission on Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[32] Saxe, G. B., Guberman, S. R., & Gearhart, M. (1987). Social processes in early number development: An intervention with Head Start families. *Monographs of the Society for Research in Child Development, 52,* iii-viii.

[33] National Research Council. (2009). *Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity*. Committee on Early Childhood Mathematics, C. T. Cross, T. A. Woods, & H. Schweingruber (Eds.), Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[34] Haugland, S. W. (2004). Early childhood classrooms in the 21st century: Using computers to maximize learning. J. Hirschbuhl (Ed.), *Computers in Education Annual Edition*. New York: McGraw Hill.

[35] Haugland, S.W. (2000a). Early childhood classrooms in the twenty first century: Utilizing technology to maximize learning. *Young Children, 55,* 12-21.

[36] Clements, D.H. (1994). The uniqueness of the computer as a learning tool: Insights from research and practice. J.L. Wright & D.D. Shade (Eds.), *Young Children: Active Learners in a Technological Age*, pp. 31-50. Washington, DC: National Association for the Education of Young Children.

[37] Clements, D. H. (2002). Computers in early childhood mathematics. *Contemporary Issues in Early Childhood, 3,* 160-181.

[38] Haugland, S.W. (2000b) Computers and young children. *ERIC Digest,* ED 438926, 1-5.

[39] Haugland, S. W. (1992). The effect of computer software on preschool children's developmental gains. *Journal of Computing in Childhood Education, 3,* 15-31.

[40] Van Scoter, J., Ellis, D., & Railsback, J. (2001). How technology can enhance early childhood learning. *Technology in Early Childhood*. Educational Technology Consortium; Northwest Regional Educational Laboratory's Child & Family Program.

[41] Murphy, K., DePasquale, R., & McNamara, E. (2003). Meaningful connections: Using technology in primary classrooms. *Young Children, 58*,12-18.

[42] Bergen, D. (2000). Linking technology and teaching practice. *Childhood Education, 76,* 252–253.

[43] Haugland, S. W. (1992). The effect of computer software on preschool children's developmental gains. *Journal of Computing in Childhood Education, 3,* 15-31.

[44] Ainsa T. (1987). Effects of computers and training in Head Start curriculum. *Journal of Educational Computing Research, 3,* 249 –260.

[45] Ainsa, T. (1989). Effects of computers and training in Head Start curriculum. *Journal of Instructional Psychology, 16*, 72–78.

[46] Li, X., & Atkins, M.S. (2004). Early childhood computer experience and cognitive and motor development. *Pediatrics, 113,* 1715-1722.

[47] Walden University, Grunwald Associates, & Eduventures. (2010). *Educators, Technology, and 21st Century Skills: Dispelling Five Myths.* Online at: http://www.grunwald.com/pdfs/Educators-Technology-21stCentury-Skills.pdf

[48] PBS & Grunwald Associates. (2009). *Digitally Inclined.* Online at: http://www.grunwald.com/pdfs/Annual-PBS-Survey-PUBLIC-REPORT-Grunwald.pdf

[49] Walden University, Grunwald Associates, & Eduventures. (2010). *Educators, Technology and 21st Century skills:* Dispelling Five Myths. Online at: http://www.grunwald.com/pdfs/Educators-Technology-21stCentury-Skills.pdf

[50] Piaget, J. (1945). *Play, Dreams, and Imitation in Childhood.* London: Heinemann.

[51] Berk, L. E., & Adam, W. (1995). *Scaffolding Children's Learning: Vygotsky and Early Childhood Education.* Washington, DC: National Association for the Education of Young Children.

[52] CTB-McGraw Hill. (2002). *Pre-Kindergarten Standards: Guidelines for Teaching and Learning.* Online at: http://legacy.ctb.com/static/resources/prekstandards.jsp

[53] Kendall, J.S., & Marzano, R.J. (2004). *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education.* Aurora, CO: Mid-continent Research for Education and Learning. Online at: http://www.mcrel.org/standards-benchmarks

[54] Harms, T., Clifford, R. M., & Cryer, D. (2005). *Early Childhood Environment Rating Scales-Revised.* New York: Teachers College Press.

[55] *Head Start Outcomes.* (2003). Washington, DC: Administration for Children and Families. Online at: http://eclkc.ohs.acf.hhs.gov/hslc/ecdh/eecd/Assessment/Child%20Outcomes/edudev_art_00090_080905.html

[56] National Association for the Education of Young Children. (2008). *Accreditation Standards and Criteria.* Washington, DC. Online at: http://www.naeyc.org/academy/primary/standardsintro

[57] National Early Literacy Panel. (2008). *Developing Literacy: A Scientific Synthesis of Early Literacy Development and Implications for Intervention*. T. Shanahan, Chair. Louisville, KY: National Center for Family Literacy.

[58] National Research Council. (2009). *Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity. Committee on Early Childhood Mathematics*, C. T. Cross, T. A. Woods, & H. Schweingruber (Eds.), Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[59] Lonigan, C., Wagner, R., Torgesen, J., & Rashotte, C. (2007). *The Test of Preschool Early Literacy (TOPEL)*. Austin, TX: PRO-ED.

[60] Whitehurst, G., & Lonigan, C. (2003). *Get Ready to Read!*. New York: Pearson Education, Inc.

[61] Assel, M., Landry, S., Swank, P., & Gunnewig, S. (2007). *C-PALLS+ Math Screener.* Houston, TX: University of Texas.

[62] Phillips, B. M., Lonigan, C. J., & Wyatt, M. A. (2008). Predictive validity of the Get Ready to Read! Screener: Concurrent and long-term relations with reading-related skills. *Journal of Learning Disabilities.* Online at: http://ldx.sagepub.com/content/early/2008/12/12/0022219408326209

[63] Sénéchal, M., & LeFevre, J. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Child Development, 73,* 445-460.

[64] Storch, S. A., & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. *Developmental Psychology, 38,* 934-947.

[65] Juel, C., Biancarosa, G., Coker, D., & Deffes, R. (2003). Walking with Rosie: A cautional tale of early reading instruction. *Educational Leadership, 52,* 12-18.

[66] Mol, S., Bus, A. & deJon, M. (2009). Interactive book reading in early education: A tool to stimulate print knowledge as well as oral language. *Review of Educational Research, 72,* 979-1007.

[67] Neuman, S. B., & Dwyer, J. (2009). *Developing Vocabulary and Conceptual Knowledge for Low-income Preschoolers: A Design Experiment.* University of Michigan: School of Education. Online at: http://www.umich.edu/~rdytolrn/pdf/rtl1122109.pdf

[68] Lonigan, C., Wagner, R., Torgesen, J., & Rashotte, C. (2007). *The Test of Preschool Early Literacy (TOPEL)*. Austin, TX: PRO-ED.

[69] Phillips, B. M., Lonigan, C. J., & Wyatt, M. A. (2008). Predictive validity of the Get Ready to Read! Screener: Concurrent and long-term relations with reading-related skills. *Journal of Learning Disabilities.* Online at: http://ldx.sagepub.com/content/early/2008/12/12/0022219408326209

[70] Adams, M. J. (1990). *Learning to Read: Thinking and Learning about Print.* Cambridge, MA: MIT Press.

[71] Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development, 69,* 848-872.

[72] Stevenson, H. W., & Newman, R. S. (1986). Long-term predictions of achievement and attitudes in mathematics and reading. *Child Development, 57,* 646-659.

[73] National Early Literacy Panel. (2008). *Developing Literacy: A Scientific Synthesis of Early Literacy Development and Implications for Intervention.* T. Shanahan, Chair. Louisville, KY: National Center for Family Literacy.

[74] National Research Council. (2009). *Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity. Committee on Early Childhood Mathematics,* C. T. Cross, T. A. Woods, & H. Schweingruber (Eds.). Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[75] PBS, & Grunwald Associates, LLC. (2009). *Digitally Inclined.* Online at: http://www.grunwald.com/pdfs/Annual-PBS-Survey-PUBLIC-REPORT-Grunwald.pdf

Relationship of the TeachSmart® Learning System with Literacy and Mathematics Outcomes for Preschoolers

Addendum December 2010

This addendum addresses two areas within the study: the findings around vocabulary and comparisons to "business as usual" early childhood programs.

Vocabulary Finding

The Vocabulary Subscale of the Test of Preschool Early Literacy (TOPEL) measures the child's one word vocabulary and ability to name objects in a picture. A comparison between the pretest and posttest **age-adjustedstandard scores** showed a decrease that was significant. However, the **raw scores** show the children actually achieved a statistically significant **gain** in vocabulary. The pretest raw score mean was 47.39 and the posttest raw score mean was 50.72. This growth is significant at the <.0001 level [t(107) = 4.15].

The reason that we reported a significant decrease though is due to using the age-adjusted standard scores. This means that as the children grew in age *and* grew in vocabulary, the growth in vocabulary was not quite enough to be even with or above their average age (which at pretest was four years six months and at posttest was five years and zero months).

The winter and spring of the 2009-2010 school year in rural west Tennessee, where the study was conducted, experienced two major weather-related events that impacted the amount of time the children were in their programs. These included several severe snow-storms in the winter and flooding in the spring, which led the children to miss several weeks of school in total. Therefore, in working with the teachers we encouraged them to prioritize phonological awareness skills in the TSLS over vocabulary.

The rationale for this was based on the findings of the National Early Literacy Panel, which did not find oral language (under which vocabulary falls) to be a strong predictor of literacy skills in kindergarten and first grade, whereas phonological awareness is a very strong predictor. "Notably, measures of vocabulary had relatively weak relationships with both decoding and reading comprehension, falling either into the low end of the moderate range or into the weak range. Although, these results should not be taken to imply that well-developed vocabularies are *unimportant* for literacy. The results suggest that well-developed vocabularies are *insufficient* for literacy." Phonological awareness on the other hand was among the strongest predictors, "...children's early PA—that is, their ability to distinguish among sounds within auditory language—was found to be an important predictor of later literacy achievement, expanding on earlier NRP findings."[1]

Acknowledging that vocabulary should be a part of an early childhood education curriculum as well as the other areas found in the NELP report to hold their predictive power (i.e., alphabet knowledge, rapid automatic naming, writing/writing name, and phonological memory), highlights the importance of looking at a combination of skills. This is why the author of the TOPEL (also a lead on the NELP project) states in the manual that the **Emergent Literacy Index** (composite of print knowledge, vocabulary, and phonological awareness) is the **best representation of a child's emergent literacy skills.**[2] The Index was highly and positively significant ($\underline{p}<.001$) in our study. Additionally, the second measure of literacy utilized in the study is the *Get Ready to Read!* Screener, which also is a composite instrument (knowledge of letters and sounds, recognition of spoken words, and phonological knowledge). As with the Early Literacy Index, the children showed a statistically significant increase ($\underline{p}<.001$).

The final issue around vocabulary is the difficulty in teaching this area to young children, especially young children of lower SES. As mentioned in the main report, a meta-analysis of approximately 35 studies found that the strongest effect sizes for children's gains in vocabulary were **not** with classroom teachers but in tightly controlled settings with personnel specifically trained in interventions.[3]

Jalonga and Sobalak lay out some of the challenges. These include the following:

- "Words may seem like simple entities, but they are not. Their surface simplicity belies a deeper complexity. For example, they connect with experience and knowledge, and their meanings vary depending on the linguistic contexts in which they can be found, including in a variety of literal and figurative contexts" (Pearson et al. 2007, p. 286). To really know a word's meaning is to know what a word represents and to begin to understand the network of concepts that goes with it (Neuman and Dwyer, 2009). Studies estimate that of 100 unfamiliar words met in reading, between 5 and 15 of them will be learned (Beck et al., 2002)."
- Before coming to a preschool program, children's vocabulary predicts language skills in late elementary grades, and logically the vocabulary of a very young child is hugely influenced by family characteristics. "The educational implications of being raised in

a poverty home can be staggering. Hart and Risley (1995) found that the socioeconomic status of a child's family could account for 42% of the variance in the child's rate of vocabulary growth, 40% of the variance in their vocabulary use and 29% of the variance in their IQ test scores when they were 3 years old. Overall, Hart and Risley (1995) concluded that vocabulary growth, at age three, was strongly correlated with family socioeconomic status ($r = .65$). Taken together, the findings of Hart and Risley (1995) show that many children are at high risk for having low vocabulary skills. In addition, further studies on the same subjects showed the vocabulary of the children at age three was equally predictive of measures of language skill at age nine or ten.

- There is strong evidence for why this occurs. "This longitudinal study produced results that have been widely cited by researchers in the field of vocabulary research. Hart and Risley (1995) found that there were many differences in the everyday lives of the children that were observed. It was concluded that a child in a family from high socioeconomic status consistently received three times more experience with language and general interaction than did a child from a family on welfare. They estimated that, by age four, the average child from a family on welfare had 13 million fewer words of language experience than did a child in a working class family. The quality of speech heard in the home of families on public assistance was also less than that of working class and high socioeconomic households. Qi et al. (2006) suggest similar reasons for the lower vocabulary ability of children from lower socioeconomic household as those that were proposed by Hart and Risley (1995). Children from lower socioeconomic households have a greater occurrence of mothers with less education and are more likely to be from single parent homes. These factors, together with low socioeconomic status, pose many challenges. It is noted that children raised in poverty have different opportunities for word learning, fewer resources in their homes, and often have parents focused on daily survival concerns that limit interaction with their children. The longitudinal research of Hart and Risley (1995) provides insight into both what contributes to the development of the vocabulary levels in children and the long lasting effects of these vocabulary levels, once formed. "
- This research highlights the sometimes daunting task of vocabulary instruction by teachers for lowincome preschoolers and is compounded by the fact that the pre-service/in-service training of teachers on vocabulary instruction frequently has been inadequate or is now outdated.[4]
- These issues are also connected to the limited number and type of words on any one external vocabulary assessment and the fact that especially if a child has not been exposed to these specific words, this can negatively impact his/her score.

In summary, the fact that the children in the TSLS study made any gains at all in vocabulary is positive. However, the vocabulary growth gains were not made at a rate that kept up with their chronological age growth. As the research cited above demonstrates, learning vocabulary 'words' is a more challenging task for children than it might appear on the surface; socioeconomic status accounts for more than 40% of vocabulary growth with low-income preschool children already showing much lower levels of vocabulary than children from higher SES levels- making the task of increasing vocabulary in school very challenging to begin with; and the National Early Literacy Panel also found vocabulary, while important, did not in and of itself play as large a role in predicting success in later reading as some other early literacy skills such as phonological awareness. Going forward, Hatch is in the process of creating more in-depth, targeted teacher training for this area that can be accessed by the web or in person with a Certified Classroom Integration Specialist.

Business As Usual Comparison

Validity is the strength of conclusions, inferences or propositions. In the study, **Relationship of the TeachSmart® Learning System with Literacy and Mathematics Outcomes for Preschoolers**, we did not have a control group. In research terms, this means that no control group (a group that doesn't receive the program or treatment, also called a comparison group) is being used to serve as a standard against which a researcher can compare the results of the treated group. Adding a control group can enable a researcher to eliminate many threats to internal validity (internal validity asks if there is a relationship between the program and the outcome we saw), but it can often introduce new threats, such as those related to selection biases and social threats. Adding a control group can be difficult, expensive or inefficient for a field researcher. For this reason, researchers have to learn to be aware of and guard against single group threats to internal validity.[5] Below we discuss the six threats, if they were so, and if yes, how we addressed them. Following this we discuss how we addressed threats to external validity. External validity refers to our ability to generalize the results of our study to other settings. In other words, could we generalize our results to other classrooms?

History
History can pose a threat to internal validity when the group under study experiences an event-- unrelated to the treatment--which has an impact on their performance on the posttest. *To our knowledge this did not occur past weather-related, which all children anywhere have and do experience.*

Maturation
A maturation threat results from the fact that the research participants are growing older, more experienced, wiser, more skillful, etc. between the pretest and the posttest, and this may be causing the observed effect rather than the treatment that is being studied. *We controlled for age, such as using age-adjusted standard scores.*

Testing
Testing can be a threat to internal validity when the fact that a group has taken a pretest or a number of pretests causes an observed effect on the posttest. In other words, a group may perform better on a posttest not because of the treatment that was implemented, but because the pretest primed the group members to perform better. *The children only received one pretest and if we had a control group they would have experienced the same situation.*

Instrumentation
When an observed effect is caused by a difference in the way the pretest and posttest are measured, rather than the impact of the treatment that was implemented, this is called an instrumentation threat. This can happen when the measurement depends on observers who become more experienced over time, or if the observers change from the pretest to the posttest. This can also happen if the measurement test has a shift in metric at certain points, for example, if a scale is less sensitive at the top or the bottom than it is in the middle. *There is no known metric shift in any of the instruments we used. Two of the three assessors were the same from pretest to posttest and the third was trained in the identical fashion.*

Mortality
A mortality threat means that participants drop out of the study between the pretest and the posttest, and an observed effect may be caused by the fact that the make-up of the group is not the same at both stages of measurement. *Almost all the children who were pre-tested were post-tested.*

Regression to the Mean
Testing measures are rarely perfectly reliable. Because of this, pretest scores on a measure will not correlate perfectly with posttest scores. The individual scores on the same two tests taken on different occasions will almost always vary. Measurement error plays a big role in regression. An observed score is comprised of the test-taker's true score plus the degree of measurement error. *The statistics used accounted for measurement error.*

External validity is related to generalizing. "Recall that validity refers to the approximate truth of propositions, inferences, or conclusions. So, external validity refers to the approximate truth of conclusions the involve generalizations. Put in more pedestrian terms, external validity is the degree to which the conclusions in your study would hold for other persons in other places and at other times. How can external validity be improved? One way, based on the sampling model, suggests that you do a good job of drawing a sample from a population. For instance, you should use random selection, if possible, rather than a nonrandom procedure."[6] "Probability sampling is a sampling technique wherein the samples are gathered in a process that gives all the individuals in the population equal chances of being selected. The advantage of using a random sample is the absence of both systematic and sampling bias. If random selection was done properly, the sample is therefore representative of the entire population. The effect of this is a minimal or absent systematic bias which is the difference between the results from the sample and the results from the population. Sampling bias is also eliminated since the subjects are randomly chosen."[7] "And, once selected, you should try to assure that the respondents participate in your study and that you keep your dropout rates low."[6] *In this study, both of these were done.*

The next area to address is the assessments themselves. By using assessments that are standardized to reflect the performance standards of the general population, which we did, we have the benefit of scores that have been controlled for measurement error **and** that have a very large group of similar children with whom to compare the scores of the study children. As Trochim & Land state "In some cases it may be desirable to include the norm group as an additional group in the design. Norming group averages are available for most standardized achievement tests for example, and might comprise an additional nonequivalent control group."[8]

The following sections are excerpts from the Assessment Manuals and Technical Reports.

"The TOPEL (Test of Preschool Early Literacy) was normed on a sample of 842 children residing in 12 states: California, Florida, Kentucky, Massachusetts, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, and Pennsylvania. The samples used to prepare the TOPEL norms were collected in the spring, fall, and winter of 2004. The characteristics of the normative sample with regard to geographic area, gender, ethnicity, family income, parental educational attainment, exceptionality status, and age were compared to those reported in *The Statistical Abstract of the United States* (U.S. Bureau of the Census, 2001) and found to closely approximate the U.S. population."[2]

"The GRTR (*Get Ready to Read!* Screener) was developed and normed on 342 children from two locations: Suffolk County, NY, and Tallahassee, FL. The Suffolk County sample consisted of 139 children drawn entirely from Head Start centers: 48% of these children were Latino; 38% were African-American, 9% were Caucasian, and the remaining 5% were from Other racial/ethnic categories. The Tallahassee sample of 203 children was comprised of three groups: A Head Start sample of 84 children was 96% African American and 4% Caucasian; a group of 69 children attending state sponsored pre-K classrooms was 71% African-American, 25% Caucasian, and 4% Other; 50 children attending private nursery schools were 8% African-American, 86% Caucasian, and 6% Other. Across the sub-samples and the sample as a whole, children were evenly divided on gender. Children were also distributed roughly evenly across the age range of 48 months to 59 months that included the four-year-olds who were the target of the screening instrument, The nursery school sub-sample was middle-class. The state pre-K sub-sample in Florida, and the Head Start samples in both New York and Florida were from low-income families.

Between early October and early December of 2000, the 342 children who were participants in the study were administered the item pool. On another occasion within two weeks, the 14 gold standard measures from the DSC, were also administered. Children in the Florida sample were administered various other tests, including a test of oral language vocabulary, a test of letter knowledge, and a collection of tests of phonological awareness. The multiple R between the 20 items and the DSC was .78, indicating a very strong relationship between the validity set and the DSC. With a mean of about 9 correct for the total sample and a standard deviation of about 4 (mean for Head Start only 8.52; middle income only 12.52), we know that 68% of children taking the test scored between roughly 5 to 13 correct. Specifically, four year olds receiving low scores on the 14 professionally administered measures of emergent literacy have an 85% chance of being reading failures at the end of second grade. These results indicate that we have a strong gold standard against which to determine the effectiveness of the *Get Ready to Read!* Screening Tool."[9]

The mean for the children participating in our study was 11.20 at pretest and 15.18 at posttest.

Findings Related to Children's Early Literacy Skills Reported in Technical Manual

- Most children begin the pre-kindergarten year with some or many of the early literacy skills they need to benefit from formal reading instruction. Generally, scores of 16 and above indicate that a child is ready to begin learning to read. The average score on the Screening Tool at the start of the year is 13.14 out of a possible 20. At the end of the year, the average score is 16.14. *This would be **all** children from a variety of programs and backgrounds regardless of their preschool experiences. This shows our study children started out quite a bit lower than the average but came very close to the average by the end of the year … in other words they grew more than the average children.*
- By the end of the pre-kindergarten year, two-thirds of the children have the early literacy skills they need to succeed in school (i.e., scores of 16+). The other third needs additional focused educational intervention and possibly assessment. *Our study children began the year with 46% of the children having these skills and ended the year with 82% of the children demonstrating they have the early literacy skills needed for school success.*

Findings Related to *Get Ready to Read!* Participation

We are able to compare growth in our study with findings from an evaluation in which there was a control group with the GRTR.

From Evaluation Findings From National Demonstrations: 2001-2003

"To ensure consistency and quality, NCLD has developed a standardized training process and materials for early childhood professionals and parents using the Screening Tool and related program resources. Teachers and child care professionals taking part in the national demonstrations received initial and follow up training (each several hours) and limited ongoing consultation for five to seven months related to the Screening Tool's administration, scoring, and interpretation, as well as in early literacy skillbuilding activities and individualized planning. In addition to evaluating progress between fall and spring, NCLD conducted a rigorous experiment/comparison study with over 500 children in three Georgia counties. The study was undertaken to compare and contrast program sites participating in *Get Ready to Read!* to other programs with similar children in the same communities not participating in *Get Ready to Read!*. While all the children were screened, this research was completed in order to **assess the overall effects of the *Get Ready to Read!* program** (i.e., staff training and consultation, Screening Tool, learning resources). Participating sites were those in which children's teachers and child-care providers received training and consultation. Nonparticipating sites, for comparison purposes, were those in which children's teachers and child care providers did not receive the training and consultation. The data show that at the end of the pre-kindergarten year, more children from participating sites than nonparticipating sites had the early literacy skills they needed to benefit from formal reading instruction in kindergarten (i.e., scores of 16+)

– 69% versus 35%"[10]. *In our study the posttest showed 82% of the children had scores above 16 [steps 4 & 5].*

- Children at participant sites also gained much more in skill development over the year than children in non-participant sites – average gains of 18.6% versus 3.7%. *Our study children showed an average gain of 15% [derived from means of 11.20 at pretest and 15.80 at posttest].*

In summary, the design used in the TSLS study was reasonably strong. We made every effort to ensure that both internal and external validity were maintained. This study represents the first in a series of research Hatch will be conducting to continue to build on and refine our findings about the efficacy of the TSLS.

Closing Thoughts

The purpose of the Study: **Relationship of the TeachSmart® Learning System with Literacy and Mathematics Outcomes for Preschoolers**, was to begin to establish the efficacy of this educational technology tool and content to assist teachers to help children (especially low-income children at-risk for school failure) to have a preschool experience that would allow them, particularly in literacy and math, to be prepared for kindergarten. Our definition of this preparation was that they would exhibit the skills research has established are needed for this to occur and the results of the study show that they did master these skills. It is abundantly clear that there is a grave issue at hand across the United States of young children entering kindergarten after having preschool who then do not succeed. Clearly current approaches are not serving these children. Our goal is to bring a product that can.

References

[1] *Developing Early Literacy: Report of the National Early Literacy Panel.* (2009). Available at: http://lincs.ed.gov/publications/pdf/NELPReport09.pdf

[2] Lonigan, C., Wagner, R., Torgensen, J. & Rashotte, C. (2007). *The Test of Preschool Literacy* (TOPEL). Austin, TX: PRO-ED.

[3] Mol, S., Bus, A., & deJon, M. (2009). Interactive book reading in early education: A tool to stimulate print knowledge as well as oral language. *Review of Educational Research,* 72, 979-1007.

[4] Jalongo, M. R., & Sobolaka, M. J. (2010). Supporting Young Children's Vocabulary Growth: The Challenges, the Benefits, and Evidence-Based Strategies. *Early Childhood Education Journal,* DOI 10.1007/s10643-010-0433-x. Available at: http://www.springerlink.com/content/g4424x42x8553204/fulltext.pdf

[5] Martin, W. (1997). *Single Group Threats to Internal Validity.* Available at: http://www.socialresearchmethods.net/tutorial/Martin/intval1.htm

[6] Trochim, W.M.K. (2006). *External Validity.* Available at: http://www.socialresearchmethods.net/kb/external.php

[7] Castillo, J.J. (2009). *Probability Sampling and Randomization.* Available from Experiment Resources at: http://www.experiment-resources.com/probability-sampling.html

[8] Trochim, W. & Land, D. (1982). Designing designs for research. *The Researcher, 1*, 1-6.

[9] Whitehurst, G. J. (2001). The NCLD *Get Ready to Read!* Screening Tool Technical Report. New York: National Center for Learning Disabilities. Available at: http://www.getreadytoread.org/index.php?option=com_content&task=view&id=80&Itemid=312

[10] National Center for Learning Disabilities. (2004). *Evaluation Findings From National Demonstrations: 2001-2003.* New York: National Center for Learning Disabilities. Available at: http://www.getreadytoread.org/index.php?option=com_content&task=view&id=175&Itemid=429