Achievement Effects of Embedded Multimedia in a Success for All Reading Program

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Abstract

Embedded multimedia refers to teaching methods that embed video content within teachers' lessons. The research of Mayer and others has suggested that multimedia instruction can enhance learning by using the capacity of both visual and verbal memory systems. The present study is an evaluation of embedded multimedia in a year-long randomized clinical trial comparing first graders who learned beginning reading using the Success for All program either with or without embedded, brief video components. A study involving 394 first graders in 10 high-poverty schools found significant positive effects on the Woodcock Word Attack scale, controlling for pretests, in HLM analyses with school as the unit of analysis. The results provide partial support for the utility of embedded multimedia as a component of beginning reading instruction.

For more than 50 years, educators and policymakers have been expectantly waiting for the video* revolution in education. Indeed, research on educational programs such as *Sesame Street* (Bogatz & Ball, 1971; Fisch & Truglio, 2000; Rice, Huston, Truglio, & Wright, 1990) and *Between the Lions* (Linebarger, Kosanic, Greenwood, & Doku, 2004) has shown positive effects of educational television for the reading and language development of young children. Yet video has remained a minor medium in the classroom, where it has been seen as a replacement for teacher instruction rather than a tool for teachers.

In recent years, however, video has begun to appear in educational practice in a new form that has great potential for education reform. Video is one example of what Mayer (2001) calls "multimedia," instructional formats that combine words and pictures. Instead of replacing instruction, multimedia can be embedded in classroom instruction to enhance teachers' lessons. This "embedded multimedia" application is not widely known or used, but research on the practice has shown initial promise. In embedded multimedia, brief multimedia segments are threaded throughout teachers' lessons. In one sense, embedded multimedia should at least share the impacts on achievement found in studies of the use of pictures, illustrations, diagrams, and other graphic content to enhance the effects of class lessons and text (see Schnotz, 2002; Shah, Mayer, & Hegarty, 1999; Carney & Levin, 2002; Vekiri, 2002). Yet well-designed embedded multimedia using video has properties that go beyond static graphics. First, video can model skills or content for students, giving them clear demonstrations of proficient performance. For example, videos can show children modeling advanced problem-solving strategies,

* Throughout this paper, the term "video" is assumed to include DVD and CD formats as well as VHS unless otherwise noted.

sounding out words, thinking out loud about their creative writing, or working through a scientific investigation. Further, any multimedia that models for children also models for teachers, providing “just-in-time” professional development. For example, showing children working in cooperative groups to solve particular kinds of problems may provide teachers with a clear idea of what cooperative learning should look like, just as it would for students.

Theoretical Background

The theoretical basis for embedded multimedia begins with Paivio’s dual coding theory (Clark & Paivio, 1991), which demonstrated that information held both in verbal memory and in visual memory is retained better than information held in only one memory system. For example, Mayer (2001) and his colleagues carried out a series of experiments in which students were taught how lightning works. Teaching about lightning using narration alone or text alone teaches only to verbal memory. Adding diagrams or moving pictures to illustrate the concept teaches to visual memory. Adding the pictures to narration or text greatly increased initial learning of the concept, as well as both retention and transfer, as long as the pictures and text or narration were closely aligned with each other and focused on the instructional objective (Mayer & Moreno, 2003).

Another key concept in multimedia learning is cognitive load. It has long been known that working memory places a severe limitation on the amount of information that can be absorbed at any given time (Solso, 2001). Each learning objective has a given intrinsic cognitive load, and if this exceeds the working memory capacity of children of a given age or level of knowledge, the objective must be broken into components that “fit” within the child's working memory capacity (Paas, Renkl, & Sweller, 2003). However, each memory system has its own limitations, which may be fairly independent of one another. That is, a learner has a limited working memory capacity for words and a limit for pictures, but "using up" the word limit does not "use up" the picture limit. Therefore, Mayer and Moreno (2003) suggest that instructors or designers can "off-load" meaningful information from one channel to the other, by using fewer words and more pictures when verbal working memory would otherwise be overloaded. Again, this "off-loading" only works if the pictures and words directly support each other. Pictures that are interesting but irrelevant to the words, containing "seductive details," can be detrimental because they fill limited working memory with the irrelevant content (Mayer, 2001).

The complementary nature of words and moving pictures has been demonstrated in a series of studies in which instructional video material was broken into audio and silent video components and compared to the full video with audio (see Kozma, 1991, for a review). In most cases children learned significantly more from the video-audio presentations, and in no case did they learn less. This supports the concept that narrative and picture information do not interfere with each other, but instead support each other.

When both memory systems are in danger of overload, Mayer and Moreno's (2003) research suggests segmentation of combined word-picture content, organizing content in "bite-size segments" with opportunities to integrate and organize new information between segments (Mayer & Chandler, 2001).

Embedded multimedia takes advantage of these theoretical principles, combining verbal and visual content (words and moving pictures) to give learners multiple pathways to retention and comprehension and interspersing “bite-sized segments” with opportunities to practice and apply new learnings. For example, a key problem in early reading instruction is teaching associations between letter shapes and letter sounds. The embedded multimedia strategy described in this paper contains a series of animations designed to link the letter shape and letter sound in a brief, memorable story. In introducing the /p/ sound, for instance, a parrot eats some watermelon, and then spits out the seeds, making the sound /p/, /p/, /p/. The seeds fall in the shade of the letter “p”. This 30-second story, which five-year-olds readily learn and remember, gives them a link in their visual memory between the shape “p” and the sound /p/ that they can easily access, adding to the verbal and tactile learning the teacher provides by having children look at a picture of the parrot in the shape of the letter “p” and having them make the /p/ sound and noticing how their lips form when they do so.

In English reading, children must learn 44 phonemes represented by more than 60 graphemes (Adams, 1990). In order to quickly and automatically recognize each, and avoid confusions among them, children need to practice them separately and in words and sentences. Practice in cooperative groups, working with the teacher, and practice in other formats, is necessary to solidify learnings from “bite-sized segments,” which is why the multimedia segments by themselves are insufficient.

Similar theories underlie other multimedia applications in beginning reading (see Pailliotet & Mosenthal, 2000). To teach sound blending, the present experiment used video skits showing puppets sounding out words, creating both visual and auditory representations in memory. To teach vocabulary, live-action skits acted out the meanings of key words, both in context and then out of context. Again, students were expected to recall the skits (in their visual memories) to gain access to word meanings (needed in their verbal memories).

Success for All and Embedded Multimedia

In 2001, researchers and developers at the nonprofit Success for All Foundation and Johns Hopkins University began a project to enhance the Success for All reading program with embedded multimedia. Success for All teaches beginning reading using a systematic phonics approach (see Slavin & Madden, 2001, for a program description). Fifty experimental-control comparisons of one or more years' duration have found, on average, positive effects of Success for All on children's reading achievement (see Borman, Hewes, Overman, & Brown, 2003; Herman, 1999; Slavin & Madden, 2001).

The addition of embedded multimedia to Success for All's beginning reading program was intended to enhance the effectiveness of the program by giving children compelling, memorable demonstrations of letter sounds, sound blending strategies, vocabulary, and comprehension strategies. A particular focus was on the needs of English language learners, who were felt to be in particular need of visual models for vocabulary and sound blending.

A preliminary study of the embedded multimedia strategy was carried out by Chambers, Slavin, Madden, Cheung, and Gifford (2004). In that study, four schools primarily serving Hispanic students were compared with four matched schools with similar demographics and achievement histories. The experimental schools used Success for All with embedded multimedia, while the control schools used traditional basal approaches. After a one-year implementation, students in the Success for All/Embedded

Multimedia treatment scored significantly higher than those in the matched control group, controlling for Peabody Picture Vocabulary Test pretests, on the Woodcock Word Identification, Word Attack, and Passage Comprehension scales. There were no differences on Letter Identification.

The Chambers et al. (2004) experiment established the combined effect of Success for All reading and embedded multimedia on reading achievement, but it did not allow for a test of the unique contribution of the embedded multimedia content.

The Present Study

The present study builds on the findings of Chambers et al. (2004) study in several ways. First, it controlled the instructional content. All schools implemented Success for All reading, so that experimental and control schools differed only in the use or non-use of the multimedia content. All schools were in the same district, the Hartford (CT) Public Schools, further ensuring similarity between experimental and control schools on all factors other than the embedded multimedia treatment. In addition, in the present study schools were randomly assigned to the embedded multimedia or control treatments. Random assignment eliminated selection bias from the experiment (see Mosteller & Boruch, 2003), as all schools had an equal chance of being assigned to the experimental or control groups. All school staffs were willing to implement the embedded multimedia program; those randomly assigned to the control group were given the materials and training in the year following the experiment, as a delayed treatment control procedure.

Methods

Design

This study employed a cluster randomized trial (CRT) design, with random assignment of schools to treatments. A total of 10 elementary schools were identified. Five were randomly assigned to standard Success for All (control) and five to Success for All with embedded multimedia.

Participants

Subjects were 450 first graders, of whom 394 completed pre- and posttests. The students attended 10 schools in inner-city Hartford, CT. Almost all students qualified for free- or reduced-price lunches, and 62% of students were Hispanic and 35% African-American. As indicated in Table 1, the two groups were well matched on the percentage of students eligible for free or reduced lunch, ethnicity, and the percentage of limited English proficient students in the school. Pretests were used as covariates in the main analyses to adjust for any initial difference between the two groups and to increase statistical power. Because the unit of random assignment and treatment was the school, the school was also the unit of analysis.

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Insert Table 1 here

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Treatments

Success for All with Embedded Multimedia. The experimental group used multimedia content embedded in teachers' daily 90-minute Success for All reading lessons. This material consisted of 30-second to three-minute skits and other demonstrations integrated with teachers' lessons. No additional time was added to the lessons to accommodate the multimedia. The purpose of the multimedia content was to directly present to students compelling demonstrations of key elements of beginning reading: letter sounds, sound blending strategies, and vocabulary. In addition, it was hoped that by showing multimedia content in class, teachers would have constant reinforcement of effective teaching strategies.

The multimedia materials ultimately created for the program were called Reading Reels. Reading Reels includes the following components.

The Animated Alphabet. Animations teach and reinforce sound/symbol relationships. For example, the animation introducing the short /e/ sound features an elephant pushing a rock with an "e" on it up a hill, making an /e/ sound with each push. At the top, the rock rolls down, and the exhausted elephant says "ehhhh" in frustration. The pairing of the memorable images, the letter sound, and the letter shape gives students many mental pathways to link the letter with its sound. There are animations for 58 different graphemes that comprise most of the phonemes used in the English language. Each animation is between 30 seconds and one minute long.

The Sound and the Furry. Multimedia skits, using SFA puppet characters, model the word blending process, phonemic awareness, spelling, fluency, reading strategies, and cooperative learning routines. For example, a puppet sees a sign, "Watch out for stick." He sounds out the word "stick" phonetically. Then he notices a stick, which he picks up. The stick sticks to his fur, and in trying to get it off he bites it—and then realizes he's in real trouble. After the skit, the sounding out section is repeated, and children sound out the word along with the puppets. More than a hundred such vignettes illustrate sound blending strategies from simple CVC words to multi-syllable words. The average puppet skit is about two minutes long.

Word Plays. Live action multimedia skits dramatize important vocabulary concepts from the Success for All beginning reading texts. These skits are particularly designed to help English language learners build the specific vocabulary for the books they will be reading. For example, when children are about to read a story about China, they first see a skit that introduces words such as "chopsticks," "fireworks," "beautiful," and "ugly." The average Word Play is about three minutes long.

Between the Lions. Puppet skits and animations from the award-winning PBS program help teach phonemic awareness, sound/symbol correspondence, and sound blending. Between the Lions segments are about one minute long.

The embedded multimedia materials were developed to be particularly beneficial to English language learners. In particular, the vocabulary skits demonstrating the vocabulary emphasized in each story children are about to read were designed to ensure that all children know the vocabulary in advance so that they can focus on the decoding and comprehension tasks required to master and enjoy each book. The alphabet and sound-blending segments are also designed to build children's language skills as well as their reading skills.

Control. Control schools used the regular 90-minute Success for All reading program without the embedded multimedia content. In place of the multimedia content, teachers used picture cards to illustrate the letter shapes and vocabulary in the student books. Demonstrations and games were used to teach word-level blending.

Measures

Participants were pretested in early October, 2003, and posttested in early May, 2004. The pretests were the Peabody Picture Vocabulary Test (PPVT) and the Word Identification subtest from the Woodcock Reading Mastery Test-Revised (WMRT-R). On average, each testing session took approximately 30 minutes per child.

The posttests included the reading fluency test from the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) (Good & Kaminski, 2002) and three scales from the WRMT-R: Word Identification, Word Attack, and Passage Comprehension. Testing sessions required, on average, 42 minute per child.

The DIBELS fluency test is a standardized, individually administered test of accuracy and fluency with connected text. Student performance is measured by having students read a passage aloud for one minute. The Woodcock Word Identification test requires the subject to identify isolated words that appear in large type on the subject pages in the test book. The Word Attack test requires the subject to read nonsense words (letter combinations that are not actual words). The test measures the subject's ability to apply phonic and structural analysis skills in order to pronounce words with which he or she is unfamiliar. The Passage Comprehension test measures the subject's ability to read a short passage—usually two to three sentences long—and to identify a key word missing from the passage.

Analyses

The data were analyzed using Hierarchical Linear Modeling (HLM; Raudenbush, 1997), with students nested within schools. Classroom-level analyses could not be done because, as part of the Success for All design, children routinely change reading teachers over the course of the year. HLM is the appropriate, conservative analysis for cluster randomized designs of this kind. Condition was the independent variable and the WRMT-R subtests and the DIBELS fluency test were the dependent measures. The PPVT and Word ID pretests were used as covariates to adjust for initial differences between the treatment and control groups and to increase statistical power. Analyses were carried out both for the overall sample and for a Hispanic subsample.

Results

Pretests

Pretests, summarized in Table 2, showed that experimental and control schools were well-matched on the PPVT, but the control schools scored higher at pretest on the Word Identification pretest than the experimental schools, with an effect size of -0.35. This was statistically significant at the individual level ($p < .01$), but was not significant at the school level.

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Insert Table 2 here

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Hierarchical Linear Modeling

For the hierarchical linear analyses, we developed 2-level hierarchical models that nested students and their pretest and posttest scores within schools. The fully specified level 1, or within-school model, nests students within schools with pretests as covariates. The linear model for level 1 model is written as

$$Y_{ij}=\beta_{0j} + \beta_{lj}\,(\text{pretest}) + rij$$

Where

Y_{ij} is the expected subtest score of child i in school j (j=1….10 schools);
β_{0j} is the mean outcomes in school j after controlling for pretest difference;
β_{lj} is the random level-1 pretest effect.

The fully specified level 2 model is written as

$$\beta_{0j}=\delta_{00} + \delta_{01}\,(\text{Treatment}) + \delta_{02}\,(\text{Mean Pretest}) + U_{0j}$$

$$\beta_{1j}=\delta_{10}$$

where
δ_{00} is the mean achievement in the control schools;
δ_{01} is the treatment effect;
δ_{02} is the school-level mean pretest effect;
δ_{10} is the pooled within-school regression coefficient for the level-1 covariate.

Because the pretest slope was no different across all schools on all four measures, it was treated as fixed at level 2 of the model and no attempt was made to model the effect with school-level predictors. The intraclass correlation was +.04.

As indicated in Tables 3 and 4, the experimental group scored significantly higher than the control group on the Word Attack subtest. Using the treatment coefficient of 6.21 for the mean achievement outcome and dividing this value by the unadjusted standard deviation for the Word Attack posttest, we estimated the magnitude of this school-level effect at ES= +0.47. Although the experimental group also scored higher than the control on Word ID (ES=+0.23), Passage Comparison (ES=+0.20), and DIBELS (ES=+0.29), these differences were not statistically significant. Analyses for the Hispanic subsample produced results very similar to those of the whole sample. No interactions between ethnicity and treatment were found.

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Insert Tables 3 and 4 here

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Discussion

The results of the current study partially support the expectation that the addition of embedded multimedia content to a beginning reading program would enhance children's reading achievement. Schools were randomly assigned to conditions and all schools used the same Success for All reading strategies, so the use of embedded multimedia content was the only factor differentiating experimental and control conditions. Using a conservative HLM analysis, only one of the four outcome measures, Word Attack, showed significant experimental-control differences, but this is in line with theoretical expectations. Three of the four multimedia segments dealt primarily with letter sounds and sound blending, which are key components of Word Attack. The fourth, Word Plays, focused on vocabulary. The other measures, especially Passage Comprehension and DIBELS, are more logically related to reading of connected text, which was emphasized equally in both treatments.

Because of the use of Word Plays and the visual content in all of the Reading Reels materials, it was expected that Hispanic children would benefit disproportionately from the embedded multimedia treatment. However, this was not the case. Effects for Hispanic children were nearly identical to those for other children (mostly African American). However, no measures of English vocabulary were used, and we were unable to obtain data on children's initial English proficiency, so it may be that there were undetected differential positive effects for the subgroup of children with limited English proficiency.

The findings of the present study and of Chambers et al. (2004) suggest that the use of embedded multimedia has potential to enhance the effectiveness of beginning reading instruction for disadvantaged children. The individual-level effect size of +0.32 for Word Attack (school level ES = +0.47) is educationally important, particularly given the minimal cost of the intervention. Adding the DVDs to an existing Success for All school costs $129 per classroom (plus the cost of a DVD player and television) and occupies an average of less than five minutes per day out of a 90-minute reading period. However, it is important to note that across all four measures, the individual-level mean effect size was +0.17 (mean school-level ES = +0.30).

Much research remains to be done to further understand these effects. First, a larger experiment, involving at least 40 schools, is needed to provide sufficient statistical power for the HLM analysis (Raudenbush, 1997). Such studies should add measurement of vocabulary outcomes, especially for English language learners. Further, it would be important to study the program's effects on teachers' practices, to assess the validity of the theory that multimedia modeling of effective teaching practices would improve teachers' implementations of the reading program and their overall teaching skill.

Further, smaller-scale studies are needed to examine the separate impacts of the multimedia components, and to vary elements of the interventions. Such studies could help build a theoretical base for embedded multimedia in reading instruction and suggest design principles for further development.

Research on multimedia learning (e.g., Mayer, 2001) shows that specific design elements matter a great deal in determining learning outcomes. However, using design principles known to contribute to learning, multimedia embedded in literacy instruction may have significant potential to improve reading outcomes for children.

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Table 1

Demographic Characteristics of Experimental and Control Schools

	Experimental	Control
Number of schools	5	5
Number of students	189	205
% free lunch	99	95
Ethnicity:		
% Hispanic	61	62
% African-American	35	35
% White	4	2
% LEP (schoolwide)	29	31

Table 2

Individual-Level Pretests (Fall, 2004)

	Experimental (N=189)		Control (N=205)		
Pretests	Means	SD	Means	SD	Individual-Level ES
PPVT	86.78	11.33	88.07	10.44	-0.12
Word ID	381.74	27.01	390.14	24.06	-0.35**

** $p<.01$ (individual-level analysis; differences were not significant in school-level analyses.)

Table 3

Individual-Level Posttests (Spring, 2004)

	Experimental (N=189)			Control (N=205)			Individual-Level ES[c]
	Post	SD[a]	Adjusted Post[b]	Post	SD[a]	Adjusted Post[b]	
Word ID	425.3	23.0	428.9	427.8	22.5	424.9	+0.15
Word Attack	480.5	13.7	481.7	478.7	12.7	477.6	+0.32
Passage Comp.	456.5	15.3	458.2	458.6	15.2	457.0	+0.08
DIBELS	29.0	23.9	32.1	32.3	24.5	29.4	+0.12

a Standard deviation of unadjusted means
b Adjusted for PPVT and Woodcock Word Identification
c Effect Size=Adjusted Posttest (exp) – Adjusted Posttest (control)/Unadjusted SD (control)

Table 4

Hierarchical Linear Modeling (HLM) Analyses

Posttests		Coefficient	SE	p-value	School Level ES
Word ID	Intercept δ_{00}	427.78	1.35	0.000	
	Treatment δ_{01}	5.11	3.17	0.151	+0.23
	Pretest δ_{02}	0.907	0.22	0.005	
Word Attack	Intercept δ_{00}	480.32	0.997	0.000	
	Treatment δ_{01}	6.21	2.32	0.032	+0.47*
	Pretest δ_{02}	0.49	0.16	0.020	
Passage Comp.	Intercept δ_{00}	458.35	1.03	0.000	
	Treatment δ_{01}	3.04	2.4	0.246	+0.20
	Pretest δ_{02}	0.629	0.16	3.761	
DIBELS	Intercept δ_{00}	31.96	1.65	0.000	
	Treatment δ_{01}	6.95	3.85	0.113	+0.29
	Pretest δ_{02}	1.21	0.269	0.003	

*p<0.05