DOCUMENT RESUME

ED 387 949 EC 304 303

| | |
|---|---|
| AUTHOR | Higgins, Kyle; Boone, Randall |
| TITLE | Hypertext CAI: Maintaining Handicapped Students in a Regular Classroom Reading Program. Final Report, 1988-1991. |
| INSTITUTION | Washington Univ., Seattle. Experimental Education Unit. |
| SPONS AGENCY | Special Education Programs (ED/OSERS), Washington, DC. |
| PUB DATE | 91 |
| NOTE | 88p.; For related documents, see EC 304 304-307. Grant made to Dr. Thomas C. Lovitt. |
| PUB TYPE | Reports - Descriptive (141) |
| EDRS PRICE | MF01/PC04 Plus Postage. |
| DESCRIPTORS | *Basal Reading; *Computer Assisted Instruction; Computer Software; Educational Media; Elementary Education; *Hypermedia; Instructional Effectiveness; Mainstreaming; Material Development; *Mild Disabilities; Multimedia Materials; Primary Education; *Reading Difficulties; Reading Instruction; *Reading Materials |

ABSTRACT

This final report describes a 3-year project at one elementary school in Renton, Washington, which used hypermedia to develop supplementary reading materials for students with and without mild disabilities in integrated elementary classrooms. The hypermedia software provided reading selections designed to supplement a basal reader series by offering easily accessible, additional information about the text along with decoding and comprehension strategies within the context and physical structure of the basal reading selection itself. The software consisted of a series of hypermedia lessons based on selected lesson segments from each basal grade level textbook series. Scope and sequence of skills and pedagogical techniques in the hypermedia lessons were kept constant with the basal teaching guidelines. The project found that the highest benefit was found for students who participated in the project for 3 years (either grades K-1-2 or 1-2-3). These students significantly outperformed peers who participated in control classrooms for 3 years. Individual sections of this report provide: a summary of project accomplishments, a listing of project objectives, identification of procedural objectives, a detailing of accomplishments, a presentation of results, and a discussion. Twenty-five tables and four figures present further detail. A research paper by Kyle Higgins and Randall Boone, entitled "Hypermedia Computer Assisted Instruction: Adapting a Basal Reader Series," and a reprint of an article by Randall Boone and Kyle Higgins, entitled "Hypertext Hypermedia Information Presentation: Developing a HyperCard Template," are also attached. (DB)

# FINAL REPORT

1988-1991

U.S. Department of Education
Office of Special Education
CFDA 84.024J

# Hypertext CAI: Maintaining handicapped students in a regular classroom reading program

PRINCIPAL INVESTIGATOR
Dr. Thomas C. Lovitt

PROJECT COORDINATORS
Dr. Kyle Higgins and Dr. Randall Boone



Report
Prepared By
Kyle Higgins
Randall Boone

Experimental Education Unit
Child Development and Mental
Retardation Center
University of Washington
Seattle, Washington 98195

# FINAL REPORT

## Hypertext CAI: Maintaining handicapped students in a regular classroom reading program

1988-1991

CFDA 84.024J

Dr. Thomas C. Lovitt
Principal Investigator

Dr. Randall Boone
Project Coordinator

Dr. Kyle Higgins
Project Coordinator

Report prepared by
Dr. Kyle Higgins and Dr. Randall Boone

University of Washington
Experimental Education Unit
College of Education
Department of Special Education
Child Development and Mental Retardation Center
Seattle, Washington 98195

# Hypertext CAI: Maintaining handicapped students in a regular classroom reading program

U. S. Department of Education
Office of Special Education
CFDA 84.024J

We express our sincere thank you and gratitude to the following people.

Dr. Gary Kohlwes, *Superintendent Renton School District*
Dr. Kathryn Fantasia, *Program Administrator Renton School District*
Dr. George McPherson, *Assistant Superintendent Renton School District*
Dr. Keith Renfrew, *Director of Special Education Renton School District*
Vicki Montgomery, *Program Administrator Renton School District*
Dian Burrows, *Reading Resource Teacher Renton School District*
Vera Risdon, *Principal Hazelwood Elementary School*
Kathy Davis, *Kindergarten Teacher Hazelwood Elementary School*
Molly Wiberg, *Kindergarten Teacher Hazelwood Elementary School*
Judy Busch, *Kindergarten Teacher Hazelwood Elementary School*
Anne Marie Zahradnik, *Kindergarten Teacher Hazelwood Elementary School*
Janice Yee Okita, *First Grade Teacher Hazelwood Elementary School*
Mary Blom, *First Grade Teacher Hazelwood Elementary School*
Sharon Huvinen, *First Grade Teacher Hazelwood Elementary School*
Martha Penton, *Second Grade Teacher Hazelwood Elementary School*
Marleen McSherry, *Second Grade Teacher Hazelwood Elementary School*
Karen Perlbachs, *Second Grade Teacher Hazelwood Elementary School*
Marilyn Heyn, *Third Grade Teacher Hazelwood Elementary School*
Anna Petticord, *Third Grade Teacher Hazelwood Elementary School*
Sharon DeCample, *Fourth and Fifth Grade Teacher Hazelwood Elementary School*
Russ Williams, *Fourth Grade Teacher Hazelwood Elementary School*
Donna Nelson, *Fourth Grade Teacher Hazelwood Elementary School*
Anita Thorsted, *Fifth Grade Teacher Hazelwood Elementary School*
Sharon Companion, *Fifth Grade Teacher Hazelwood Elementary School*
Jack Holmes, *Fifth Grade Teacher Hazelwood Elementary School*
Pat Lamborn, *Secretary Hazelwood Elementary School*
Roxi Reynolds, *Educational Assistant Hazelwood Elementary School*
James Thurston, *Research Assistant*

**And a special thanks to the *students* of Hazelwood Elementary School who were so helpful, cooperative, and friendly.**

# Table of Contents

## Introduction

This project addressed two areas that are in the forefront of current research and practice in the field of Special Education: maintaining students with handicaps within the general education classroom, and the impact of technology on students with and without the handicaps. While systematic reading instruction is at the core of the elementary school curriculum, as much as 70 % of reading instruction time in these classrooms does not involve the teacher. Instead, the students work independently on noninteractive reading -related assignments such as worksheets (National Academy of Education, 1985). Given the current trend in public schools to educate students with mild handicaps in the general education classroom, and with the majority of elementary school teachers using the basal reader approach (National Academy of Education, 1985), adapting a basal reader to multimedia computer assisted instruction for these students appears to be an appropriate use of the hypermedia technology.

State of the art microcomputer software designed to aid students with handicaps (learning disabled, emotionally disturbed, educable mentally handicapped) in the development of successful reading skills in a general elementary school setting was developed and tested. The software provided hypermedia reading selections designed as supplementary material for a basal reader series. The hypermedia reading material offered easily accessible, additional information about the text along with decoding and comprehension strategies within the context and physical structure of the reading selection itself. The software consisted of a series of hypermedia lessons based on selected lesson segments from each basal grade level textbook series. Scope and sequence of skills and pedagogical techniques in the hypermedia lessons were kept constant with the basal text teaching guidelines.

## Summary of Project Accomplishments

### Year One

1. Cooperating teachers at Hazelwood Elementary School (Renton, WA) were selected and trained in the use of the computer hardware and software.

2. A hypermedia authoring system for construction of the hypermedia computer based reading lessons was developed.

3. Reading passages from the Macmillan basal reader series were selected as the basis for the hypermedia CAI lessons.

4. Thirty hypermedia lessons per grade level (K-3) were developed using the authoring system, resulting in a total of 120 separate hypermedia CAI lessons (1-3) and 26 separate lessons for kindergarten.

5. Students (K-3) were trained in the use of the computer hardware and software.

6. Criterion referenced pretests that addressed vocabulary development, pronoun and anaphora identification, and interpretive and factual comprehension were administered and recorded.

8. A pilot test of the hypermedia CAI reading lessons was conducted in each experimental classroom.

9. Data concerning the referral rate of students to special education prior to the beginning of this project was collected. Post intervention data concerning referral rate to special education was collected at the end of the year.

10. Study One, involving first year software and comparing the hypermedia group's reading gains to that of the non-hypermedia group, began on January 30, 1989. Data concerning the order of presentation of hypermedia material in the instructional sequence was collected. A criterion referenced posttest was administered. The data were analyzed.

11. Preliminary findings from Study One, as well as information concerning the development of the authoring template and hypermedia CAI lesson software, was presented at three national conferences: Council for Exceptional Children, San Francisco, April 1989; the Arizona State Microcomputers in Education Conference, Tempe, March 1989; and, the National Educational Computing Conference, Boston, June, 1989.

12. Production of the software for Year Two began. This software built on the existing first year software, adding enhancement of syntactic and semantic structures to the same text passages. All first year features were kept intact as well as the instructional design and the "feel" of the lessons.

Year Two

1. A new kindergarten experimental and control classroom were added at the beginning of the second year of the project. As the first year kindergarten students made the transition to first grade, new pre-school classes provided students for kindergarten, as well as contributing to the longitudinal aspect of the study.

2. Longitudinal information was collected through the follow-up of third grade students as they made the transition into fourth grade. Criterion referenced tests were administered to these students at the beginning and end of the second year of the project. In this manner the project was able to ascertain the effect of the software on the first-year third graders into the second year of the project.

3. Software design and classroom management strategies were reviewed and updated with the teachers.

4. Production of software for Year Two was completed. This year the enhanced semantic and syntactic features were added to the software. These involved pronoun and anaphora recognition.

5. Cooperating teachers at Hazelwood Elementary School (Renton, WA) received additional training in the use of the computer hardware and software.

6. Criterion referenced pretests that addressed vocabulary development, pronoun and anaphora identification, and interpretive and factual comprehension were administered and recorded.

7. Students received additional training in the use of the computer hardware and software.

8. Study Two, involving second year software and comparing the hypermedia group's reading gains to that of the non-hypermedia group, began on September 30, 1989. Data concerning the order of presentation of hypermedia material in the instructional sequence was collected. A criterion referenced posttest was administered. The data were analyzed.

9. Findings from Study One along with preliminary findings from Study Two were presented at the International Conference of the Council for Learning Disabilities, Denver, Colorado, October 1989; the New Mexico Council for Exceptional Children Conference, Albuquerque, NM, November, 1989; the Learning Disabilities Association of America Conference, Anaheim, CA, February, 1990; the Arizona State Microcomputers in Education Conference, Tempe, March 1990. Findings from both Study One and Study Two were presented at the National Educational Computing Conference, Nashville, TN, June 1990.

10. Production of software for Year Three began. This software built on the existing software, adding enhancement of deep structures including comprehension and self-monitoring to the same text passages. All first and second year features were kept intact as was the instructional design and the "feel" of the lessons.

Year Three

1. As the second year kindergarten students made the transition to first grade, new kindergarten students entered kindergarten and were added to the study contributing to the longitudinal aspect of the study.

2. Longitudinal information was collected through follow-up of first-year third graders as they made the transition to fifth grade, and second-year third grade students as they made the transition to fourth grade. Criterion referenced tests administered to these students at the beginning and end of the year allowed the project to ascertain the effect of the hypermedia software on the original second and third graders over the three years of the project.

3. Software design and classroom management strategies were updated.

4. Production of software for Year Three was completed. This year the comprehension features were added to the software. These involved pre-reading strategies, locating the answer to a question in the text, and comprehension summary statements.

5. Cooperating teachers at Hazelwood Elementary School (Renton, WA) received additional training in the use of the computer hardware and software.

6. Criterion referenced pretests that addressed vocabulary development, pronoun and anaphora identification, and interpretive and factual comprehension were administered and recorded.

7. Students received additional training in the use of the computer hardware and software.

8. Study Three, involving third year software and comparing the hypermedia group's reading gains to that of the non-hypermedia group, began on October 30, 1990. Data concerning the order of presentation of hypermedia material in the instructional sequence was collected. A criterion referenced posttest was administered. The data were analyzed.

9. Findings from Study One, Study Two, and Study Three were presented at the International Conference of the Council for Learning Disabilities, Austin, TX, October 1990; Washington State International Reading Association WORD Conference, Bellevue, WA, March, 1991; the Council for Exceptional Children Conference, Atlanta, GA, April, 1991; and the Center for Special Education Technology Seminar on Multimedia, Washington, D.C., May 1991.

10. Articles concerning the project were published in *Intervention in School and Clinic* and *Educational Technology.* Articles have been accepted for publication in *Journal of Reading, Writing, and Learning Disabilities* and *Journal of Special Education Technology*. A special issue of the Council for Exceptional Children *Technology and Media Newsletter* authored by the project coordinators will concern the project and will be published in December, 1991. An invited article concerning the project will be in the *Center for Special Education Technology Multimedia Seminar Proceedings*. Articles are in preparation for the *Journal of Early Intervention*, the *Journal of Educational Multimedia and Hypermedia*, and *The Reading Teacher*.

11. Three monographs concerning various aspects of the project and hypermedia/multimedia has been published by the project staff and disseminated in the cooperating district and to computer educators across the nation.

12. A hypermedia development handbook for use by teachers in the Renton School District was published and disseminated throughout the district.

13. A video was produced by the project. The video was disseminated in the cooperating district and has been sent to computer educators throughout the country.

# Project Objectives

## Project Goal and Six Related Objectives

The overriding goal of this project was to provide teachers with an instructional tool helpful in maintaining learners with handicaps (learning disabled, emotionally disturbed, educable mentally retarded) in a general elementary classroom reading program. Research objectives identified in the initial proposal include:

1. **To create an authoring system** for construction of computer based reading lessons in a hypermedia format.

2. **To create a minimum of 30 hypermedia reading lessons per grade level** that provide supplemental instruction to handicapped students in a regular elementary school classroom reading program (grades K-3). These computer based lessons address the interactive nature of reading through the development of three separate levels of sophistication:
   a. enhanced surface structures
   b. enhanced syntactic and semantic structures
   c. enhanced deep meaning structures including self-monitoring of comprehension.

3. **To conduct at least two training sessions** per year for cooperating teachers and students who will be participating in the project.

4. **To administer yearly pre and post measurements** concerning academic and social progress, and student referral rate for special education services outside the regular classroom. These include: (a) criterion referenced tests addressing vocabulary development and factual and interpretive comprehension skills; (b) baseline data and post intervention data concerning the referral rate of students for special education services.

5. **To field test the hypermedia lessons** through three separate studies conducted in regular education classrooms in the Renton School District.

6. **To disseminate** the results throughout the duration of the project.

The procedural objectives of the study did not change over the course of the three year project. A list of the original procedural objectives follows.

PROCEDURAL OBJECTIVES OF THE STUDY

1. **Select and train cooperating teachers.** Four elementary school teachers, one from each grade level (K-3), will be randomly selected for the intervention classrooms. These teachers will be instructed in the use of the computer and accompanying software along with classroom management strategies for using the computer in their classrooms. An additional four teachers at the same grade levels will be selected as control classroom teachers. (Year 1-Semester 1)

2. **Construct an authoring system** for building the hypermedia lessons. A template program allowing for easy, consistent input of text and graphics will be built for development of the hypermedia lessons. (Year 1-Semester 1)

3. **Determine the particular reading passages** which will be used to develop the hypermedia lessons. Reading selections will be taken from throughout each basal grade level text. A minimum of 30 reading passages from each grade level will be selected for the computer based lessons. (Year 1-Semester 1)

4. **Produce level-one hypermedia lessons.** Software developed for the first year will include surface level enhancements to the text. The focus of this level will be to include additional information for the student. (Year 1-Semester 1)

5. **Pilot test and train students.** hypermedia lessons of the same general content and structure will be administered in the semester before the study begins. At this time students will learn how to use the computers and the accompanying software. Based on observations and discussions with students and teachers, software design and classroom management strategies will be modified to provide better instruction. (Year 1-Semester 1)

6. **Study One.** A criterion referenced reading pretest which addresses vocabulary development and interpretive and factual comprehension skills will be administered. Baseline data on student participation in reading group activities will be collected. Study One, involving level-one software, will compare the hypermedia group's reading gains to that of the non-hypermedia group. Data concerning the order of presentation of hypermedia material in the instructional sequence will be collected. A criterion referenced posttest will be administered. Post intervention data will be collected concerning student referral to special education. Data will be analyzed. (Year 1-Semesters 1 & 2)

7. **Review and update software design and management strategies.** Discussion with the cooperating teachers along with a schedule of reliability checks will determine if the computer software structure or classroom management scheme need updating. (Year 1-Semesters 1 & 2)

8. **Produce level-two software.** The level-two software will build on the existing level-one software, adding enhancements of syntactic and semantic structures to the same text passages. All level-one features will be kept intact as will the instructional design and "feel of the lessons. (Year 1-Semester 2-Summer)

## End of Year One

9. **Training sessions for cooperating teachers and students will be continued.** The teachers and students will be instructed in further use of the computer and accompanying hypermedia CAI software. Classroom management strategies for using the computer in the classroom will be included in the teacher training. (Year 2-Semester 1)

10. **Study Two.** A criterion referenced reading pretest which addresses vocabulary development and interpretive and factual comprehension skills will be administered. Baseline data on student participation in reading group activities will be collected. Study Two, involving level-two software, will compare the hypermedia group's reading gains to that of the non-hypermedia group. Data concerning the order of presentation of hypermedia material in the instructional sequence will be collected. A criterion referenced posttest will be administered. Post intervention data will be collected concerning student referral to special education. Data will be analyzed. (Year 2-Semesters 1 & 2)

11. **Review and update software design and management strategies.** Discussion with the cooperating teachers along with a schedule of reliability checks will determine if the computer software structure or classroom management scheme need updating. (Year 2-Semester 2)

12. **Produce level-three software.** The level-three software will build on the existing level-two software, adding enhancements of deep structures for comprehension including self-monitoring strategies, to the same text passages. All level-one and level-two features will be kept intact as will the instructional design and "feel" of the lessons.
(Year 2-Semester 2-Summer)

## End of Year Two

13. **Training sessions for cooperating teachers and students will be continued.** Training for teachers and students will continue as to the use of the computer and accompanying hypermedia CAI software. Classroom management strategies for using the computer in the classroom will again be included in the teacher training. (Year 3-Semester 1)

14. **Conduct Study Three.** A criterion referenced reading pretest which addresses vocabulary development and interpretive and factual comprehension skills will be administered. Baseline data on student participation in reading group activities will be collected. Study Three, involving level-three software, will compare the hypermedia group's reading gains to that of the non-hypermedia group. Data concerning the order of presentation of hypermedia material in the instructional sequence will be collected. A criterion referenced posttest will be administered. Post intervention data will be collected concerning student referral to special education. Data will be analyzed. (Year 3-Semesters 1 & 2)

15. **Disseminate findings.** The research findings will be disseminated throughout the duration of the project at the rate of at least two presentations and two published papers per year (Years 1, 2, & 3). A yearly monograph will be published concerning the research findings (Years 1, 2, & 3). A manual which outlines the instructional design and production process for the computer software will be produced (Year 3). Workshops for local school district personnel will be provided (Years 2 & 3). Results of the research will be communicated to textbook and software publishers encouraging them to incorporate the hypermedia materials and strategies into their product line (Years 1, 2, & 3).

**End of Year Three**

## Accomplishments

The following are descriptions of the accomplishments of the project in regard to the six objectives outlined in the original proposal. As noted in the project timeline (see Figure 1), the project addressed each objective yearly over the course of the three year study.

### Six Research Objectives: Accomplishments

**(1). To create an authoring system for construction of computer based reading lessons in a hypermedia format.**

The authoring system that was developed and used to create the CAI software for this project is based on a conceptual framework of electronic notecards. Within this framework, the computer screen represents a single card in a stack of related cards. These cards are linked and accessed by activating cursor sensitive areas called buttons. Cards are linked in such a way that users can move easily and quickly from one card to another through button selection.

Any single card has the capacity to hold up to 30,000 text characters, high resolution graphics, including animated sequences, and digitized sound. Individual cards are linked into files, or collections of cards, called stacks. Computer code for controlling the linking relationships between the individual cards in the stacks have been written in the HyperTalk language. This code is used to control the operation of cards within stacks, and to respond to the user's selection of buttons and links. This system has been written for the Macintosh computer in the Hypercard programming environment.

Construction of a hypermedia CAI lesson, using the template provided in the authoring system developed the first year, requires only the entering of text, graphics, and sound resources into the computer. All button links are pre-programmed into the system. This system provides non-programmers the ability to create sophisticated hypermedia CAI lessons for any text or subject matter desired. Lessons created with the authoring system automatically collect and record the following data: student name; date and time lesson is begun and ended; a list, in chronological order, of all enhanced words selected by the student including the amount of time spent viewing the enhancement; the order in which pages (screens) are viewed along with the amount of time spent viewing each page; and the extent to which the student completes the lesson. These data are recorded in a computer format that is readable by data base and spreadsheet programs for ease of permanent recording and analysis.

**(2). To create a minimum of 30 hypermedia reading lessons that provide supplemental instruction to handicapped students in a regular elementary school classroom reading program. These computer based lessons will address the interactive nature of reading through the development of materials at three separate levels of sophistication:**

**a. text with enhanced surface structures**
**b. text with enhanced syntactic and semantic structures**
**c. text with enhanced comprehension and self-monitoring**

The software was developed in three levels of increasing sophistication for grade level materials K-3 over the three years of the project. The software developed for the three years of the project is discussed below.

Year One: Enhanced surface structures. Software developed for the first year of the project included surface level enhancements to the text. Text and graphic windows along with digitized speech were used in these hypermedia lessons. The emphasis at this level has been to include as much additional information as possible for the student to have available for access.

Thirty hypermedia CAI lessons were developed at each grade level (1-3) and 26 lessons for kindergarten. These lessons were based on verbatim text selections from the basal readers for each grade level. Scope and sequence of skills and pedagogical techniques in the lessons were kept constant with the basal text teaching guidelines.

Many students either do not have the experiential background or do not access the information they do possess that is necessary for understanding even the surface meaning of words. Inclusion of related graphics, animated graphic sequences, simple definitions, synonyms, and digitized speech, linked through buttons to the words or pictures on the original text page, provides the reader directly with additional experiential information. Indirectly, an association between information from the print itself and information the reader brings to the reading act may be formed.

Year Two: Enhanced semantic and syntactic structures. Software developed for the second year of the project included semantic and syntactic enhancements to the text. Dynamic, graphical, interactive teaching segments that illustrate the relationship between pronoun/antecedent pairs and other anaphora/referent words were added to the Year One software. Since elementary school children are less likely to use pronoun clues for understanding text than are adult readers (Lesgold, 1972) and since making logical connections between pronouns and their referent words may be necessary to prevent potential ambiguity of meaning Chai (1967), the emphasis at this level was to link semantic segments of the text to syntactic clues (e.g., the antecedent usually comes before the pronoun in the sentence paragraph).

Year Three: Enhanced deep structures including self-monitoring for comprehension. The final level of sophistication emphasized leading the reader through one or more process strategies for improving comprehension. Such techniques include paragraph summaries, or re-reading strategies similar to those used in a teacher directed reading activity. A teaching sequence routinely followed by teachers in a directed reading activity as outlined in a basal reader teacher's guide follows: (a) new vocabulary is presented and explained in context either textually or graphically; (b) a reason for reading is presented; (c) silent reading takes place; (d) comprehension questions are asked; (e) students are asked to locate where the answer in found in the text; and (f) student responses are reinforced. The hypermedia lesson presented the same sequence, with appropriate interaction and reinforcement. Two strategies, questions inserted in text as prompts (Wong, 1980) and questions presented as prereading goals (Wong, 1979), have proven successful with students with mild disabilities.

The multimedia/hypermedia capabilities of the microcomputer hardware and software helped define the instructional strategies selected for adaptation to the lessons in this project. Thus, strategies that could be faithfully "reproduced" by the multimedia/hypermedia format were chosen (e.g., lead a student through the same sequence of prompts as a teacher would), and only those that were successfully implemented in a pilot test were included in the software (see Figure 2).

**(3). To conduct at least two training sessions per year for cooperating teachers and students who will be participating in the project.**

Teachers participating in the project as experimental classroom teachers received training in the use of the Macintosh computer as well as the accompanying software every year of the project. The teachers were assigned two computers for their classroom. This allowed the teachers the opportunity to use the computer at their leisure and to become comfortable with the machine before the actual study began every year and to work on the computers before and after school.

Formal training of the teachers involved workshops at school and all day workshops held at the University of Washington. The workshops included training in the use of various public domain programs for the Macintosh as well as the hypermedia CAI reading software that was used in the classroom.

Each year of the project students were trained in the use of the computer in their classrooms. This first session of the year was a "get acquainted with the computer session" in which students learned the basic mechanics of using a Macintosh Plus computer. The second yearly session was designed to acquaint the students with the hypermedia software. In this session students were instructed on starting up the software, proceeding through a lesson, ending a lesson, and leaving the computer ready for the next student.

The training of the students was followed by two pilot tests of the hypermedia CAI reading lessons identical, except for textual content, to the intervention lessons. Each pilot test was conducted for one week with an observer in the classroom to record anecdotal data concerning classroom management of the software lesson and integration of the software into the classroom reading time. The purpose of the pilot testing was to identify and correct any problems with the software or the classroom management plan for providing the students with access to the lessons. No significant problems concerning the implementation of the software were noted in any of the classrooms.

**(4). To administer yearly pre and post measurements concerning both academic and social progress: (a) criterion referenced tests addressing vocabulary development and factual and interpretive comprehension skills, and (b) baseline data and post intervention data concerning the referral rate of students for special education services.**

The Macmillan Reading Series Achievement Test (1983) was used as the measure of student reading progress over the course of a school year. This is the achievement test that is regularly administered in the Renton School District. The test is divided into subtest areas which include both vocabulary and comprehension skills.

Data concerning the referral rate of students for special education services outside the general education classroom was collected. Baseline data is comprised of the referral rates prior to the beginning of the project. These data have been compared to referral rates collected after the end of the project.

**(5). To field test the hypermedia reading lessons through three year-long separate studies conducted in general education classrooms in the Renton School District.**

The field testing involved the use of the hypermedia lessons as supplementary reading instructional material in elementary classrooms in the Renton School District. Four classrooms (K-3) were involved each year of the grant, with followup data being collected in fourth and fifth grade classrooms during the second and third years of the project, respectively. Followup in the fourth and fifth grade classes allowed the project to ascertain the effect of the treatment on the original second and third graders over the three years of the project.

<u>Year One.</u> Teachers (K-3) identified appropriate measures for the integration of the software into their individual classrooms and reading programs. This included the development of schedules for student access to the computer lessons, placement of the computers in the classroom environment to maximize computer usage and minimize classroom distraction, and incorporation of the computer lessons into the daily reading rotation.

The level-one software was implemented in four classrooms (K-3) for five months beginning in January of the first year. Students were assigned the computer based lessons on a regular basis much as they were assigned their workbook and skill sheet lessons.

<u>Year Two.</u> Level-two software was pilot tested during October of the second year of the project. The purpose of the pilot testing was to identify and correct any problems with the second-level software or the classroom management plan for providing the students with access to the lessons. No significant problems concerning the implementation of the software were noted in any of the classrooms. Once again teachers (K-3) identified appropriate measures for the integration of the software into their individual classrooms and reading programs. This included the development of schedules for student access to the computer lessons, placement of the computers in the classroom environment to maximize computer usage and minimize classroom distraction, and incorporation of the computer lessons into the daily reading rotation.

The level-two software was implemented in four classrooms (K-3) over a seven month period which began in November of the second year (1989-1990). Students were assigned the computer based lessons on a regular basis. A minimum of 30 hypermedia lessons per grade level were produced and were implemented in Year Two.

<u>Year Three.</u> Level-three software was pilot tested during October of the third year of the project. No significant problems concerning the implementation of the software were noted in any of the classrooms. Once again teachers (K-3) identified appropriate measures for the integration of the software into their individual classrooms and reading programs. This included the development of schedules for student access to the computer lessons, placement of the computers in the classroom environment to maximize computer usage and minimize classroom distraction, and incorporation of the computer lessons into the daily reading rotation.

The level-three software was implemented in four classrooms (K-3) over a seven month period which began in November of the third year (1990-1991). Students were assigned the computer based lessons on a regular basis. A minimum of 30 hypermedia lessons per grade level were produced and were implemented in Year Three.

**(6). To disseminate the results throughout the duration of the project.**

Dissemination of the results occurred throughout the duration of the project. Dissemination includes: (a) a manual outlining the instructional design and production process for the computer software and including computer code and documentation for a hypermedia authoring system; (b) workshops for personnel from the Renton School

District; (c) a yearly monograph outlining the three levels of treatment proposed in the project; (d) communication with textbook and software publishers concerning results of the project in an effort to encourage the adoption of those methods and strategies; (e) articles published in juried journals; (f) presentations at local and national conferences; and (g) a video concerning the project. Project accomplishments in this area include:

(a). A manual outlining the instructional design and production process for the computer software along with computer code and documentation for a hypermedia authoring system is available through the project office and has been disseminated throughout the cooperating district and to interested computer educators across the nation. A copy is included with this report.

**Boone, R. & Higgins, K.(Authors). (1991, May). *Hypermedia in the Classroom: A Development Handbook for Teachers*. (Available from [Randall Boone, 2237 Minor Ave. E., Seattle, WA])**

This manual provides teachers with step-by-step information to create hypermedia instructional materials. A template is provided along with a hypermedia tutorial. The appendix includes definitions of hypermedia terms, publishers of hypermedia materials, and books and magazines dealing with hypermedia.

(b). Workshops have been conducted in the Renton School District for the Renton School Board members, for the Hazelwood Elementary School PTA Board members, for control and experimental teachers participating in the project, and for doctoral students at the University of Washington.

(c). Three monographs have been produced by the project. The monographs have been distributed to teachers and administrators in the cooperating district and to interested computer educators and researchers nationally. Copies of the monographs are included in this report.

**Higgins, K. & Boone, R. (1991). *Hypermedia CAI: Three years of school-based research* (Hypertext CAI Monograph No. 3). Seattle: University of Washington, Experimental Education Unit.**

Background information concerning the project is presented and discussed along with representative examples of the software. The data from the three-year project are presented and discussed separately for the three years of the project and longitudinally.

**Boone, R. & Higgins, K. (1990). *Hypertext and Hypermedia: Applications for Educational Use* (Hypertext CAI Monograph No. 2). Seattle: University of Washington, Experimental Education Unit.**

This monograph contains three articles: *Hypertext: What is it ?*, *Hypertext Lessons: A HyperCard Template for Teachers*, *Hyperetext Computer Study Guides and the Social Studies Achievement of Students with Learning Disabilities, Remedial Students, and Regular Education Students.*

**Higgins, K. & Boone, R. (1989). *Hypertext CAI: Maintaining Handicapped Students in a Regular Classroom Reading Program* (Hypertext CAI Monograph No. 1). Seattle: University of Washington, Experimental Education Unit.**

This monograph contains two articles: *Hypertext: A New Vehicle for Computer Use in Reading Instruction* and *Hypermedia CAI: A Supplement to an Elementary School Basal Reading Program.*

(d). The project has been in contact with various publishers and computer companies concerning the project.

- •The project has communicated with Macmillan Publishing Company concerning the results of the study. The Renton School District Language Arts Coordinator, Vicki Montgomery, plans to continue communicating with the company concerning the use of hypermedia in basal readers.
- •Dr. Gary Moulton of Apple Computer's Office of Education has been sent the monographs.
- •Project personal have met with Tom Greaves of IBM Multimedia Development concerning the use of hypermedia in education.

(e). The following articles have been published or are in press concerning the project. The complete articles are in the appendix of this report.

**Boone, R., & Higgins, K. (in press). Hypermedia applications for content area study guides. *Journal of Reading, Writing, and Learning Disabilities.***

Hypermedia, a new mode of computer text and information presentation, provides a flexible format for adapting materials currently in use by teachers to the computer medium. A hypermedia presentation system provides a reader access to related information by means of a simple selection process. The process "brings up" to the computer screen new windows of related text, related pictures, and computer generated voice that provide supplementary information, clarification, and elaboration needed by the reader, all within in a familiar context and a single medium. The results from two companion studies at the high school level and a similar study at the elementary level indicate that the use of hypermedia to construct computer study guides holds promise. Hypermedia computer study guides were found to be as effective an instructional technique as a teacher presented lecture and were especially successful with remedial students and students with learning disabilities in the high school studies. The elementary school study corroborated the effectiveness of hypermedia study materials with poor readers.

**Boone, R., & Higgins, K. (1991). Hypertext / hypermedia information presentation: Developing a hypercard presentation template. *Educational Technology*, 31(2), 21-30.**

Instructions for creating a simple hypertext / hypermedia document template and subsequent hypertext / hypermedia lessons are provided for the reader. This is not a HyperCard tutorial. Those who are somewhat familiar with HyperCard or who have some programming experience and a HyperCard manual should have little trouble following the instructions provided in this article.

**Boone, R., & Higgins, K. (1990). Hypermedia CAI: The development and integration of elementary reading materials. In E. Ellis (Ed.), *Proceedings of NECC '90* (pp.5). Eugene: ICCE, University of Oregon for National Educational Computing Conference.**

This article reports on the findings from the first two years of a three-year longitudinal research project involving the development and testing of hypermedia

computer assisted instructional (CAI) reading materials in grades K-3. The effect of the software on reading achievement will be reported along with a detailed examination of representative lessons from the project, a description of the development process, and a discussion of the implementation and integration process into the classroom.

**Boone, R., & Higgins, K. (1989). Hypertext CAI: A supplement to an elementary school basal reading program. In W. C. Ryan (Ed.), *Proceedings of NECC '89* (pp.141-142). Eugene: ICCE, University of Oregon for National Educational Computing Conference.**

This article discusses the first year of a three-year federally funded project involving the development and testing of hypertext computer assisted instructional (CAI) reading materials. These materials were designed to facilitate the successful participation of both handicapped learners (learning disabled, emotionally disturbed, and educable mentally retarded) and nonhandicapped learners in a regular elementary classroom basal reading program (K-3). The hypertext reading lessons provide students with a reading environment offering additional information about words and concepts from their basal reading textbook. This differs from traditional computer assisted reading software which often presents lessons on isolated skills not specifically related to basal textbook content or pedagogy.

**Higgins, K., & Boone, R. (in press). Hypermedia computer assisted instruction: Adapting a basal reading series. In J. Wilson (Ed.), *Proceedings of Center for Special Education Technology: Technology Seminar in Multimedia*. Reston: Center for Special Education Technology, Council for Exceptional Children.**

The theoretical and practical implications of the use of hypermedia to adapt a basal reader are discussed. Data from the first two years of the project are provided for the reader.

**Higgins, K., & Boone, R. (1990). Hypertext: A new vehicle for computer use in reading instruction. *Intervention in School and Clinic*, 26(1), 26-31.**

*Hypertext and hypermedia* are relatively new terms for today's teachers who are working hard to keep abreast of the quickly changing field of computer technology in education. Since this capability for microcomputers became available in 1987, interest in hypertext has been growing rapidly throughout the educational community. This recent interest has resulted in a rapid increase in the number of magazine and journal articles, papers and presentations at educational conferences, and hypertext/hypermedia educational software programs available for classroom use. Hypertext as an educational tool is very different from traditional computer assisted instructional software, offering a new format for providing instruction and information via a computer. This article provides the reader with information concerning hypertext and its uses in the classroom.

**Higgins, K., & Boone, R. (in press). Hypermedia CAI: A supplement to an elementary school basal reader program. *Journal of Special Education Technology*.**

The results from the first year of a longitudinal study involving the development and testing of hypermedia computer assisted instructional (CAI) reading materials for grades K-3 are discussed. The hypermedia materials were designed to facilitate the

successful participation of both handicapped and non-handicapped students as well as students at risk for special education referral in a regular elementary classroom basal reading program. The hypermedia reading lessons provided students with a reading environment offering additional information about words and concepts from their basal reading textbook. This differs from traditional computer assisted reading software which often presents lessons on isolated skills not specifically related to basal textbook content or pedagogy.

The results from the first year of the three-year study indicate that hypermedia is a promising instructional tool for students who have been classified as poor readers by means of an achievement test. Results are inconclusive as to whether the hypermedia CAI lessons are best used before or after a teacher directed reading activity.

(f.) The following articles are in preparation concerning the project.

Boone, R., Higgins, K., & Lovitt, T.C. (1991). *Hypermedia applications for reading instruction: A search for "cooperative" text.* Manuscript in preparation.

Higgins, K., Boone, R., Notari, A., & Stump, C.S. (1991). *Hypermedia CAI: The effects on kindergarten letter identification.* Manuscript in preparation.

(g). The following presentations have been made concerning the project by Dr. Boone and Dr. Higgins.

## Invited Presentations

*Panel: Multimedia Research in Progress*. Presentation for Center for Special Education Technology: Technology Seminar in Multimedia with Drs. David Rose and Ted Hasselbring, Washington, D.C., May 1991.

*Use of computers for individuals with disabilities.* Presentation for Computer CurbCuts computer users group focusing on access to computers by individuals with disabilities at the University of Washington, Seattle, Washington, November, 1990.

*Promising federally funded computer applications.* Sponsored by the Department of Education, Office of Special Education. Presentation for Learning Disabilities Association of America with Drs. Bea Berman, Ted Hasselbring, and Bridgett Dalton, Los Angeles, California, February, 1990.

*The use of hypertext in the elementary classroom.* Presentation for the Puget Sound Computer Education Specialists, Renton, Washington, January 1989.

## Regional and National Presentations

*The development and classroom implementation of hypermedia computer assisted reading materials.* Presentation for the 69th Annual Council for Exceptional Children Conference, Atlanta, Georgia, April, 1991.

*Basal reader instruction through hypermedia computer assisted instruction.* Presentation for Washington• Organization•Reading•Development Conference, International Reading Association, Bellevue, Washington, March 1991.

*Hypermedia CAI reading materials: Design and development, integration and effectiveness.* Presentation for the 12th International Conference on Learning Disabilities, Austin, Texas, October, 1990.

*Hypermedia CAI: The development and integration of elementary reading materials.* Presentation for the National Educational Computing Conference, Nashville, Tennessee, June 1990.

*Hypermedia CAI: The development and integration of elementary reading materials.* Presentation for Arizona State University's Tenth Annual Microcomputers in Education Conference, Tempe, Arizona, March 1990.

*Hypermedia CAI reading materials: Design and development, integration, and effectiveness.* Presentation for the Nineteenth Northwest Council for Computer Education Conference with Marilyn Heyn, Janice Okita, Karen Perlbachs, Eugene, Oregon, March, 1990.

*Hypermedia CAI: The development of elementary reading materials.* Presentation for the New Mexico Council of Exceptional Children Annual Conference, Albuquerque, New Mexico, November, 1989.

*Hypertext CAI: The development of elementary reading materials.* Presentation for the 11th International Conference on Learning Disabilities, Denver, Colorado, October, 1989.

*Hypertext CAI: A supplement to an elementary school basal reading program.* Presentation for the National Educational Computing Conference, Boston, Massachusetts, June 1989.

*Workshop: Hypertext CAI: The development of elementary reading materials.* Workshop for Arizona State University's Ninth Annual Microcomputers in Education Conference, Tempe, Arizona, March 1989.

(h). A video was produced by project staff and has been disseminated throughout the coopera'ng school district and to interested computer educators across the nation. A copy is included with this report.

**Higgins, K. & Boone, R., (joint production). (1991). *Hypermedia CAI : Adapting a basal reader* [Film]. Seattle, WA: University of Washington. Funded by the U.S. Department of Education , Office of Special Education Research; Grant #84.024J; Thomas C. Lovitt, Principal Investigator.**

This video provides an introduction to the adaptation of a basal reader to the hypermedia format. The viewer is introduced to the concept of hypermedia in general and specifically to the project. Students and teachers discuss the project and demonstrate the software.

## Results

Eight classrooms (K-3) involving over 300 students in both experimental and control settings participated in this project. New kindergarten students were added each year of the project and follow-up was conducted on the third grade students as they transitioned into fourth and fifth grade (see Tables 1, 6, 7, 13, 14, and 15).

The natural movement of students from one grade level to the next resulted in random assignment of students to control and experimental classrooms each year (see Figure 3). Thus, the project accumulated longitudinal information on five separate subgroups based on the sequence and number of years the students participated in either experimental or control classrooms:

- Students who use the multimedia/hypermedia reading materials every year for three years.
- Students who use the multimedia/hypermedia reading materials two years in a row.
- Students who use the multimedia/hypermedia reading materials two years with a one-year hiatus between the two years.
- Students who use the multimedia/hypermedia reading materials for one year.
- Students who do not use the multimedia/hypermedia reading materials any year.

### Research Questions

The six research objectives allowed the project to answer the following research questions.

Question 1. Over the period of one school year, does the use of supplemental hypermedia lessons improve a student's reading ability in *vocabulary development* as measured by a criterion-referenced test?

Question 2. Over the period of one school year, does the use of supplemental hypermedia lessons improve a student's reading ability in *factual comprehension* as measured by a criterion-referenced test?

Question 3. Over the period of one school year, does the use of supplemental hypermedia lessons improve a student's reading ability in *interpretive comprehension* as measured by a criterion referenced test?

Question 4. Longitudinally, over a period of three years, does the *frequency of participation* as a member of the experimental group affect a student's reading progress?

Question 5. Longitudinally, over a period of three years, does the *order of participation* (e.g., Years 1 & 2, Years 2 & 3, or Years 1 & 3) in the experimental group affect a student's reading progress?

Question 6. Longitudinally, over a period of three years, does the *complexity of the experimental materials* affect a student's reading progress?

Question 7. Does the order of presentation of the hypermedia lesson in the instructional sequence affect a student's progress in *vocabulary development*?

Question 8. Does the order of presentation of the hypermedia lesson in the instructional sequence affect a student's progress in developing *factual comprehension skills*?

Question 9. Does the order of presentation of the hypermedia lesson in the instructional sequence affect a student's progress in developing *interpretive comprehension skills*?

Question 10. To what extent does the use of supplemental hypermedia CAI reading lessons help maintain handicapped students in the regular education classroom?

## Results

### Year One

Data from Year One were examined by treatment grouping (experimental and control), ability grouping (low, medium, and high), and instructional sequence grouping in experimental classrooms (intervention either before or after teacher-directed activity). Students were ability grouped based on the results of the Macmillan Achievement Test (1983) given as a pretest. Although the groups labeled as low were considered most likely to include the students who were at risk to be referred for special education services, the three special education students who had been in the low groups changed schools before the study was completed.

An analysis of covariance (ANCOVA) was performed on students' posttest scores from the Macmillan Achievement Test (1983) to determine statistical significance for differences in scores between the experimental and control classrooms at each grade level. The pretest score for each subtest and total test served as the covariate for the ANCOVA. An ANCOVA was also used to compare the results from the two instructional sequence groups within each experimental classroom: (a) students receiving a computer lesson immediately before a teacher directed lesson, and (b) students receiving a computer lesson immediately after a teacher directed lesson. Alpha level was set at .05.

Experimental And Control. When comparing entire classes on total test scores, entire class significance was shown with experimental classes outperforming control classes at kindergarten, second grade, and third grade. There was no entire class significance at the first grade level for total test scores (see Tables 2-5).

When comparing entire classrooms, students in the experimental kindergarten significantly outperformed their control classroom peers in visual discrimination, letter identification, oral vocabulary, spatial abilities, and on total test scores. When the classrooms were broken down into ability groups, low students in the kindergarten experimental class achieved significantly higher test scores in auditory discrimination for initial sounds, oral vocabulary, auditory rhyming, listening comprehension, and total test scores. Low students in the control kindergarten achieved higher test scores in visual discrimination of letters and words, letter identification, and spatial abilities. Kindergarten students in the experimental medium ability group achieved significantly higher test scores in letter identification and auditory discrimination for initial sounds than control kindergartners. High ability students in the experimental kindergarten achieved higher scores in letter identification, oral vocabulary, and total test, while high ability students in the control classroom achieved higher scores in visual discrimination and spatial abilities (see Table 2).

At the first grade level entire class significance was found between the experimental and control classrooms only on the subtest of decoding and phonics with the control class outperforming the experimental class. When the classrooms were divided into ability groups, the low group in the control classroom showed significantly higher scores than the experimental low group in decoding and phonics. Medium and high students in the control classroom also had significantly higher scores than the experimental students in decoding and phonics, study skills, and total test scores. The medium control group did significantly better in vocabulary while the high experimental group had higher scores in vocabulary than the control group (see Table 3).

When comparing entire classroom scores at second grade the experimental class had significantly higher test scores than the control class in decoding and phonics, comprehension, language, and total test scores while the control class had significantly higher scores in vocabulary and study skills. Students in the second grade experimental class defined as low obtained significantly higher scores in decoding and phonics, vocabulary, comprehension, language, and total test. Low students in the control classroom had higher scores in study skills. Second grade control students in the medium group had higher scores than their experimental peers in all subtest categories. Experimental students in the high group outperformed the control high group in vocabulary, comprehension, and total test scores, while the control group had the higher scores in study skills (see Table 4).

In third grade, as an entire class the experimental classroom had significantly higher scores on the total test than did the control class. The entire control class had higher scores on the vocabulary and study skills subtests. Experimental students in the low group had higher test scores in study skills and total test with the control low group receiving higher scores in vocabulary. Medium group students in the experimental classroom had higher tests scores in vocabulary and language while control students had higher scores in comprehension and study skills. Students in the control classroom high group had higher test scores than their experimental peers in vocabulary, comprehension, language, and study skills (see Table 5).

<u>Before And After Teacher Instruction</u>. At the kindergarten level when the total test scores of the entire class were analyzed according to instructional sequence grouping (intervention either before or after teacher-directed activity) students who worked with the hypermedia CAI lessons before teacher-directed instruction achieved higher scores than students who worked with the software after teacher instruction. When students were broken down into ability groups this also held true for students in the low group while students in the medium group who accessed the software after teacher instruction performed significantly better. There was no difference in the performance of students in the high group for instructional sequence (see Table 2).

In the experimental first grade, those students who worked with the hypermedia CAI lessons before working with the teacher had significantly higher total test scores as an entire class than students who worked with the lessons after reading group. This was also true for the students in the low and medium groups. Students in the high group achieved higher total test scores when they used the software after teacher-directed reading instruction (see Table 3).

As an entire class, the second grade students who worked with the software before teacher instruction had significantly higher total test scores than those students who worked with the software after teacher instruction. This was true for students in the low group also. For students in the medium and high groups there was no difference in the total test scores of students who used the hypermedia CAI lessons before or after teacher-directed instruction (see Table 4).

Third grade students who used the hypermedia lesson before teacher instruction had significantly higher total test scores when analyzed as an entire class. When the class was divided into ability groups, this held true for students in the low group, but there was no difference in total test scores for the medium and high groups in terms of instructional sequence (see Table 5).

## Year Two

Data from Year Two were examined by treatment grouping (experimental and control), ability grouping (low, medium, and high), and instructional sequence grouping in experimental classrooms (intervention either before or after teacher-directed activity). Students were ability grouped based on the results of the Macmillan Achievement Test (1983) given as a pretest. The groups labeled as low were considered most likely to include the students who were at risk to be referred for special education services and in kindergarten contained two students identified as at risk for referral, in the second grade control classroom contained two students identified as at risk for referral, and in the experimental third grade contained two students identififed as learning disabled. Students labeled at risk for special education referral are defined as students who score at the 25 percentile level or below on the Metropolitan Achievement Test (1984).

An analysis of covariance (ANCOVA) was performed on students' posttest scores from the Macmillan Achievement Test (1983) to determine statistical significance for differences in scores between the experimental and control classrooms at each grade level. The pretest score for each subtest and total test served as the covariate for the ANCOVA. An ANCOVA was also used to compare the results from the two instructional sequence groups within each experimental classroom: (a) students receiving a computer lesson immediately before a teacher directed lesson, and (b) students receiving a computer lesson immediately after a teacher directed lesson. Alpha level was set at .05.

Experimental And Control. When comparing entire classes on total test scores, no entire class significance was shown at the first grade, second grade, or third grade levels for total test scores (see Tables 9-11). No total test score was figured for the kindergarten class for the second year of the study.

When comparing entire classrooms, students in the experimental kindergarten significantly outperformed their control classroom peers in spatial abilities. Control students outperformed experimental students in visual discrimination of letters and words and letter identification. When the classrooms were broken down into ability groups, low students in the kindergarten experimental class achieved significantly higher test scores in spatial ability. Low students in the control kindergarten achieved higher test scores in visual discrimination of letters and words and letter identification. Kindergarten students in the experimental medium ability group achieved significantly higher test scores in letter identification than control kindergartners. While control kindergartners in the medium group achieved higher scores in visual discrimination of letters and words and spatial abilities High ability students in the control kindergarten achieved higher scores in visual discrimination, letter identification, and spatial abilities (see Table 8).

At the first grade level entire class significance was not found between the experimental and control classrooms. When the classrooms were divided into ability groups, the low group in the experimental classroom showed significantly higher scores than the control low group in decoding and phonics, vocabulary, comprehension, study skills, and total test. Medium students in the experimental classroom also had significantly higher scores than the control students in decoding and phonics, vocabulary, comprehension, study skills, and total test scores. The experimental high group did significantly better in decoding and phonics, study skills, and total test. The high control group had higher scores in comprehension while no difference was found between the two groups in vocabulary (see Table 9).

When comparing entire classroom scores at second grade the experimental class had significantly higher test scores than the control class in vocabulary, comprehension, language, and study skills while the control class had significantly higher scores in decoding and phonics and total test. Students in the second grade experimental class defined as low obtained significantly higher scores in vocabulary, comprehension, language, study skills, and total test. Low students in the control classroom had higher scores in decoding and phonics. Second grade control students in the medium group had higher scores than their experimental peers in decoding and phonics, comprehension, language, and total test. Experimental students in the medium group had higher scores in vocabulary. There was no difference between the medium groups in study skills. Experimental students in the high group outperformed the control high group in vocabulary and language, while the control group had the higher scores in study skills and total test. No differences were found in decoding and phonics and comprehension between the experimental and control high groups (see Table 10).

In third grade, as an entire class there were no differences between the experimental and control classrooms on vocabulary, comprehension, study skills and total test. The entire control class had higher scores on the decoding and phonics and language subtests. Control students in the low group had higher test scores in decoding and phonics, vocabulary, comprehension, study skills and total test with the control low group receiving higher scores in vocabulary. There was no difference between the low groups on the language subtest. Medium group students in the control classroom had higher tests scores in decoding and phonics while there were no differences on the other subtests for the two groups. Students in the experimental classroom high group had higher test scores than their control peers in comprehension while their control peers had higher scores in decoding and phonics, vocabulary, language, study skills, and total test (see Table 11).

For the second year of the study, test data was collected on the original third graders as they transitioned into fourth grade as a follow-up to the instruction the students received in third grade. The students were broken down into their original instructional groups from third grade of experimental or control. When the students were broken down into entire classes there was no difference in the test scores of the two groups for any of the subtests or total test score. This held true for the low groups also. For the medium group, the experimental students outperformed the control students on study skills, while the control students had higher scores on vocabulary and total test. There were no differences between the medium students on decoding and phonics, comprehension, and language. Students in the experimental group had higher scores in language while the control group had higher scores in study skills. No differences were found between the high groups on the subtests of decoding and phonics, vocabulary, comprehension, and total test scores (see Table 12).

<u>Before And After Teacher Instruction</u>. At the kindergarten level when the total test scores of the entire class were analyzed according to instructional sequence grouping (intervention either before or after teacher-directed activity) students who worked with the hypermedia CAI lessons before teacher-directed instruction achieved higher scores in visual discrimination and spatial abilities than students who worked with the software after teacher

instruction. There was no difference in test scores for letter identification. When students were broken down into ability groups, there was no difference in the performance of students in the low or high group for instructional sequence. Students in the medium after-instruction group achieved higher scores than before-instruction students in visual discrimination and letter identification (see Table 8).

In the experimental first grade, those students who worked with the hypermedia CAI lessons after working with the teacher had significantly higher total test scores as an entire class than students who worked with the lessons before reading group. This was also true for the students in the low and medium groups. Due to student attrition there were no students in the experimental before group by the end of the year so this data was not analyzed (see Table 9).

As an entire class, the second grade students who worked with the software before teacher instruction had significantly higher total test scores than those students who worked with the software after teacher instruction. This was true for students in the low group, and the medium group. For students in the high group there was no difference in the total test scores of students who used the hypermedia CAI lessons before or after teacher-directed instruction (see Table 10).

Third grade students who used the hypermedia lesson before teacher instruction had significantly higher total test scores when analyzed as an entire class. When the class was divided into ability groups, this held true for students in the low group, but there was no difference in total test scores for the medium and high groups in terms of instructional sequence (see Table 11).

## Year Three

Data from Year Three were examined by treatment grouping (experimental and control), ability grouping (low, medium, and high), and instructional sequence grouping in experimental classrooms (intervention either before or after teacher-directed activity). Students were ability grouped based on the results of the Macmillan Achievement Test (1983) given as a pretest. The groups labeled as low were considered most likely to include the students who were at risk to be referred for special education services and in the experimental kindergarten contained three students labeled as at risk for special education referral, one student labeled as health impaired, and one student labeled as physically impaired; in the control kindergarten two students were labeled as at risk for special education referral ; in the control first grade one student was labeled as at risk for special education referral; in the experimental second grade one student was labeled as at risk for special education referral; in the control second grade three students were labeled as at risk for special education referral; in the third grade experimental classroom one student was labeled as learning disabled, one student was labeled as physically impaired, and three students were labeled as at risk for special education referral; in the control third grade four students were labeled as at risk for special education referral. Students labeled at risk for special education referral are defined as students who score at the 25 percentile level or below on the Metropolitan Achievement Test (1984).

An analysis of covariance (ANCOVA) was performed on students' posttest scores from the Macmillan Achievement Test (1983) to determine statistical significance for differences in scores between the experimental and control classrooms at each grade level. The pretest score for each subtest and total test served as the covariate for the ANCOVA.

An ANCOVA was also used to compare the results from the two instructional sequence groups within each experimental classroom: (a) students receiving a computer lesson immediately before a teacher directed lesson, and (b) students receiving a computer lesson immediately after a teacher directed lesson. Alpha level was set at .05.

Experimental And Control. When comparing entire classes on total test scores, no entire class significance was shown at the kindergarten, second grade, or third grade levels (see Tables 16-19). Significance was found at first grade with the control class having higher total test scores than the experimental class.

When comparing entire classrooms, students in the control kindergarten significantly outperformed their experimental class peers in spatial abilities. No differences were found between the two groups in visual discrimination, letter identification, or total test scores. When the classrooms were broken down into ability groups, low students in the kindergarten experimental class achieved significantly higher test scores in visual discrimination of letters and words and total test scores. Low students in the control kindergarten achieved higher test scores in spatial abilities. There was no difference between the low groups in letter identification. Kindergarten students in the experimental medium ability group achieved significantly higher test scores in all of the subtests (visual discrimination of letters and words, letter identification, spatial abilities) and total test scores than did their control class peers. High ability students in the experimental kindergarten achieved higher scores in letter identification, and total test scores while control students had higher scores in visual discrimination of letters and words. For the experimental and control high groups, there was no difference in the subtest scores in spatial abilities (see Table 16).

At the first grade level entire class significance was found with the control class outperforming the experimental class for total test scores. When the classrooms were divided into ability groups, the low group in the experimental classroom showed significantly higher scores than the control low group in decoding and phonics. No differences were found between the two groups for vocabulary, comprehension, study skills, and total test scores. Medium students in the experimental classroom had significantly higher scores than the control students in comprehension and study skills, while control students had higher scores for vocabulary and total test scores. There was no difference in the scores of the medium students in decoding and phonics. For the experimental and control high groups no difference was found between the two groups on any of the subtests or for the total test score (see Table 17).

When comparing entire classroom scores at second grade the control class had significantly higher test scores than the experimental class in decoding and phonics, comprehension, language, and study skills. No differences were found for the entire class in vocabulary and total test scores. For students in the second grade defined as low there were no differences found on any of the subtests or total test score between the experimental and control group. Second grade control students in the medium group had higher scores than their experimental peers in decoding and phonics, vocabulary, language, study skills, and total test. Experimental students in the medium group had higher scores in comprehension. Control students in the high group outperfomed the experimental high group on all subtests and total test scores (see Table 18).

In third grade, as an entire class, there were no differences between the experimental and control classrooms on decoding and phonics, comprehension, language, study skills and total test. The entire experimental class had higher scores on vocabulary than the control class. When students were broken down into ability groups, there were no differences between students defined as low on any of the five subtests or for total test scores. Medium group students in the experimental classroom had higher tests scores on all the subtests (decoding and phonics, vocabulary, comprehension, language, and study skills) and on total test scores than medium control students. Students in the experimental classroom high group had higher test scores than their control peers in decoding and phonics, vocabulary, and total test scores, while control students had higher scores in comprehension. No differences were found in language and study skills (see Table 19).

For the third year of the study, test data was collected on the second-year third graders as they made the transition into fourth grade as a follow-up to the instruction the students received in third grade. The students were broken down into their original instructional groups from third grade of experimental or control. When the students were broken down into entire classes, control students had higher test scores in decoding and phonics, comprehension, language, study skills, and total test. There was no difference between the experimental and control groups on the vocabulary subtest. When the students were divided into ability groups, the low group in the control class had higher scores in decoding and phonics, vocabulary, comprehension, language, and study skills. No difference was found between the low experimental and control groups for total test scores. For the medium group, the experimental students outperformed the control students on vocabulary and language, while no differences were found on decoding and phonics, comprehension, study skills, and total test scores. No differences were found between the high groups on any of the subtests or total test scores (see Table 20).

Test data was collected on the original third graders from Year One as they transitioned from fourth grade into fifth grade as a follow-up to the instruction the students received the first year of the project (see Figure 4). The students were broken down into their original instructional groups from third grade of experimental or control. When the students were broken down into entire classes experimental students outperformed control students in decoding and phonics and total test scores, while control students had higher scores in comprehension, language, and study skills. When students were divided into ability groups, students in the experimental low group had higher scores than the control students in comprehension, and study skills. The low control students had higher scores in decoding and phonics, vocabulary, and language. No differences were found between the low experimental and control groups in total test scores. For the medium group, the experimental students outperformed the control students in language, while the control students had higher scores on vocabulary and study skills. There were no differences between the medium students on decoding and phonics, comprehension, and total test. No differences were found between the experimental and control high groups on any of the subtest or total test scores (see Table 21).

Before And After Teacher Instruction. At the kindergarten level when the total test scores of the entire class were analyzed according to instructional sequence grouping (intervention either before or after teacher-directed activity) students who worked with the hypermedia CAI lessons before teacher-directed instruction achieved higher total test scores than students who worked with the software after teacher instruction. When students were broken down into ability groups, there was no difference in the performance of students in the low group for instructional sequence. Students in the medium and high before-instruction groups achieved higher scores than after-instruction students for total test scores (see Table 16).

In the experimental first grade, as an entire class there was no difference in the total test scores for those students who worked with the hypermedia CAI lessons before or after working with the teacher. This was also true for the students in the medium group. Students in the low group who worked with the software after teacher directed instruction had higher scores than the students in the before group. For students in the high group, those who worked with the software before teacher directed instruction had higher scores than those who worked with the software after teacher directed instruction (see Table 17).

As an entire class, the second grade students who worked with the software before teacher instruction had significantly higher total test scores than those students who worked with the software after teacher instruction. Medium students in the after group had higher scores than students in the before group. For students in the low and high group there was no difference in the total test scores of students who used the hypermedia CAI lessons before or after teacher-directed instruction (see Table 18).

Third grade students who used the hypermedia lesson after teacher instruction had significantly higher total test scores when analyzed as an entire class. When the class was divided into ability groups, there was no difference in total test scores for the low and medium groups in terms of instructional sequence . Students in the high ability group who used the software before teacher instruction had higher scores than those students who worked with the software after teacher instruction (see Table 19).

## Longitudinal Data

Longitudinal data from the three years of the project were examined by treatment grouping (experimental and control) over the course of the three years.
An analysis of covariance (ANCOVA) was performed on students' posttest scores from the Macmillan Achievement Test (1983) administered for the third year of the project. The dependent variables were the posttest scores of the last year of the study. The students were grouped into three tracks for the longitudinal analysis: (a) students who participated in kindergarten, first, and second grades; (b) students who participated in first, second, and third grades; (c) students who participated in second and third grades with follow-up in fourth grade; and (d) students who participated in third grade with follow-up in fourth and fifth grades. The students were divided into four student groups: (a) students who were always control, (b) students who were experimental once, (c) students who were experimental twice, and (d) students who were always experimental. Alpha level was set at .05 for the ANCOVA.

Since all of the longitudinal groups except for the third-fourth-fifth grade group had more than two experimental groups, a post hoc test was needed to ascertain where the significant differences between the means occurred. The Least Significant Difference Test was used with alpha set at .05. This allows for the differences between pairs of means, adjusted for the covariate, to be tested for significance.

The ANCOVA for the K-1-2 group of students revealed significance for all subtests and the total test score (see Table 22). The Least Significant Difference Test showed exactly where the significant differences were between the means on the subtests and total test scores for the four student groups (see Table 23). When looking at the total test scores of students who participated in the study in kindergarten, first, and second grades, students who were in the control group for three years had higher test scores than the students who participated in the experimental group for only one year, students who were in the experimental group for two years had higher test scores than students who were in the control group for three years, students who were in the experimental group for three years had higher scores than students who were in the control group for three years, and students who were in the experimental group for three years had higher scores than the students who were in the experimental group for one year.

The ANCOVA for the 1-2-3 group of students revealed significance for all subtests and the total test score (see Table 22). The Least Significant Difference Test showed exactly where the significant differences were between the means on the subtests and total test scores for the four student groups (see Table 24). When looking at the total test scores of students who participated in the study in first, second, and third grades, students who were in the experimental group for three years had higher test scores than the students who participated in the control group for three years. There were no other significant differences between any of the other pairing of the means.

The ANCOVA for the 2-3-4 group of students revealed significance for all subtests and the total test score (see Table 22). The Least Significant Difference Test showed exactly where the significant differences were between the means on the subtests and total test scores for the four student groups (see Table 25). When looking at the total test scores of students who participated in the study in second, and third grades with follow-up in fourth grade, students who were in the experimental in second grade then control group in third grade had higher test scores than the students who participated in the control group for two years. There were no other significant differences between any of the other pairing of the means.

The ANCOVA for the 3-4-5 group of students revealed significance for four of the five subtests (decoding and phonics, comprehension, language, and study skills) and the total test score with the students who participated in the control classroom at third grade performing significantly higher than students who were in the experimental classroom in third grade. Students who participated as experimental students in the third grade had significantly higher tests scores on the vocabulary subtest than did their control peers (see Table 22).

## Referral to Special Education

The following referral and placement data was provided by Dr. Keith Renfrew, Director of Special Education in Renton School District.

Baseline Referral Data School Year 1987-1988

Hazelwood Elementary School Referrals: 5

Hazelwood Elementary School Placements: 4 Specific Learning Disabilities

In Washington, students with specific learning disabilities are defined as students whose intellectual functioning is above that specified as mentally retarded and who exhibit a severe discrepancy between intellectual ability and academic achievement in one or more of the following areas: oral expression, listening comprehension, written expression, basic reading skill, reading comprehension, mathematics calculations, and mathematics reasoning. A severe discrepancy is defined as a functioning level of two-thirds or below expected performance and a functioning level below chronological age/grade in one or more of the seven areas described in the definition of a student with learning disabilities.

Year One of Project 1988-1989 End of Year Referral Data

| | |
|---|---|
| Renton School District Referrals: | 155 |
| Renton School District Placements: | 62 Specific Learning Disabilities<br>6 Seriously Behaviorally Disordered<br>8 Health Impaired |

| | |
|---|---|
| Hazelwood Elementary School Referrals: | 10 |
| Hazelwood Elementary School Placements: | 2 Specific Learning Disabilities<br>1 Seriously Behaviorally Disordered<br>1 Health Impaired |

In Washington, students with serious behavior disorders are defined as students who exhibit one or more of the following characteristics over a long period of time and to a marked degree, which adversely affects their own educational performance: (a) an inability to learn which cannot be explained by intellectual, sensory, or health factors, (b) an inability to build or maintain satisfactory interpersonal relationships with peers and teachers, (c) inappropriate types of behavior or feelings under normal circumstances, (d) a general pervasive mood of unhappiness or depression, and (e) a tendency to develop physical symptoms or fears associated with personal or school problems.

In Washington, students with health impairments are defined as students who have chronic or acute health problems such as students with serious congenital heart defects, other congenital syndrome(s), other disorders of the cardiorespiratory systems, disorders of the central nervous system including epilepsy or neurological impairment, autism or other profound health circumstance or degenerative condition(s) that adversely affect or with a high degree of professional certainly will affect their educational performance.

<u>Year Two of Project 1989-1990 End of Year Referral Data</u>

| | |
|---|---|
| Renton School District Referrals: | 202 |
| Renton School District Placements: | 87 Specific Learning Disabilities<br>15 Seriously Behaviorally Disordered<br>7 Health Impaired<br>11 Developmentally Handicapped<br>5 Communication Disordered<br>2 Hard of Hearing<br>1 Visually Handicapped |
| Hazelwood Elementary School Referrals: | 13 |
| Hazelwood Elementary School Placements: | 9 Specific Learning Disabilities<br>1 Health Impaired |

<u>Year Three of Project 1990-1991 End of Year Referral Data</u>

| | |
|---|---|
| Renton School District Referrals: | 130 |
| Renton School District Placements: | 51 Specific Learning Disabilities<br>3 Seriously Behaviorally Disordered<br>10 Health Impaired<br>9 Developmentally Handicapped<br>2 Communication Disordered<br>3 Mentally Retarded |
| Hazelwood Elementary School Referrals: | 15 |
| Hazelwood Elementary School Placements: | 6 Specific Learning Disabilities<br>2 Health Impaired |

## Discussion

### Year One

The results from the first year of this three-year longitudinal study indicate that hypermedia CAI reading lessons when used as a supplement to basal reader instruction hold possibilities for educational use, especially with lower-achieving students in elementary school classrooms. The most significant reading gains achieved by the experimental students were in kindergarten, second, and third grades. This is reflected by the significantly higher total test scores at these grade levels when the students were grouped as an entire class.

One of the most interesting findings from the study came from the first grade classrooms. When grouped as entire classes, there was no significant difference in total test scores between experimental and control. While students in the control first grade class defined as medium and high had significantly higher subtest and total test scores than the medium and high students in the experimental classroom, the only significant difference found between students defined as low was in the subtest of decoding and phonics. Explaining the lack of significant differences between the low groups in the experimental and control classes is difficult in light of the significantly greater success of the control class students in the medium and high ability groups.

Observation in the two first grade classrooms indicated that the reading instruction program in place in the control classroom was more regular and consistent with a conventional basal approach in tactics and techniques than in the experimental classroom. Similar disparities were not found at the other grade levels. While instructional effectiveness based on teacher difference might account for such significant differences as was found between the control and experimental medium and high groups, the lack of any significant difference between the control and experimental low groups remains a question.

The pattern of scores from kindergarten, second, and third grades, suggests that students in the experimental low groups were significantly benefitted by the intervention. Extrapolating this benefit for low group students to the first grade data, an argument may be made that the intervention provided the low students in the experimental first grade class with a level of instruction that kept them on a more even par with the low students in the control class. This would explain the lack of difference in the two low groups' scores despite more effective teaching in the control classroom.

While there is no conclusive evidence from the first year's data to suggest a favored instructional sequence for the hypermedia lessons, total test scores for low groups and the entire class at every grade level were significantly higher with the hypermedia lesson coming before the teacher directed reading activity. Although there was no consistent favored instructional sequence for the medium and high groups, anecdotal information from the teachers in the experimental classrooms indicates that the hypermedia CAI lessons, when used before the teacher directed reading activity, provided some students with the confidence and additional skills to actively participate in reading group.

### Year Two

The results from the second year of this three-year study indicate that hypermedia CAI reading lessons when used as a supplement to basal reader instruction continue to hold possibilities for educational use, especially with lower-achieving students in elementary school classrooms. The most significant reading gains achieved by the low experimental students were in first and second grades. This is reflected by the significantly higher subtest and total test scores at these grade levels. The experimental first grade students defined as medium and high also had significantly higher tests scores than their control peers. The results indicate that for the second year of the study the findings in the kindergarten and third grade are mixed with neither experimental or control groups achieving consistently higher.

Once again there is no conclusive evidence from the second year's data to suggest a favored instructional sequence for the hypermedia lessons. Total test scores for all groups and the entire class at the first grade level were significantly higher with the hypermedia lesson coming after the teacher directed reading activity, while at the second grade level higher scores were achieved by the entire class and the low and medium groups who used the software before teacher-directed instruction. In kindergarten and third grade the results were mixed. In kindergarten the entire class before students had higher score in visual discrimination for letters and words and in spatial abilities, while the medium students in the after group had higher scores in visual discrimination and letter identification. No other significant differences were found at the kindergarten level. When looking at the total test scores for the entire experimental class in the third grade, students in the before group had significantly higher scores than students in the after teacher-directed instruction group. This was also true for students in the low group. There were no significant differences for the medium and high groups in terms of instructional sequence.

## Year Three

The results from the third year of this study are interesting in light of the previous two years. With many of the students participating in the study for two or three years as either experimental or control, the data are fairly stable for first, second, and third grades. At first grade there is a strong pattern of no significance when the data are viewed for the low group and high groups. Yet the entire control class outperforms the experimental class for total test. This pattern of no significance is also true at second grade for the entire class and the low group, while the medium and high control groups outperformed the experimental medium and high groups. This pattern of no significance is repeated in third grade for the entire class and low groups while the experimental medium and high groups outperformed their control peers. The pattern of no significance is not exhibited by the new kindergarten students. The experimental students in the low, medium, and high groups outperformed their control counterparts on total tests scores and on many of the subtests.

Results from the third year of the study support the data from the previous two years as to no conclusive evidence from the data to suggest a favored instructional sequence for the hypermedia lessons. Total test scores for the entire class of kindergartners indicate that students in the before group outperformed the after group. The is was true for kindergarten student in the high and medium ability groups, but there was no preferred instructional sequence for students in the low group. The total test scores of the entire first grade experimental class indicated no preferred instructional sequence. The is also true for the medium ability group. Low students in the first grade who accessed the software after teacher-directed instruction outperformed students who used the software before teacher-directed instruction, while students in the high group who accessed the software before teacher-directed instruction outperformed students who used the software after teacher-directed instruction. In the experimental second grade the total test scores for the entire class indicated that students in the before instruction group had higher test scores than the after students. Second graders in the low and high ability groups had no preferred instructional sequence, while second graders in the medium group who used the software after teacher directed instruction achieved higher scores than students in the after group.

Total test scores for the entire class of third graders indicate that students in the after group outperformed the before group, while student in the high ability before group had higher scores than students in the high ability after group. The were no significant differences between the before and after groups in the third grade low and medium groups.

## Longitudinal Data

The most interesting findings of the longitudinal data are for students in the K-1-2 and 1-2-3 grade level groups. These are the students who participated in the project for all three years. Thus, there are students in these two groups whose whole experience in learning to read has included a hypermedia component. When viewing this data, we see that the students in these two groups who participated as experimental students for three years significantly outperformed their peers who participated in control classrooms for three years. Also, in the K-1-2 group students in the experimental classroom for two years have higher test scores than three-year control students. Students in the control class for three years and students in the experimental class for three years both outperformed the students who participated in the experimental class for only one year. This may suggest that the continuity of being in an experimental or control class is better than alternating between different instructional programs.

For students in the 2-3-4 group, the significance of being in the experimental classroom declines sharply once the students move into fourth grade. In fact, there is no significant difference between any of the groups except for the experimental/control group over the control for two years group on total test scores once the students are in fourth grade with no hypermedia intervention. This is also seen in the follow-up data of the first-year experimental third graders who in fifth grade are outperformed on every subtest except vocabulary by their control third grade counterparts. This is interesting in light of the fact that the only hypermedia intervention this experimental group received was the vocabulary intervention in the first year of the project.

## References

Chai, D.T. (1967). *Communication of pronominal referents in ambiguous english sentences for children and adults*. Ann Arbor, MI: Center for Human Growth and Development. (ERIC Document Reproduction Service No. ED 012 889).

Lesgold, A. M. (1972). *Effects of pronouns on children's memory for sentences*. Pittsburgh, Pa.: University of Pittsburgh Learning Research and Development Center. (ERIC Document Reproduction Service No. ED 068 974).

Macmillan Achievement Test Series-R (1983). New York, NY: Macmillan Publishing Co., Inc.

Prescott G. A., Balow, I. H., Hogan, T. P., & Farr, R. C. (1984). The Metropolitan Achievement Test. New York: The Psychological Corporation, Harcourt, Brace, Jovanovich.

National Academy of Education (1985). *Becoming a nation of readers*. Washington, D. C.: The National Institute of Education.

Wong, B. Y. L. (1979). Increasing retention of main ideas through questioning strategies. *Learning Disability Quarterly*, 2, 42-47.

Wong, B. Y. L. (1980). Activating the inactive learner: Use of questions/prompts to enhance comprehension and retention of implied information in learning disabled children. *Learning Disability Quarterly*, 3, 29-37.

Figure 1.

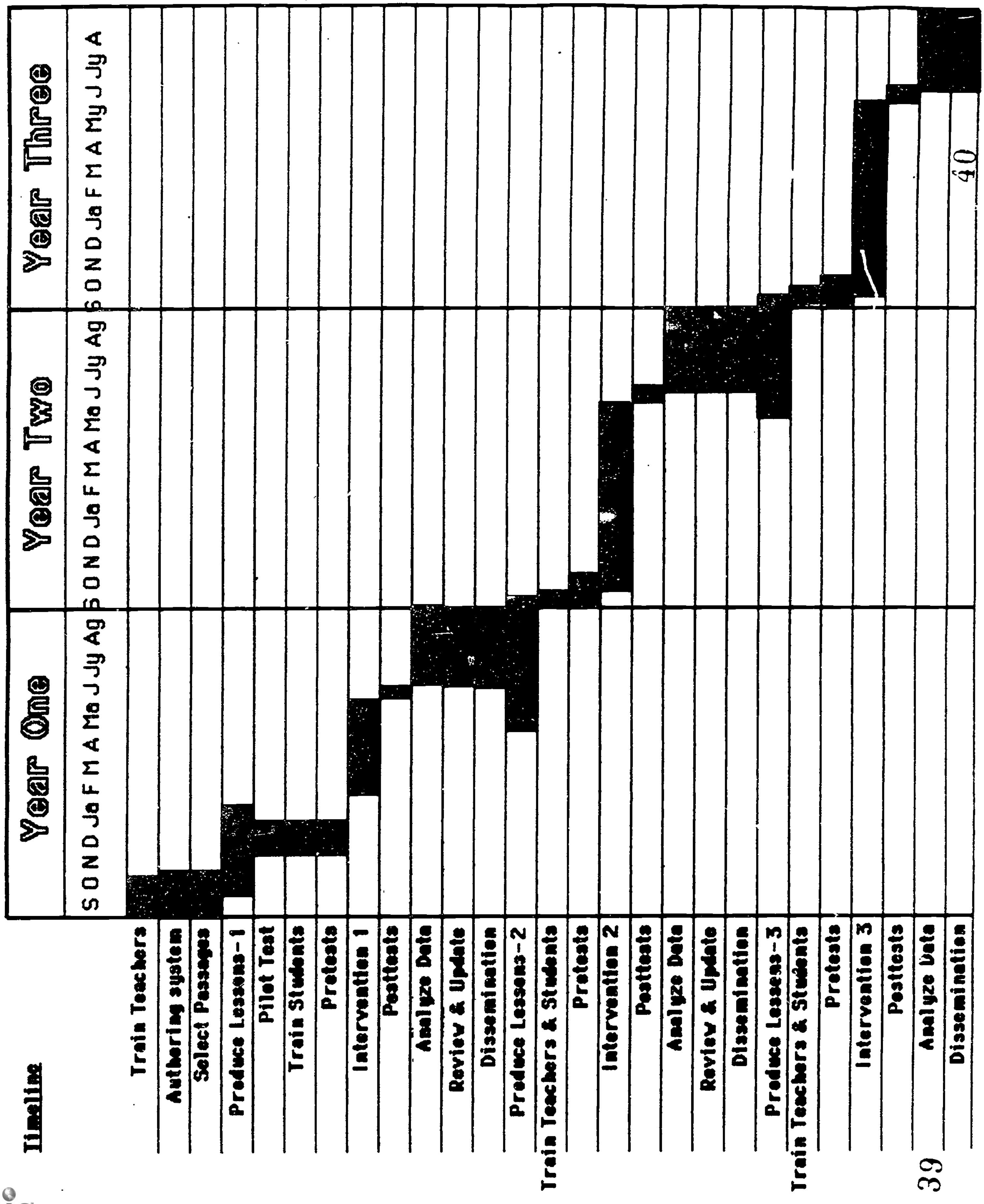
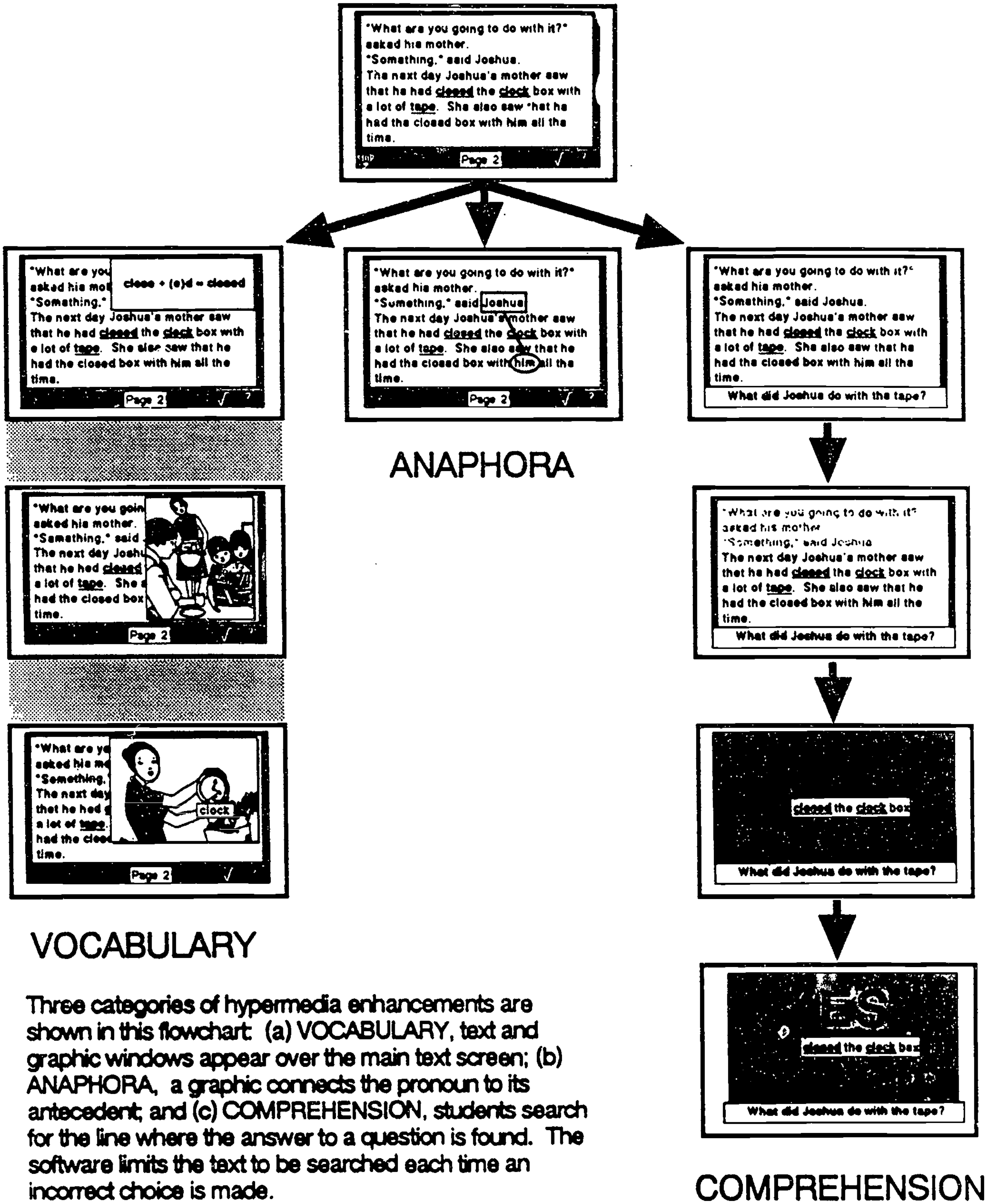
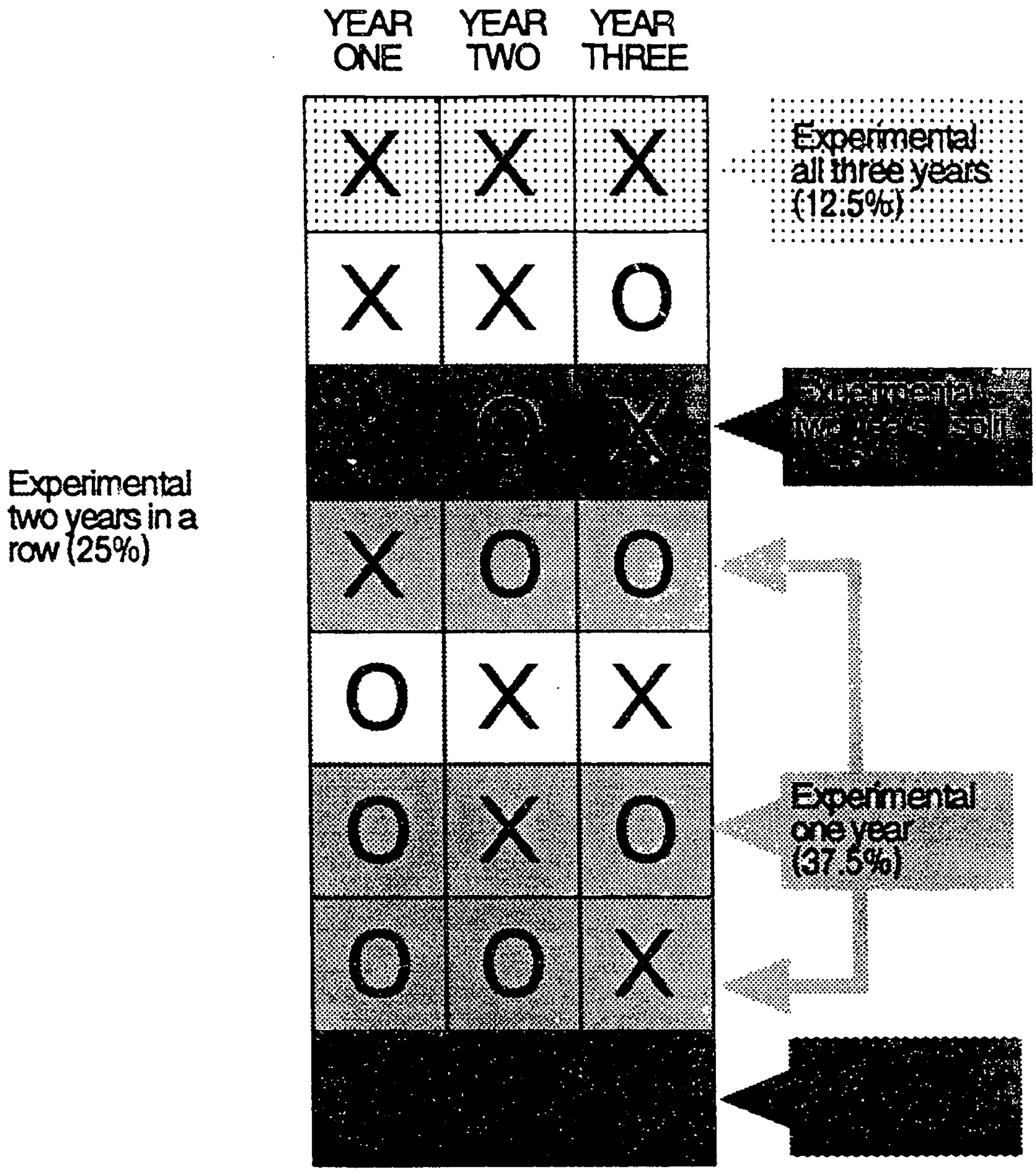

Timeline
Year One
Year Two
Year Three
S O N D Ja F M A Ma J Jy Ag
S O N D Ja F M A Ma J Jy Ag
S O N D Ja F M A My J Jy A
Train Teachers
Authoring system
Select Passages
Produce Lessons-1
Pilot Test
Train Students
Pretests
Intervention 1
Posttests
Analyze Data
Review & Update
Dissemination
Produce Lessons-2
Train Teachers & Students
Pretests
Intervention 2
Posttests
Analyze Data
Review & Update
Dissemination
Produce Lessons-3
Train Teachers & Students
Pretests
Intervention 3
Posttests
Analyze Data
Dissemination
40

Figure 2.




Three categories of hypermedia enhancements are shown in this flowchart: (a) VOCABULARY, text and graphic windows appear over the main text screen; (b) ANAPHORA, a graphic connects the pronoun to its antecedent; and (c) COMPREHENSION, students search for the line where the answer to a question is found. The software limits the text to be searched each time an incorrect choice is made.

Figure 3.




A truth table indicating a single student's chances of being in the experimental classroom each year of the project. X indicates experimental. O indicates control group.

# Grade Level Transition Map of the Experimental Classrooms

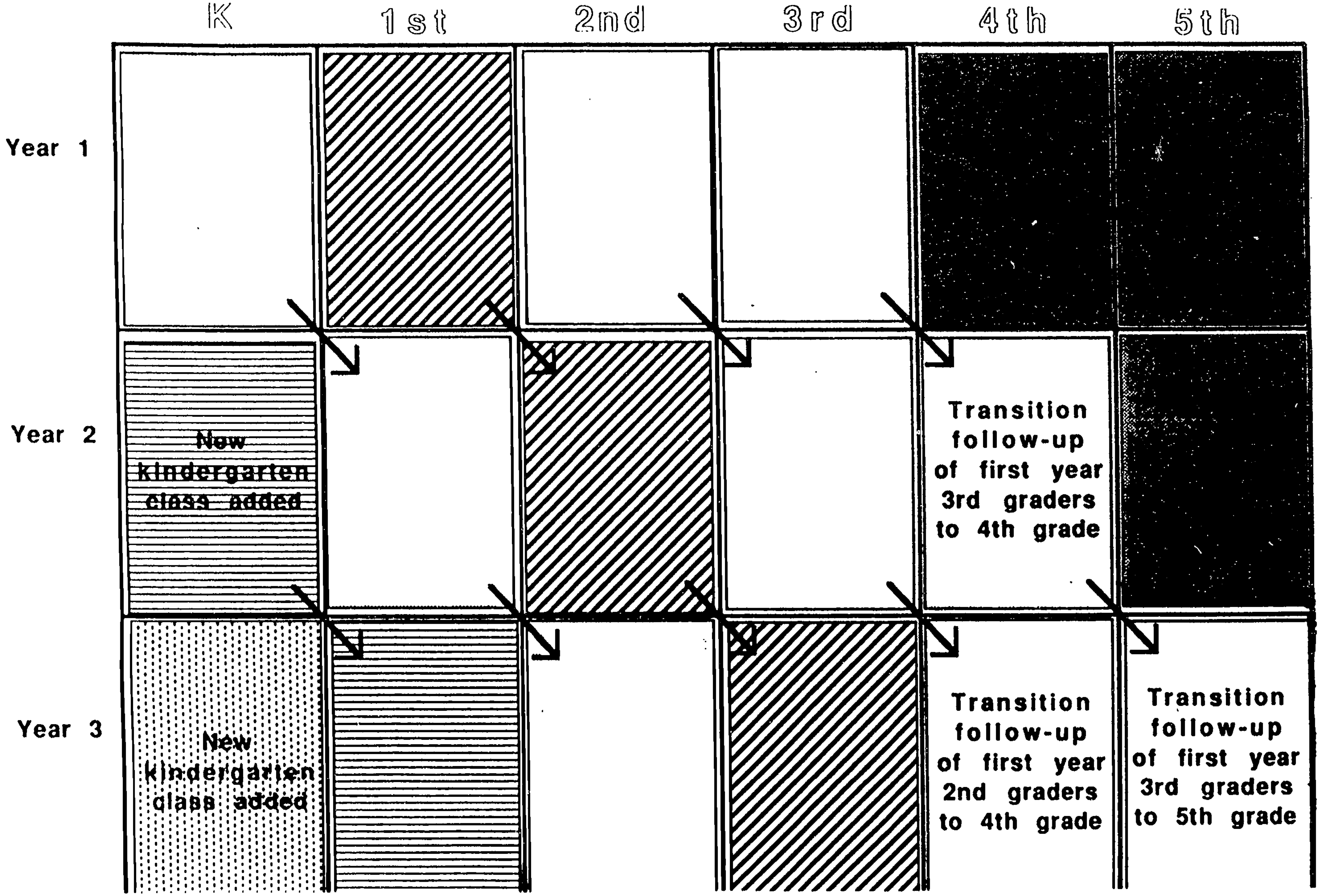



Figure 4.

# Table 1: Description of Subjects by Experimental and Control Classroom–Year One

| | K Experimental | K Control | 1st Experimental | 1st Control | 2nd Experimental | 2nd Control | 3rd Experimental | 3rd Control |
|---|---|---|---|---|---|---|---|---|
| Numbers: | | | | | | | | |
| male | 12 | 16 | 12 | 13 | 9 | 9 | 9 | 9 |
| female | 7 | 8 | 13 | 10 | 12 | 11 | 9 | 10 |
| Sp. Ed. | 0 | 0 | 0 | 1* | 2* | 0 | 0 | 0 |
| total | 19 | 24 | 25 | 24 | 23 | 20 | 18 | 19 |
| Age: | | | | | | | | |
| mean | 6.7 | 6.5 | 7.5 | 7.5 | 8.3 | 8.5 | 9.6 | 9.6 |
| Race: | | | | | | | | |
| Anglo | 16 | 20 | 22 | 20 | 18 | 18 | 18 | 16 |
| Hispanic | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Black | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Asian | 2 | 3 | 3 | 4 | 3 | 2 | 0 | 2 |
| SES: | UN | UN | UN | UN | UN | UN | UN | UN |
| IQ: | UN | UN | UN | UN | UN | UN | UN | UN |
| MAT reading mean: | UN | UN | UN | UN | 71 (8-99) | 78 (28-99) | 72 (34-97) | 74 (13-97) |
| Pre-MacMillan total test score mean: | 83 (51-99) | 82 (62-98) | 49 (0-96) | 48 (24-73) | 78 (23-98) | 76 (44-99) | 85 (71-96) | 83 (35-96) |
| Post-MacMillan total test score mean: | 94 (82-100) | 90 (77-99) | 87 (58-100) | 97 (83-100) | 94 (83-100) | 91 (72-100) | 93 (83-99) | 93 (72-99) |
| Pre-reading rate mean: | | | | | | | | |
| corrects | 21 (12-38) | 20 (6-32) | 94 (24-171) | 60 (12-138) | 104 (50-162) | 108 (49-163) | 119 (80-158) | 128 (66-183) |
| errors | 2 (0-6) | 2 (0-6) | 4 (1-10) | 2 (0-8) | 2 (0-6) | 2 (0-9) | 4 (0-14) | 2 (0-4) |
| Post-reading rate mean: | | | | | | | | |
| corrects | 26 (17-38) | 26 (9-38) | 111 (62-188) | 91 (53-175) | 116 (56-167) | 118 (75-153) | 128 (93-220) | 132 (70-181) |
| errors | 1 (0-5) | 2 (1-7) | 2 (0-4) | 2 (0-5) | 1 (0-4) | 1 (0-3) | 2 (0-6) | 1 (0-3) |

Note. MacMillan and MAT test scores are indicated as percentages.
Reading rate indicates words per minute.
Ranges are indicated in ( ).
*Students with learning disabilities who moved before study was completed.
UN indicates unavailable information.

## Table 2: Summary of ANCOVA Results for Kindergarten Including Posttest Mean Scores and p Values–Year One

### Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Visual Discrimination | Letter ID | Auditory - Initial Sounds | Oral Vocabulary | Auditory - Rhyming Words | Spatial Abilities | Listening Comprehension | Total Test |
|---|---|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | | | |
| EXPERIMENTAL | 96.05 * | 99.47 * | 89.95 | 98.95 * | 86.84 | 98.68 * | 94.84 | 95.05 * |
| CONTROL | 94.43 | 98.91 | 83.04 | 97.61 | 79.13 | 98.52 | 84.39 | 91.00 |
| p VALUE | 0.0000 | 0.0000 | NS | 0.0000 | NS | 0.0000 | NS | 0.0000 |
| **Low Groups** | | | | | | | | |
| EXPERIMENTAL | 94.60 | 98.00 | 75.80 * | 98.60 * | 88.00 * | 95.00 | 92.80 * | 91.80 * |
| CONTROL | 95.75 * | 100.00 * | 75.25 | 97.50 | 76.25 | 97.88 * | 75.25 | 88.38 |
| p VALUE | 0.0000 | 0.0000 | 0.0578 | 0.0028 | 0.0123 | 0.0000 | 0.0359 | 0.0033 |
| **Medium Groups** | | | | | | | | |
| EXPERIMENTAL | 96.14 | 100.00 * | 97.00 * | 98.14 | 77.14 | 100.00 | 96.43 | 95.14 |
| CONTROL | 89.57 | 97.14 | 87.71 | 99.00 | 71.43 | 97.57 | 85.71 | 90.00 |
| p VALUE | NS | 0.0407 | 0.0118 | NS | NS | NS | NS | NS |
| **High Groups** | | | | | | | | |
| EXPERIMENTAL | 97.00 | 100.00 * | 93.00 | 100.00 * | 95.71 | 100.00 | 94.71 | 97.26 * |
| CONTROL | 97.38* | 99.38 | 86.75 | 96.50 | 88.75 | 100.00 * | 92.38 | 94.50 |
| p VALUE | 0.0000 | 0.0000 | NS | 0.0085 | NS | 0.0000 | NS | 0.0355 |
| **BEFORE AFTER** | | | | | | | | |
| **Entire Class** | | | | | | | | |
| BEFORE | 95.56 | 100.00 * | 93.78 | 100.00* | 80.00 | 100.00 * | 95.89 | 95.11 * |
| AFTER | 96.50 * | 99.00 | 86.50 | 98.00 | 93.00 | 97.50 | 93.90 | 95.00 |
| p VALUE | 0.0018 | 0.0000 | NS | 0.0007 | NS | 0.0231 | 0.0678 | 0.0003 |
| **Low Groups** | | | | | | | | |
| BEFORE | 90.00 | 100.00 * | 93.00 | 100.00* | 85.00 | 100.00 | 100.00 | 95.50 * |
| AFTER | 97.67 * | 96.67 | 64.33 | 97.67 | 90.00 | 91.67 | 88.00 | 89.33 |
| p VALUE | 0.0111 | 0.0035 | NS | 0.0308 | NS | NS | NS | 0.0104 |
| **Medium Groups** | | | | | | | | |
| BEFORE | 93.33 | 100.00 | 95.33 | 100.00* | 53.33 | 100.00 | 91.67 | 90.67 |
| AFTER | 98.25 | 95.00 | 98.25* | 96.75 | 95.00 | 95.75 | 96.50 * | 99.00 * |
| p VALUE | 0.0798 | NS | 0.0002 | 0.0461 | NS | NS | 0.0118 | 0.0020 |
| **High Groups** | | | | | | | | |
| BEFORE | 100.00 | 100.00 | 93.00 | 100.00 | 97.50 | 100.00 | 97.00 | 98.25 |
| AFTER | 93.00 | 100.00 | 93.00 | 100.00 | 93.33 | 100.00 | 91.67 | 96.00 |
| p VALUE | NS | NS | NS | NS | 0.0874 | NS | 0.0679 | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 3: Summary of ANCOVA Results for First Grade Including Posttest Mean Scores and p Values--Year One

## Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| EXPERIMENTAL | 91.64 | 79.20 | 81.36 | 83.00 | 86.84 |
| CONTROL | 98.18 * | 97.55 | 96.77 | 98.14 | 98.82 |
| p VALUE | 0.0043 | NS | NS | NS | NS |
| **Low Groups** | | | | | |
| EXPERIMENTAL | 87.63 | 65.88 | 74.88 | 69.75 | 97.63 |
| CONTROL | 97.67 * | 94.50 | 97.67 | 95.83 | 96.67 |
| p VALUE | 0.0006 | NS | NS | NS | NS |
| **Medium Groups** | | | | | |
| EXPERIMENTAL | 89.11 | 73.33 | 79.33 | 82.33 | 84.11 |
| CONTROL | 98.22 * | 98.44 * | 96.00 | 99.11 * | 98.11 * |
| p VALUE | 0.0009 | 0.0412 | 0.0966 | 0.0146 | 0.0010 |
| **High Groups** | | | | | |
| EXPERIMENTAL | 98.50 | 99.13 * | 90.13 | 97.00 | 97.13 |
| CONTROL | 98.57 * | 99.00 | 97.00 | 98.86 * | 98.43 * |
| p VALUE | 0.0000 | 0.0000 | NS | 0.0002 | 0.0072 |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| BEFORE | 90.71 | 81.43 * | 88.71 * | 86.93 * | 88.36 * |
| AFTER | 92.82 * | 76.36 | 72.00 | 78.00 | 84.91 |
| p VALUE | 0.0000 | 0.0258 | 0.0001 | 0.0011 | 0.0001 |
| **Low Groups** | | | | | |
| BEFORE | 89.60 * | 69.40 | 82.80 * | 81.60 * | 84.00 * |
| AFTER | 84.33 | 60.00 | 61.67 | 50.00 | 72.33 |
| p VALUE | 0.0012 | NS | 0.0042 | 0.0036 | 0.0042 |
| **Medium Groups** | | | | | |
| BEFORE | 88.00 | 82.17 * | 92.83 * | 88.83 * | 88.00 * |
| AFTER | 91.33 * | 55.67 | 52.33 | 69.33 | 76.33 |
| p VALUE | 0.0002 | 0.0052 | 0.0000 | 0.0003 | 0.0013 |
| **High Groups** | | | | | |
| BEFORE | 98.00 | 100.00 * | 90.33 * | 92.00 | 96.33 |
| AFTER | 98.80 * | 98.60 | 90.00 | 100.00 | 97.60 * |
| p VALUE | 0.0000 | 0.0000 | 0.0255 | NS | 0.0000 |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 4: Summary of ANCOVA Results for Second Grade Including Posttest Mean Scores and p Values—Year One

## Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 93.83 * | 93.30 | 93.48 * | 98.70 * | 93.48 | 93.91 * |
| CONTROL | 90.55 | 93.60 * | 89.25 | 96.50 | 96.00 * | 92.20 |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0000 |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 92.63 * | 89.25 * | 94.00 * | 97.50 * | 92.50 | 92.75 * |
| CONTROL | 80.83 | 87.83 | 79.33 | 93.33 | 96.67 * | 84.67 |
| p VALUE | 0.0000 | 0.0002 | 0.0004 | 0.0052 | 0.0006 | 0.0000 |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 91.63 | 93.25 | 88.00 | 100.00 | 90.00 | 91.25 |
| CONTROL | 93.00 * | 94.33 * | 92.00 * | 100.00 * | 90.00 * | 93.67 * |
| p VALUE | 0.0067 | 0.0128 | 0.0537 | 0.0000 | 0.0134 | 0.0080 |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 97.71 | 98.00 * | 99.14 * | 98.57 | 98.57 | 98.29 * |
| CONTROL | 96.00 | 97.38 | 94.63 | 96.25 | 100.00 * | 96.75 |
| p VALUE | NS | 0.0002 | 0.0386 | NS | 0.0000 | 0.0428 |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| BEFORE | 94.09 * | 93.91 * | 95.36 | 99.09 * | 95.45 | 94.73 * |
| AFTER | 93.58 | 92.75 | 91.75 | 98.33 | 91.67 | 93.17 |
| p VALUE | 0.0080 | 0.0390 | NS | 0.0000 | NS | 0.0034 |
| **Low Groups** | | | | | | |
| BEFORE | 96.67 * | 93.33 * | 100.00 * | 100.00 * | 93.33 | 96.67 * |
| AFTER | 90.20 | 86.80 | 90.40 | 96.00 | 92.00 | 90.40 |
| p VALUE | 0.0021 | 0.0000 | 0.0000 | 0.0001 | NS | 0.0000 |
| **Medium Groups** | | | | | | |
| BEFORE | 90.25 | 90.00 | 88.75 | 100.00 | 95.00 * | 90.75 |
| AFTER | 93.00 | 96.50 | 87.25 | 100.00 | 85.00 | 91.75 |
| p VALUE | NS | NS | NS | NS | 0.0536 | NS |
| **High Groups** | | | | | | |
| BEFORE | 96.00 | 98.25 | 98.50 | 97.50 | 97.50 | 97.25 |
| AFTER | 100.00 | 97.67 | 100.00 * | 100.00 * | 100.00 | 99.67 |
| p VALUE | NS | NS | 0.0199 | 0.0003 | 0.0810 | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

## Table 5: Summary of ANCOVA Results for Third Grade Including Posttest Mean Scores and p Values–Year One

### Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 92.28 | 92.94 | 93.28 | 95.89 | 95.94 | 93.39 * |
| CONTROL | 90.63 | 94.21 * | 94.26 | 93.84 | 96.95 * | 93.11 |
| p VALUE | NS | 0.0081 | NS | 0.0726 | 0.0030 | 0.0419 |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 89.00 | 88.33 | 87.83 | 91.67 | 96.00 * | 89.50 * |
| CONTROL | 84.29 | 91.43 * | 86.71 | 86.71 | 91.71 | 87.14 |
| p VALUE | NS | 0.0016 | NS | 0.0719 | 0.0376 | 0.0156 |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 90.67 | 95.00 * | 94.67 | 97.33 * | 98.67 | 94.00 |
| CONTROL | 92.71 | 94.29 | 98.14 * | 96.57 | 100.00 * | 95.57 |
| p VALUE | NS | 0.0215 | 0.0007 | 0.0004 | 0.0000 | NS |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 97.17 | 95.50 | 97.33 | 98.67 | 93.17 | 96.67 |
| CONTROL | 96.60 | 98.00 * | 99.40 * | 100.00 * | 100.00 * | 98.00 |
| p VALUE | NS | 0.0030 | 0.0000 | 0.0004 | 0.0106 | 0.0909 |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| BEFORE | 93.00 * | 93.80 * | 95.80 * | 97.60 * | 95.10 | 94.40 * |
| AFTER | 91.38 | 91.88 | 90.13 | 93.75 | 97.00 * | 92.13 |
| p VALUE | 0.0049 | 0.0005 | 0.0001 | 0.0036 | 0.0000 | 0.0001 |
| **Low Groups** | | | | | | |
| BEFORE | 92.33 | 88.33 | 93.33 | 97.33 | 97.33 | 92.67 * |
| AFTER | 85.67 | 88.33 | 82.33 | 86.00 | 94.67 | 86.33 |
| p VALUE | NS | NS | NS | NS | NS | 0.0283 |
| **Medium Groups** | | | | | | |
| BEFORE | 86.33 | 96.67 | 97.00 | 94.67 | 97.33 | 92.67 |
| AFTER | 95.00 | 93.33 | 92.33 | 100.00 | 100.00 | 95.33 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **High Groups** | | | | | | |
| BEFORE | 98.50 * | 95.75 | 96.75 | 100.00 * | 91.75 | 97.00 |
| AFTER | 94.50 | 95.00 | 98.50 * | 96.00 | 96.00 * | 96.00 |
| p VALUE | 0.0290 | NS | 0.0161 | 0.0086 | 0.0253 | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

## Table 6: Description of Subjects by Experimental and Control Classroom—Year Two

| | K Experimental | K Control | 1st Experimental | 1st Control | 2nd Experimental | 2nd Control | 3rd Experimental | 3rd Control |
|---|---|---|---|---|---|---|---|---|
| **Numbers:** | | | | | | | | |
| male | 8 | 28 | 14 | 13 | 10 | 19 | 9 | 12 |
| female | 7 | 13 | 11 | 9 | 10 | 17 | 13 | 14 |
| Sp. Ed. | 2* | 0 | 0 | 0 | 0 | 2* | 2* | 0 |
| total | 17 | 41 | 25 | 22 | 20 | 38 | 24 | 26 |
| **Age:** | | | | | | | | |
| mean | 5.5 | 5.7 | 7.6 | 7.5 | 8.6 | 8.1 | 9.6 | 9.6 |
| **Race:** | | | | | | | | |
| Anglo | 15 | 33 | 22 | 17 | 19 | 32 | 20 | 21 |
| Hispanic | 0 | 2 | 3 | 1 | 0 | 0 | 3 | 1 |
| Black | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| Asian | 1 | 3 | 0 | 4 | 1 | 5 | 1 | 4 |
| **SES:** | UN | UN | UN | UN | UN | UN | UN | UN |
| **IQ:** | UN | UN | UN | UN | UN | UN | UN | UN |
| **MAT reading mean:** | UN | UN | UN | UN | 65 (15-96) | 64 (11-99) | 62 (10-99) | 70 (31-97) |
| **Pre-MacMillan total test score mean:** | 88 (71-100) | 89 (60-100) | 51 (12-91) | 49 (13-93) | 69 (29-93) | 70 (28-98) | 73 (34-99) | 84 (60-98) |
| **Post-MacMillan total test score mean:** | 95 (85-100) | 96 (91-100) | 97 (88-100) | 88 (62-99) | 92 (86-99) | 92 (58-98) | 84 (59-100) | 94 (84-98) |
| **Pre-reading rate mean:** | | | | | | | | |
| corrects | 15 (0-30) | 17 (0-41) | 56 (24-120) | 58 (22-120) | 67 (46-103) | 90 (36-150) | 110 (65-200) | 102 (49-132) |
| errors | 11 (0-27) | 7 (0-21) | 1 (0-4) | 2 (0-6) | 3 (1-8) | 2 (0-6) | 2 (0-5) | 2 (0-5) |
| **Post-reading rate mean:** | | | | | | | | |
| corrects | 35 (20-50) | 33 (16-48) | 80 (32-155) | 94 (35-121) | 124 (86-204) | 123 (68-199) | 128 (87-227) | 129 (80-178) |
| errors | 2 (0-8) | 2 (0-8) | 1 (0-4) | 1 (0-3) | 1 (0-2) | 1 (0-5) | 2 (0-5) | 2 (0-6) |

Note. MacMillan and MAT test scores are indicated as percentages.
Reading rate indicates words per minute.
Ranges are indicated in ( ).
*Students with learning disabilities and students at risk for referral to Special Education .
UN indicates unavailable information.

## Table 7: Description of Fourth Grade Follow-up Subjects by Original Experimental and Control Classroom--Year Two

| | 4th Experimental | 4th Control |
|---|---|---|
| Numbers: | | |
| male | 5 | 5 |
| female | 7 | 6 |
| Sp. Ed. | 0 | 0 |
| total | 12 | 11 |
| Age: | | |
| mean | 10.6 | 10.6 |
| Race: | | |
| Anglo | 12 | 11 |
| Hispanic | 0 | 0 |
| Black | 0 | 0 |
| Asian | 0 | 1 |
| SES: | UN | UN |
| IQ: | UN | UN |
| MAT reading mean: | 74 (54-94) | 67 (3-91) |
| Pre-MacMillan total test score mean: | 80 (66-89) | 76 (52-92) |
| Post-MacMillan total test score mean: | 88 (83-98) | 86 (52-96) |

Note. MacMillan and MAT test scores are indicated as percentages.
Ranges are indicated in ( ).
UN indicates unavailable information.

# Table 8: Summary of ANCOVA Results for Kindergarten Including Posttest Mean Scores and p Values--Year Two

## Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Visual Discrimination | Letter ID | Spatial Abilities |
|---|---|---|---|
| **Entire Class** | | | |
| EXPERIMENTAL | 90.53 | 97.65 | 98.00 * |
| CONTROL | 93.59 * | 97.93 * | 96.41 |
| p VALUE | 0.0000 | 0.0000 | 0.0001 |
| **Low Groups** | | | |
| EXPERIMENTAL | 85.00 | 92.50 | 100.00 * |
| CONTROL | 91.36 * | 95.45 * | 89.73 |
| p VALUE | 0.0041 | 0.0000 | NS |
| **Medium Groups** | | | |
| EXPERIMENTAL | 90.43 | 99.29 * | 97.57 |
| CONTROL | 93.86 * | 98.21 | 98.89 * |
| p VALUE | 0.0000 | 0.0000 | 0.0000 |
| **High Groups** | | | |
| EXPERIMENTAL | 94.33 | 99.17 | 97.17 |
| CONTROL | 94.86 * | 99.38 * | 98.94 * |
| p VALUE | 0.0000 | 0.0000 | 0.0000 |

| BEFORE AFTER | | | |
|---|---|---|---|
| **Entire Class** | | | |
| BEFORE | 94.11 * | 96.11 | 100.00 * |
| AFTER | 86.50 | 99.38 | 95.75 |
| p VALUE | 0.0010 | 0.0987 | 0.0001 |
| **Low Groups** | | | |
| BEFORE | 87.00 | 87.50 | 100.00 |
| AFTER | 83.00 | 97.50 | 100.00 |
| p VALUE | NS | NS | NS |
| **Medium Groups** | | | |
| BEFORE | 95.00 | 98.75 | 100.00 |
| AFTER | 84.33 * | 100.00 * | 94.33 |
| p VALUE | 0.0067 | 0.0019 | 0.0099 |
| **High Groups** | | | |
| BEFORE | 97.67 | 98.33 | 100.00 |
| AFTER | 91.00 | 100.00 | 94.33 |
| p VALUE | 0.0639 | NS | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 9: Summary of ANCOVA Results for First Grade Including Posttest Mean Scores and p Values–Year Two

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| EXPERIMENTAL | 97.62 * | 93.90 | 96.95 | 96.05 | 96.81 |
| CONTROL | 89.64 | 86.91 | 88.32 | 80.68 | 87.77 |
| p VALUE | 0.0250 | NS | NS | 0.0719 | 0.0754 |
| **Low Groups** | | | | | |
| EXPERIMENTAL | 98.00 * | 84.57 * | 92.86 * | 92.86 * | 94.43 * |
| CONTROL | 87.00 | 82.29 | 83.14 | 72.00 | 83.57 |
| p VALUE | 0.0000 | 0.0002 | 0.0000 | 0.0046 | 0.0000 |
| **Medium Groups** | | | | | |
| EXPERIMENTAL | 97.23 * | 98.46 * | 99.46 * | 97.46 * | 97.92 * |
| CONTROL | 91.33 | 86.67 | 97.67 | 94.33 | 91.67 |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **High Groups** | | | | | |
| EXPERIMENTAL | 100.00 * | 100.00 | 93.00 | 100.00 * | 99.00 * |
| CONTROL | 96.00 | 100.00 | 97.20 * | 96.80 | 97.20 |
| p VALUE | 0.0122 | NS | 0.0002 | 0.0207 | 0.0010 |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| BEFORE | 97.33 | 93.83 | 95.83 | 95.83 | 96.42 |
| AFTER | 98.00 * | 94.00 * | 98.44 * | 96.33 * | 97.33 * |
| p VALUE | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| **Low Groups** | | | | | |
| BEFORE | 97.33 | 82.00 | 88.00 | 94.33 * | 93.00 |
| AFTER | 98.50 * | 86.50 | 96.50 | 91.75 | 95.50 * |
| p VALUE | 0.0000 | NS | 0.0981 | 0.0426 | 0.0054 |
| **Medium Groups** | | | | | |
| BEFORE | 97.00 | 97.50 | 99.13 | 95.88 | 97.38 |
| AFTER | 97.60 * | 100.00 * | 100.00 * | 100.00 * | 98.00 * |
| p VALUE | 0.0002 | 0.0000 | 0.0000 | 0.0003 | 0.0000 |
| **High Groups** | | | | | |
| BEFORE | Due to student attrition there were no students in the experimental class "before" group by the end of the year. | | | | |
| AFTER | | | | | |
| p VALUE | | | | | |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

## Table 10: Summary of ANCOVA Results for Second Grade Including Posttest Mean Scores and p Values–Year Two

### Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 89.11 | 95.68 * | 92.53 * | 95.79 * | 97.37 * | 92.21 |
| CONTROL | 91.76 * | 91.91 | 90.70 | 95.15 | 94.85 | 92.39 * |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 78.40 | 89.20 * | 91.20 * | 94.00 * | 98.00 * | 86.60 * |
| CONTROL | 84.17 * | 83.33 | 85.08 | 91.67 | 93.33 | 86.17 |
| p VALUE | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0000 | 0.0012 |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 88.71 | 97.00 * | 91.29 | 95.71 | 98.57 | 92.43 |
| CONTROL | 94.25 * | 93.38 | 97.75 * | 97.50 * | 91.25 | 94.63 * |
| p VALUE | 0.0038 | 0.0160 | 0.0000 | 0.0057 | NS | 0.0001 |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 97.14 | 99.00 * | 94.71 | 97.14 * | 95.71 | 96.00 |
| CONTROL | 97.23 | 98.92 | 91.54 | 96.92 | 98.46 * | 96.77 * |
| p VALUE | 0.0000 | 0.0000 | 0.0899 | 0.0000 | 0.0000 | 0.0000 |
| **BEFORE AFTER** | | | | | | |
| **Entire Class** | | | | | | |
| BEFORE | 88.67 | 95.50 | 93.25 * | 98.33 * | 97.50 * | 92.83 * |
| AFTER | 89.86 * | 96.00 * | 91.29 | 91.43 | 97.14 | 91.14 |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Low Groups** | | | | | | |
| BEFORE | 78.67 * | 86.67 | 93.67 * | 100.00 * | 100.00 * | 87.67 * |
| AFTER | 78.00 | 93.00 * | 87.50 | 85.00 | 95.00 | 85.00 |
| p VALUE | 0.0051 | 0.0199 | 0.0186 | 0.0106 | 0.0080 | 0.0002 |
| **Medium Groups** | | | | | | |
| BEFORE | 88.40 | 97.20 * | 91.40 * | 98.00 * | 100.00 * | 92.80 * |
| AFTER | 89.50 | 96.50 | 91.00 | 90.00 | 95.00 | 91.50 |
| p VALUE | NS | 0.0001 | 0.0006 | 0.0055 | 0.0001 | 0.0119 |
| **High Groups** | | | | | | |
| BEFORE | 96.50 | 100.00 * | 95.25 | 97.50 | 92.50 | 96.75 |
| AFTER | 98.00 | 97.67 | 94.00 | 96.67 * | 100.00 * | 95.00 |
| p VALUE | 0.0001 | 0.0002 | NS | 0.0265 | 0.0136 | 0.0113 |

_Note._ Scores are indicated as percentages.
NS indicates no significance.
*_p_ < .05

# Table 11: Summary of ANCOVA Results for Third Grade Including Posttest Mean Scores and p Values--Year Two

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 84.50 | 89.17 | 82.88 | 75.33 | 82.71 | 83.71 |
| CONTROL | 91.74 * | 94.35 | 94.39 | 92.48* | 97.13 | 93.52 |
| p VALUE | NS | NS | NS | 0.0355 | NS | NS |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 78.10 | 89.50 | 74.60 | 68.20 | 76.70 | 77.90 |
| CONTROL | 80.50* | 91.25 * | 90.75 * | 81.25 | 98.00 * | 86.75 * |
| p VALUE | 0.0003 | 0.0000 | 0.0001 | 0.0002 | 0.0496 | 0.0007 |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 87.11 | 86.67 | 84.44 | 73.22 | 81.56 | 84.33 |
| CONTROL | 92.00 * | 93.57 | 93.29 | 95.43 | 96.43 | 93.43 |
| p VALUE | 0.0007 | 0.0663 | 0.0625 | NS | NS | NS |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 92.60 | 93.00 | 96.60 * | 93.40 | 96.80 | 94.20 |
| CONTROL | 95.33 * | 95.83 * | 96.25 | 94.50* | 97.25 * | 95.83 * |
| p VALUE | 0.0000 | 0.0019 | 0.0371 | 0.0068 | 0.0039 | 0.0011 |
| **BEFORE AFTER** | | | | | | |
| **Entire Class** | | | | | | |
| BEFORE | 84.31 | 89.23 * | 87.38 * | 76.23 | 86.62 | 85.15 * |
| AFTER | 84.73 * | 89.09 | 77.55 | 74.27 | 78.09 | 82.00 |
| p VALUE | 0.0295 | 0.0020 | 0.0005 | 0.0822 | 0.0842 | 0.0029 |
| **Low Groups** | | | | | | |
| BEFORE | 84.17 * | 92.50 * | 81.50 * | 69.33* | 84.83 | 83.33 * |
| AFTER | 69.00 | 85.00 | 64.25 | 66.50 | 64.50 | 69.75 |
| p VALUE | 0.0028 | 0.0004 | 0.0002 | 0.0182 | 0.0679 | 0.0007 |
| **Medium Groups** | | | | | | |
| BEFORE | 83.40 | 85.00 | 89.40 * | 80.00 | 85.00 | 84.80 |
| AFTER | 91.75 * | 88.75 | 78.25 | 64.75 | 77.25 | 83.75 |
| p VALUE | 0.0255 | NS | 0.0241 | NS | NS | NS |
| **High Groups** | | | | | | |
| BEFORE | 87.00 | 90.00 | 100.00 | 87.50 | 96.00 | 91.50 |
| AFTER | 96.33 | 95.00 | 94.33 | 97.33 | 97.33 * | 96.00 |
| p VALUE | 0.0609 | NS | NS | NS | 0.0503 | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 12: Summary of ANCOVA Results for Fourth Grade Follow-Up Including Posttest Mean Scores and p Values–Year Two

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 84.67 | 84.58 | 90.92 | 84.50 | 91.75 | 87.92 |
| CONTROL | 83.09 | 86.36 | 87.45 | 83.82 | 88.91 | 86.18 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 79.00 | 80.00 | 87.50 | 81.50 | 89.25 | 83.50 |
| CONTROL | 75.25 | 78.75 | 78.00 | 76.75 | 82.00 | 77.75 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 87.33 | 81.67 | 95.67 | 77.00 | 93.00 * | 89.00 |
| CONTROL | 87.50 | 87.50 * | 91.25 | 86.25 | 91.00 | 89.25 * |
| p VALUE | NS | 0.0165 | NS | NS | 0.0497 | 0.0540 |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 87.60 | 90.00 | 90.80 | 91.40 * | 93.00 | 90.80 |
| CONTROL | 87.67 | 95.00 | 95.00 | 90.00 | 95.00 * | 93.33 |
| p VALUE | NS | NS | NS | 0.0042 | 0.0214 | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

## Table 13: Description of Subjects by Experimental and Control Classroom—Year Three

| | K Experimental | K Control | 1st Experimental | 1st Control | 2nd Experimental | 2nd Control | 3rd Experimental | 3rd Control |
|---|---|---|---|---|---|---|---|---|
| Numbers: | | | | | | | | |
| male | 14 | 13 | 15 | 14 | 13 | 15 | 10 | 12 |
| female | 9 | 11 | 8 | 6 | 12 | 10 | 13 | 11 |
| Sp. Ed. | 5* | 2* | 0 | 1* | 1* | 3* | 4* | 4* |
| total | 23 | 24 | 23 | 20 | 25 | 25 | 23 | 23 |
| Age: | | | | | | | | |
| mean | 6.4 | 6.5 | 7.5 | 7.5 | 8.6 | 8.5 | 9.6 | 9.1 |
| Race: | | | | | | | | |
| Anglo | 20 | 24 | 20 | 19 | 24 | 19 | 19 | 19 |
| Hispanic | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Black | 1 | 0 | 1 | 0 | 0 | 2 | 1 | 0 |
| Asian | 2 | 0 | 2 | 1 | 1 | 2 | 4 | 4 |
| SES: | UN | UN | UN | UN | UN | UN | UN | UN |
| IQ: | UN | UN | UN | UN | UN | UN | UN | UN |
| MAT reading mean: | UN | UN | UN | UN | UN | UN | UN | UN |
| Pre-MacMillan total test score mean: | 83 (20-100) | 81 (18-98) | 32 (1-53) | 29 (0-88) | 76 (48-94) | 63 (23-93) | 79 (37-98) | 80 (37-98) |
| Post-MacMillan total test score mean: | 96 (69-100) | 93 (33-100) | 83 (57-100) | 88 (57-100) | 90 (53-100) | 92 (73-99) | 92 (52-98) | 90 (62-100) |

Note. MacMillan and MAT test scores are indicated as percentages.
Ranges are indicated in ( ).
*Students with learning disabilities, health impairments, physical impairments, and students at risk for referral to Special Education.
UN indicates unavailable information.

## Table 14: Description of Fourth Grade Follow-up Subjects by Original Experimental and Control Classroom–Year Three

| | 4th Experimental | 4th Control |
|---|---|---|
| Numbers: | | |
| male | 4 | 11 |
| female | 11 | 8 |
| Sp. Ed. | 0 | 0 |
| total | 15 | 19 |
| Age: | | |
| mean | 10.6 | 10.6 |
| Race: | | |
| Anglo | 14 | 15 |
| Hispanic | 0 | 1 |
| Black | 0 | 0 |
| Asian | 1 | 3 |
| SES: | UN | UN |
| IQ: | UN | UN |
| MAT reading mean: | 63 (14-99) | 73 (31-97) |
| Pre-MacMillan total test score mean: | 71 (57-97) | 80 (60-98) |
| Post-MacMillan total test score mean: | 85 (70-100) | 88 (72-98) |

Note. MacMillan and MAT test scores are indicated as percentages.
Ranges are indicated in ( ).
UN indicates unavailable information.

## Table 15: Description of Fifth Grade Follow-up Subjects by Original Experimental and Control Classroom–Year Three

| | 5th Experimental | 5th Control |
|---|---|---|
| Numbers: | | |
| male | 8 | 7 |
| female | 7 | 6 |
| Sp. Ed. | 0 | 0 |
| total | 15 | 13 |
| Age: | | |
| mean | 11.6 | 11.7 |
| Race: | | |
| Anglo | 15 | 12 |
| Hispanic | 0 | 0 |
| Black | 0 | 0 |
| Asian | 0 | 1 |
| SES: | UN | UN |
| IQ: | UN | UN |
| MAT reading mean: | UN | UN |
| Pre-MacMillan total test score mean: | 79 (40-92) | 76 (24-94) |
| Post-MacMillan total test score mean: | 8 (72-96) | 91 (77-98) |

Note. MacMillan and MAT test scores are indicated as percentages.
Ranges are indicated in ( ).
UN indicates unavailable information.

## Table 16: Summary of ANCOVA Results for Kindergarten Including Posttest Mean Scores and p Values--Year Three

### Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Visual Discrimination | Letter ID | Spatial Abilities | Total Test |
|---|---|---|---|---|
| **Entire Class** | | | | |
| EXPERIMENTAL | 92.90 | 98.57 | 97.57 | 96.33 |
| CONTROL | 89.50 | 93.18 | 97.68 * | 93.36 |
| p VALUE | NS | NS | 0.0210 | NS |
| **Low Groups** | | | | |
| EXPERIMENTAL | 87.43 * | 97.14 | 95.14 | 93.29 * |
| CONTROL | 72.00 | 76.00 | 100.00 * | 82.40 |
| p VALUE | 0.0488 | 0.0899 | 0.0001 | 0.0224 |
| **Medium Groups** | | | | |
| EXPERIMENTAL | 94.60 * | 98.00 * | 96.60 * | 96.20 * |
| CONTROL | 91.50 | 98.00 | 96.60 | 95.30 |
| p VALUE | 0.0047 | 0.0000 | 0.0017 | 0.0009 |
| **High Groups** | | | | |
| EXPERIMENTAL | 96.22 | 100.00 * | 100.00 | 98.78 * |
| CONTROL | 99.14 * | 98.57 | 97.57 | 98.43 |
| p VALUE | 0.0013 | 0.0000 | NS | 0.0271 |

| BEFORE AFTER | Visual Discrimination | Letter ID | Spatial Abilities | Total Test |
|---|---|---|---|---|
| **Entire Class** | | | | |
| BEFORE | 96.50 * | 98.75 * | 97.17 | 97.50 * |
| AFTER | 88.11 | 98.33 | 98.11 * | 94.78 |
| p VALUE | 0.0008 | 0.0000 | 0.0000 | 0.0000 |
| **Low Groups** | | | | |
| BEFORE | 93.00 | 98.33 * | 94.33 | 95.33 |
| AFTER | 83.25 | 96.25 | 95.75 * | 91.75 |
| p VALUE | NS | 0.0152 | 0.0172 | NS |
| **Medium Groups** | | | | |
| BEFORE | 98.25 * | 97.50 | 95.75 | 97.00 * |
| AFTER | 80.00 | 100.00 | 100.00 | 93.00 |
| p VALUE | 0.0140 | NS | NS | 0.0517 |
| **High Groups** | | | | |
| BEFORE | 97.20 * | 100.00 | 100.00 | 99.20 * |
| AFTER | 95.00 | 100.00 | 100.00 | 98.25 |
| p VALUE | 0.0362 | NS | NS | 0.0180 |

*Note.* Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 17: Summary of ANCOVA Results for First Grade Including Posttest Mean Scores and p Values—Year Three

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| EXPERIMENTAL | 87.32 | 75.95 | 73.68 | 82.18 | 82.68 |
| CONTROL | 89.12 * | 93.41 | 83.24 | 85.29 * | 88.29 * |
| p VALUE | 0.0002 | NS | NS | 0.0040 | 0.0032 |
| **Low Groups** | | | | | |
| EXPERIMENTAL | 80.86 * | 57.00 | 58.00 | 69.14 | 71.86 |
| CONTROL | 76.20 | 92.00 | 85.80 | 89.80 | 82.20 |
| p VALUE | 0.0244 | NS | NS | NS | NS |
| **Medium Groups** | | | | | |
| EXPERIMENTAL | 86.10 | 79.90 | 78.60 * | 84.90 * | 83.80 |
| CONTROL | 90.86 | 91.57 * | 77.43 | 73.86 | 86.29 * |
| p VALUE | 0.0001 | 0.0313 | 0.0042 | 0.0021 | 0.0006 |
| **High Groups** | | | | | |
| EXPERIMENTAL | 98.80 | 94.60 | 85.80 | 95.00 | 95.60 |
| CONTROL | 99.60 | 97.40 | 88.80 | 96.80 | 97.20 |
| p VALUE | NS | NS | NS | NS | NS |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Study Skills | Total Test |
|---|---|---|---|---|---|
| **Entire Class** | | | | | |
| BEFORE | 86.91 | 70.82 | 72.64 | 80.27 | 81.27 |
| AFTER | 87.73 | 81.09 | 74.73 | 84.09 | 84.09 |
| p VALUE | NS | NS | NS | NS | NS |
| **Low Groups** | | | | | |
| BEFORE | 81.00 * | 37.67 | 57.00 | 64.00 | 68.00 |
| AFTER | 80.75 | 71.50 * | 58.75 | 73.00 * | 74.75 * |
| p VALUE | 0.0328 | 0.0185 | 0.0937 | 0.0339 | 0.0515 |
| **Medium Groups** | | | | | |
| BEFORE | 83.00 | 75.80 | 67.00 | 78.20 | 78.80 |
| AFTER | 89.20 | 84.00 | 90.20 | 91.60 | 88.80 |
| p VALUE | NS | NS | 0.0766 | NS | NS |
| **High Groups** | | | | | |
| BEFORE | 99.33 | 95.67 * | 97.67 | 100.00 * | 98.67 * |
| AFTER | 98.00 * | 93.00 | 68.00 | 87.50 | 91.00 |
| p VALUE | 0.0002 | 0.0128 | NS | 0.0244 | 0.0049 |

Note. Scores are indicated as percentages.
NS indicates no significance.
*p <.05

## Table 18: Summary of ANCOVA Results for Second Grade Including Posttest Mean Scores and p Values—Year Three

### Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 89.00 | 90.50 | 89.75 | 91.25 | 95.00 | 90.29 |
| CONTROL | 89.67 * | 95.19 | 89.76 * | 95.24 * | 95.71 * | 91.90 |
| p VALUE | 0.0310 | NS | 0.0460 | 0.0016 | 0.0010 | NS |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 73.00 | 50.00 | 53.50 | 80.00 | 90.00 | 68.00 |
| CONTROL | 68.00 | 83.50 | 62.50 | 85.00 | 75.00 | 73.00 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 86.88 | 92.50 | 92.38 * | 91.25 | 96.25 | 90.25 |
| CONTROL | 89.58 * | 94.33 * | 89.83 | 95.00 * | 96.67 * | 91.75 * |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 92.50 | 95.14 | 93.43 | 92.86 | 95.00 | 93.50 |
| CONTROL | 96.00 * | 100.00 * | 97.43 * | 98.57 * | 97.14 * | 97.57 * |
| p VALUE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **BEFORE AFTER** | | | | | | |
| **Entire Class** | | | | | | |
| BEFORE | 88.69 * | 91.23 * | 91.08 * | 90.00 | 94.62 | 90.31 * |
| AFTER | 89.36 | 89.64 | 88.18 | 92.73 * | 95.45 * | 90.27 |
| p VALUE | 0.0033 | 0.0105 | 0.0086 | 0.0063 | 0.0019 | 0.0092 |
| **Low Groups** | | | | | | |
| BEFORE | 87.00 | 73.00 | 69.00 | 100.00 | 90.00 | 83.00 |
| AFTER | 59.00 | 27.00 | 38.00 | 60.00 | 90.00 | 53.00 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **Medium Groups** | | | | | | |
| BEFORE | 83.20 | 90.60 | 90.20 | 88.00 | 96.00 | 87.40 |
| AFTER | 93.00 * | 95.67 * | 96.00 * | 96.67 * | 96.67 * | 95.00 * |
| p VALUE | 0.0007 | 0.0002 | 0.0001 | 0.0504 | 0.0031 | 0.0002 |
| **High Groups** | | | | | | |
| BEFORE | 92.86 | 94.29 | 94.86 | 90.00 | 94.29 | 93.43 |
| AFTER | 92.14 | 96.00 | 92.00 | 95.71 | 95.71 | 93.57 |
| p VALUE | NS | NS | NS | NS | NS | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
$^*p < .05$

# Table 19: Summary of ANCOVA Results for Third Grade Including Posttest Mean Scores and p Values--Year Three

## Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 92.52 | 92.83 * | 89.96 | 90.70 | 93.52 | 91.52 |
| CONTROL | 88.45 | 91.82 | 90.27 | 89.36 | 90.18 | 89.77 |
| p VALUE | 0.0949 | 0.0261 | NS | NS | NS | NS |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 86.17 | 87.50 | 81.00 | 69.67 | 77.83 | 82.00 |
| CONTROL | 77.83 | 87.50 | 81.33 | 79.17 | 81.83 | 80.83 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 94.13 * | 93.75 * | 91.88 * | 97.00 * | 99.00 * | 94.00 * |
| CONTROL | 92.80 | 91.00 | 91.40 | 91.60 | 98.40 | 92.80 |
| p VALUE | 0.0011 | 0.0001 | 0.0026 | 0.0000 | 0.0000 | 0.0008 |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 95.33 * | 95.56 * | 94.22 | 99.11 | 99.11 | 95.67 * |
| CONTROL | 92.27 | 94.55 | 94.64 * | 93.91 | 91.00 | 93.27 |
| p VALUE | 0.0162 | 0.0000 | 0.0103 | 0.0738 | NS | 0.0001 |

| BEFORE AFTER | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| BEFORE | 92.08 | 92.31 | 90.15 * | 90.54 | 93.62 * | 91.38 |
| AFTER | 93.10 * | 93.50 * | 89.70 | 90.90 * | 93.40 | 91.70 * |
| p VALUE | 0.0013 | 0.0000 | 0.0011 | 0.0474 | 0.0324 | 0.0000 |
| **Low Groups** | | | | | | |
| BEFORE | 87.25 | 83.75 | 79.00 | 73.25 | 79.25 | 81.75 |
| AFTER | 84.00 | 95.00 * | 85.00 * | 62.50 | 75.00 | 82.50 |
| p VALUE | NS | 0.0121 | 0.0972 | NS | NS | NS |
| **Medium Groups** | | | | | | |
| BEFORE | 94.00 | 93.75 | 93.50 | 98.00 | 100.00 | 94.50 |
| AFTER | 94.25 | 93.75 | 90.25 | 96.00 | 98.00 | 93.50 |
| p VALUE | NS | NS | NS | NS | NS | NS |
| **High Groups** | | | | | | |
| BEFORE | 94.40 | 98.00 * | 96.40 * | 98.40 | 100.00 * | 96.60 * |
| AFTER | 96.50 * | 92.50 | 91.50 | 100.00 * | 98.00 | 94.50 |
| p VALUE | 0.0000 | 0.0000 | 0.0023 | 0.0001 | 0.0002 | 0.0000 |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

## Table 20: Summary of ANCOVA Results for Fourth Grade Follow-Up Including Posttest Mean Scores and p Values--Year Three

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 81.38 | 78.44 | 87.06 | 86.81 | 89.94 | 84.81 |
| CONTROL | 84.95 * | 78.68 | 92.37 * | 89.05 * | 92.26 * | 87.95 * |
| p VALUE | 0.0005 | NS | 0.0097 | 0.0001 | 0.0002 | 0.0152 |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 77.56 | 69.44 | 85.22 | 82.78 | 89.89 | 81.00 |
| CONTROL | 81.00 * | 73.75 * | 85.75 * | 87.50 * | 93.00 * | 84.00 |
| p VALUE | 0.0122 | 0.0110 | 0.0039 | 0.0025 | 0.0000 | NS |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 82.00 | 86.25 * | 84.75 | 87.50 * | 86.00 | 85.75 |
| CONTROL | 82.20 | 77.00 | 93.00 | 87.20 | 89.50 | 86.90 |
| p VALUE | NS | 0.0102 | 0.0799 | 0.0000 | 0.0023 | NS |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 92.00 | 95.00 | 95.67 | 98.00 | 95.33 | 95.00 |
| CONTROL | 93.60 | 86.00 | 96.40 | 94.00 | 97.20 | 93.20 |
| p VALUE | NS | NS | NS | 0.0723 | NS | NS |

_Note._ Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 21: Summary of ANCOVA Results for Fifth Grade Follow-Up Including Posttest Mean Scores and p Values—Year Three

Sub-tests from MacMillan Achievement Test

| EXPERIMENTAL CONTROL | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **Entire Class** | | | | | | |
| EXPERIMENTAL | 94.73 * | 86.67 | 89.67 | 78.67 | 88.67 | 87.93 * |
| CONTROL | 94.31 | 85.77 | 91.92 * | 87.69 * | 92.00 * | 84.08 |
| p VALUE | 0.0005 | NS | 0.0097 | 0.0001 | 0.0002 | 0.0152 |
| **Low Groups** | | | | | | |
| EXPERIMENTAL | 91.40 | 79.00 | 82.60 * | 72.00 | 87.80 * | 82.40 |
| CONTROL | 96.00 * | 80.00 * | 79.00 | 76.67 * | 87.67 | 82.33 |
| p VALUE | 0.0122 | 0.0110 | 0.0039 | 0.0025 | 0.0000 | NS |
| **Medium Groups** | | | | | | |
| EXPERIMENTAL | 94.00 | 88.00 | 94.80 | 92.00 * | 88.80 | 92.00 |
| CONTROL | 91.67 | 85.83 * | 94.67 | 87.50 | 92.83 * | 77.33 |
| p VALUE | NS | 0.0102 | 0.0799 | 0.0000 | 0.0023 | NS |
| **High Groups** | | | | | | |
| EXPERIMENTAL | 98.80 | 93.00 | 91.60 | 72.00 | 89.40 | 89.40 |
| CONTROL | 97.00 | 90.00 | 97.50 | 96.25 | 94.00 | 95.50 |
| p VALUE | NS | NS | NS | 0.0723 | NS | NS |

Note. Scores are indicated as percentages.
NS indicates no significance.
*$p < .05$

# Table 22: Summary of ANCOVA Results: Longitudinal Data

Sub-tests from MacMillan Achievement Test

| STUDENT GROUP OVER THREE YEARS | Decoding and Phonics | Vocabulary | Comprehension | Language | Study Skills | Total Test |
|---|---|---|---|---|---|---|
| **K-1-2** | | | | | | |
| Always Control | 96.00 | 90.00 | 91.00 | 100.00 | NA | 93.50 |
| Experimental Once | 89.43 | 94.29 | 90.29 | 92.86 | | 91.43 |
| Experimental Twice | 92.20 | 97.20 | 91.40 | 100.00 | | 93.60 |
| Always Experimental | 93.00 | 97.67 | 97.00 | 95.00 | | 95.33 |
| p Value | 0.0001 * | 0.0000 * | 0.0000 * | 0.0000 * | | 0.0000 * |
| **1-2-3** | | | | | | |
| Always Control | 91.00 | 95.00 | 94.00 | 86.60 | 85.20 | 91.40 |
| Experimental Once | 94.38 | 94.38 | 92.25 | 95.88 | 94.88 | 94.25 |
| Experimental Twice | 93.13 | 93.13 | 93.13 | 92.75 | 100.00 | 93.63 |
| Always Experimental | 94.67 | 93.33 | 93.17 | 97.33 | 97.33 | 94.17 |
| p Value | 0.0001 * | 0.0000 * | 0.0000 * | 0.0001 * | 0.0000 * | 0.0000 * |
| **2-3-4** | | | | | | |
| Control Twice | 90.40 | 75.00 | 92.40 | 90.20 | 90.20 | 88.40 |
| Control/Experimental | 82.00 | 76.00 | 86.00 | 88.80 | 95.80 | 86.00 |
| Experimental/Control | 82.00 | 83.33 | 93.33 | 89.11 | 93.00 | 88.44 |
| Experimental Twice | 84.57 | 85.83 | 85.17 | 88.67 | 83.67 | 85.17 |
| p Value | 0.0000 * | 0.0472 * | 0.0954 | 0.0716 | 0.0000 * | 0.0012 * |
| **3-4-5** | | | | | | |
| Control in 3rd Grade | 96.13 | 86.88 | 93.75 | 88.75 | 93.68 | 92.13 |
| Experimental in 3rd Grade | 94.50 | 90.50 | 92.20 | 82.50 | 92.30 | 90.80 |
| p Value | 0.0024 * | 0.0001 * | 0.0013 * | NS | 0.0009 * | 0.0001 * |

Note. Scores are indicated as percentages.
NS indicates no significance.
$^{*}p < .05$

Table 23: Least Significant Difference Multiple Comparison Test: K-1-2 Group

**SUBTEST A**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | * Control 3 Years | | |
| EXPERIMENTAL 2 YEARS | * Experimental 2 years | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | * Experimental 3 years | * Experimental 3 years | No Significant Difference |

**SUBTEST B**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST C**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | * Experimental 3 years | No Significant Difference |

**SUBTEST D**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | * Experimental 1 year | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | * Experimental 3 years | No Significant Difference | * Experimental 3 years |

**TOTAL TEST**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | * Control 3 years | | |
| EXPERIMENTAL 2 YEARS | * Experimental 2 years | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | * Experimental 3 years | * Experimental 3 years | No Significant Difference |

Note. * $p < .05$

Table 24. Least Significant Difference Multiple Comparison Test: 1-2-3 Group

**SUBTEST A**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST B**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST C**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST D**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | * Experimental 3 years | No Significant Difference | No Significant Difference |

**SUBTEST E**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**TOTAL TEST**

| | CONTROL 3 YEARS | EXPERIMENTAL 1 YEAR | EXPERIMENTAL 2 YEARS |
|---|---|---|---|
| CONTROL 3 YEARS | | | |
| EXPERIMENTAL 1 YEAR | No Significant Difference | | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 3 YEARS | * Experimental 3 years | No Significant Difference | No Significant Difference |

Note. * $p < .05$

Table 25. Least Significant Difference Multiple Comparison Test: 2-3-4 Group

**SUBTEST A**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST B**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST C**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST D**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**SUBTEST E**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | No Significant Difference | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

**TOTAL TEST**

| | CONTROL 2 YEARS | CONTROL then EXPERIMENTAL | EXPERIMENTAL then CONTROL |
|---|---|---|---|
| CONTROL 2 YEARS | | | |
| CONTROL then EXP | No Significant Difference | | |
| EXP then CONTROL | * Experimental then Control | No Significant Difference | |
| EXPERIMENTAL 2 YEARS | No Significant Difference | No Significant Difference | No Significant Difference |

Note. *$p < .05$

# Hypermedia Computer Assisted Instruction: Adapting a Basal Reading Series

Kyle Higgins, Project Coordinator

Randall Boone, Project Coordinator

University of Washington
Experimental Education Unit, WJ-10
Seattle, WA 98195
(206) 543-4011

Preparation of this paper was supported by U.S. Department of Education Grant 84.024J to Thomas C. Lovitt.

We gratefully acknowledge the assistance of Kathryn Fantasia, Vera Risdon, Kathy Davis, Anne Marie Zahradnik, Molly Wiberg, Judy Busch, Janice Okita, Mary Blom, Sharon Huvinen, Karen Perlbachs, Martha Penton, Marilyn Heyn, Anna Petticord, and James Thurston in this project.

Running Head: Hypermedia CAI

# Hypermedia Computer Assisted Instruction: Adapting a Basai Reading Series

Every day in elementary school classrooms across the country students sit in teacher-directed reading groups and read from their basal readers. Often this type of instruction follows the teaching strategies outlined in the teacher's guide for the basal, including work on vocabulary skills, semantic and syntactic reading skills, and comprehension skills.

While systematic reading instruction is at the core of the elementary school curriculum, as much as 70 % of reading instruction time in these classrooms does not involve the teacher. Instead, the students work independently on noninteractive reading-related assignments such as worksheets (National Academy of Education, 1985). Given the current trend in public schools to educate students with mild handicaps in the general education classroom, and with the majority of elementary school teachers using the basal reader approach (National Academy of Education, 1985), adapting a basal reader to multimedia computer assisted instruction for these students is an exciting approach to using technology in the elementary classroom.

## The Research Project

A school-based, cooperative research project between the University of Washington and Hazelwood Elementary School is being conducted in Renton, Washington. This three-year longitudinal project involves developing and testing multimedia reading materials in a hypermedia format based on the elementary basal reading series used in the district. Specifically, the multimedia/hypermedia reading materials are designed to facilitate successful participation of students with mild disabilities in a general elementary classroom basal reading program (K-3). The project is evaluating the impact of these materials on children's development of reading skills, participation in reading-related classroom activities, and yearly achievement gains in language arts.

Eight classrooms (K-3) involving over 300 students in both experimental and control settings are participating in the study. The natural movement of students from one grade level to the next results in random assignment of students to control and experimental classrooms each year. Thus, the project is accumulating longitudinal information on five separate subgroups based on the sequence and number of years the students participate in either experimental or control classrooms:

- Students who use the multimedia/hypermedia reading materials every year for three years.
- Students who use the multimedia/hypermedia reading materials two years in a row.
- Students who use the multimedia/hypermedia reading materials two years with a one-year hiatus between the two years.

- Students who use the multimedia/hypermedia reading materials for one year.
- Students who do not use the multimedia/hypermedia reading materials any year.

## The Software

### Technological Features

The multimedia software developed and used in this project is accessed through a hypermedia interface written in HyperCard (Atkinson, 1987) for the Macintosh family of computers. The technology requirements are exclusively microcomputer based and do not include additional hardware such as a CD-ROM drive or videodisc player and monitor. Limiting the software to the microcomputer's audio and visual capabilities achieves two purposes:

- The cost of a single student workstation is kept to a minimum. This provides research data based on a reasonably priced technology that schools can afford and therefore are more likely to implement.
- The use of a single-screen format is consistent with the gestalt law of closure (i.e., we see things that are within a closed region as having correspondence to one another), which dictates that a single screen be used to present information (Nielsen, 1990) to assure that students are not confused about where they should look for information (A. P. Givens, personal communication, April 1, 1991). In addition, using this format, students are more likely to understand the connections between the layered hypermedia information and the original text (Nielsen, 1990).

### Educational Strategies

Unlike much commercial multimedia and hypermedia software that is more a database of information to be explored by students the software in this project employs educational strategies based on specific learning goals. This is , rather than computer assisted instruction. The "look and feel" of the interface between the student and the software is kept constant from lesson to lesson through visual iconic representations of commands for controlling the lessons, as well as auditory cues, instructions, and reinforcements relayed to the student via headphones.

### Format

Lessons consist of verbatim text from the basal readers presented on a computer screen in a large (18 or 24 point) typeface. The nonscrolling pages are linked linearly from first to last with the option of paging forward or backward. The first and last pages are also linked to provide a metaphor of circularity. Multimedia enhancements are available on each page through the hypermedia interface of buttons linked to text windows, graphic windows, and digitized speech. There are no relational links from page to page as found in many hypertext and hypermedia documents. This limited or guided hypermedia format provides students with the relational information inherent in good hypermedia while lessening the chances for confusion within a large network of information.

## Instructional Strategies

The multimedia/hypermedia capabilities of the microcomputer hardware and software helped define the instructional strategies selected for adaptation to the lessons in this project. Thus, strategies that could be faithfully "reproduced" by the multimedia/hypermedia format were chosen (e.g., lead a student through the same sequence of prompts as a teacher would), and only those that were successfully implemented in a pilot test were included in the software (see Figure 1).

Instructional strategies incorporated into the software through its hypermedia links meet three criteria:

- The instruction must constitute an effective reading strategy or intervention for students with mild disabilities.
- The instruction must be similar to a strategy the teachers are likely to be using or with which they are familiar.
- The instruction must be transportable to the microcomputer format without sacrificing important elements of the strategy.

### Year 1

Software developed for the first year of the project includes *vocabulary enhancements* to the basal reader text. Research indicates that pairing unknown words with additional information about those words is a highly effective vocabulary learning procedure (Graham & Johnson, 1989). Computerized pictures, animated graphic sequences, definitions, synonyms, and digitized speech, linked to words and pictures from the original basal text, provide the students with new experiences related to reading.

### Year 2

The second year software builds on the existing software from year one, adding instructional enhancements for *understanding syntactic and semantic structures* in the text. Since elementary school children are less likely to use pronoun clues for understanding text than are adult readers (Lesgold, 1972), Chai (1967) concluded that making logical connections between pronouns and their referent words may be necessary to prevent potential ambiguity of meaning. Based on these findings, the new software features for the second year graphically depict the relationship between pronouns and anaphora with their referent words.

### Year 3

Software developed for the third year builds on the second year software, adding enhancements for *comprehension strategies*. Two strategies, questions inserted in text as prompts (Wong, 1980) and questions presented as prereading goals (Wong, 1979), have proven successful with students with mild disabilities. As a result, questions inserted in text, rereading to find specific information, and prereading goals are implemented in the third year comprehension strategies.

Teacher Considerations

Recognizing that any instructional strategy, including computer assisted instruction, can be successful only when used regularly by a teacher, the project took the following principles into consideration:

- Teachers prefer to use computer software that directly relates to what they are already doing instructionally (Howell, 1990; Mokros & Russell, 1986), therefore, the software should support the already established curriculum.
- Software for use in a mainstreamed classroom setting should provide increased interactive instructional time for students without increasing the demands on the teacher's time for either instruction or evaluation.
- Meaningful integration of a computer assisted component into the instructional and management schemes of a classroom requires both a flexible instructional product and adequate teacher support.

Approximately 50 % of the stories from the basal reader series, preprimer through fourth grade, were adapted as multimedia/hypermedia lessons. Students used the lessons independently either before or after a teacher-directed reading activity, rotating from independent seat work at their desks to the computer station in their classroom. Throughout the three years of the project, the teachers received training on the use of the computers and software, participated in scheduled group support meetings after school, and received frequent support within their individual classrooms during the school day.

## Results

Achievement gains from the first and second years, based on pretest and posttest scores from the basal criterion referenced test, were examined by treatment grouping (experimental vs. control) and instructional sequence grouping (intervention either before or after teacher-directed reading group). When comparing entire classes, almost no difference was found between experimental and control groups at any of the four grade levels. However, classifying students within classes into ability groups (e.g., high, medium, low, resource room) provided evidence that the intervention was a significant educational help for some low-achieving students and for students with mild disabilities.

Results are inconclusive as to whether the lessons are best used before or after a teacher-directed reading activity. However, anecdotal information from the teachers in the experimental classrooms indicates that when used as advanced organizers, the lessons provide some students with increased confidence and additional skills for participating more actively in the teacher-directed reading group.

Year 1 Data. Low students in the kindergarten experimental classroom achieved higher improvement scores than their counterparts in the control class in letter identification, auditory discrimination, and total test scores. Whole group significance was found, with experimental kindergarten students outperforming the control group in letter identification and auditory discrimination. Further, the medium group in the kindergarten experimental class performed significantly better than the corresponding control class group in auditory discrimination and total test.

Students in the second grade experimental class defined as low obt ined significantly higher improvement scores in comprehension and total test. While no significant differences between experimental and control students were found in the low groups, at the third grade level students defined as medium and high outperformed their counterparts in the control classroom in vocabulary and comprehension skills, respectively. No difference was found in improvement scores between the students defined as low in the two first grade classrooms.

Year 2 Data. Whole group significance was found at the kindergarten level with experimental students outperforming the control students in letter identification. Low group students in the experimental classroom performed significantly better than the control group in letter identification. However, no difference was found in the performance of the medium and high groups at this level.

In first grade, whole group significance was found with the experimental group outperforming the control group in decoding, vocabulary, and total test scores. By ability level, students in the experimental low group had significantly higher test scores than the control students in decoding. Similarly, students in the experimental high group had significantly higher test scores than the control students in decoding, vocabulary, and total tes. scores.

In the second grade, students in the experimental classroom low group outperformed the control group in language skills, while the high group outperformed the control group in vocabulary skills. Finally, for third grade students, the high experimental group had significantly higher test scores in decoding and total test.

One of the most interesting results of the second year was the achievement gains of two resource room students in the third grade experimental classroom. Over the course of the year, these students advanced out of a resource room for all their reading instruction, to full participation in the middle reading group in their home classroom setting. Protocoi analysis with these two students revealed an understanding of the key instructional elements of the software as well as enthusiasm for reading the lesson on the computer. Anecdotal teacher information indicates that the students came to reading group prepared to participate with the other children, with knowledge of lesson vocabulary, and with enthusiasm.

## Recommendations

The teachers who are using this multimedia/hypermedia software contribute perhaps the keenest insight into which aspects of the project are most important both instructionally and in terms of classroom integration. This commentary from the classroom provides a useful point of departure for discussion of further research. Informal formative evaluation conducted during after-school support meetings along with videotaped interviews near the end of the third year reveals several aspects of the project the teachers felt were salient to their success.

- The students were able to use the computer independently with no teacher involvement for either operating the hardware or successfully completing the lessons.
- The software directly supported what the teacher was currently doing instructionally both in content and in instructional strategy.
- The software was instructional, not just drill and practice for information or concepts already presented by the teacher.

The teachers' acceptance of the computers and software as a regular component of their reading programs for a three-year period is perhaps as important a research finding as the project's effect on student reading achievement. Finally, it is imperative to retain the three features suggested by the participating teachers as components of educational multimedia and hypermedia research. Such research should examine not only development of more powerful technologies and instructional designs, but also alternate paradigms for the role of computer assisted instruction in the elementary classroom.

## References

Atkinson, B. (1987). HyperCard [Computer program]. Cupertino, CA: Apple Computer, Inc.

Chai, D.T. (1967). *Communication of pronominal referents in ambiguous english sentences for children and adults*. Ann Arbor, MI: Center for Human Growth and Development. (ERIC Document Reproduction Service No. ED 012 889)

Graham, S., & Johnson, L. A. (1989). Teaching reading to learning disabled students: A review of research-supported procedures. *Focus on Exceptional Children*, 21, 1-11.

Howell, R. D. (1990). Technology and change in special education: An interactional perspective. *Theory Into Practice*, 29 (4), 276-282.

Lesgold, A. M. (1972). *Effects of pronouns on children's memory for sentences*. Pittsburgh, Pa.: University of Pittsburgh Learning Research and Development Center. (ERIC Document Reproduction Service No. ED 068 974)

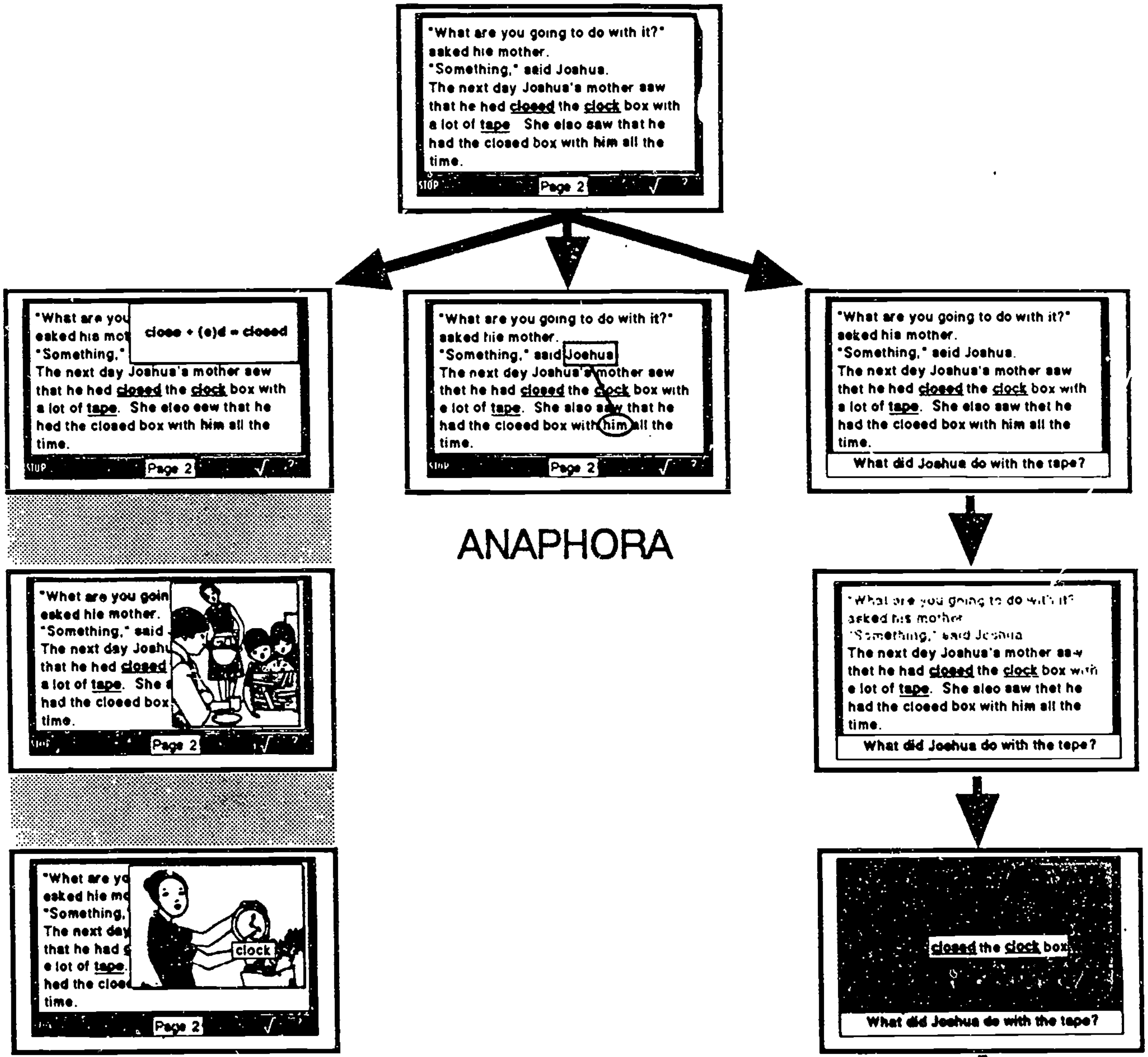
Mokros, J. R., & Russell, S. J. (1986). Learner-centered software: A survey of microcomputer use with special needs students. *Journal of Learning Disabilities*, 19(3), 185-190.

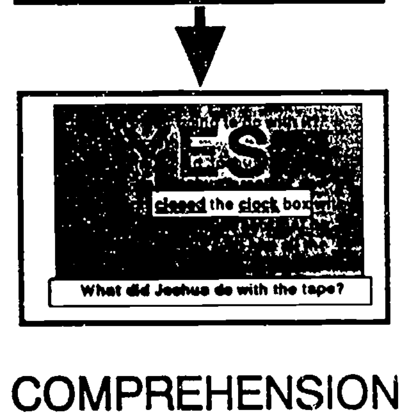
National Academy of Education (1985). *Becoming a nation of readers*. Washington, D. C.: The National Institute of Education.

Nielsen, J. (1990). *Hypertext and Hypermedia*. San Diego: Academic Press.

Wong, B. Y. L. (1979). Increasing retention of main ideas through questioning strategies. *Learning Disability Quarterly*, 2, 42-47.

Wong, B. Y. L. (1980). Activating the inactive learner: Use of questions/prompts to enhance comprehension and retention of implied information in learning disabled children. *Learning Disability Quarterly*, 3, 29-37.




Three categories of hypermedia enhancements are shown in this flowchart: (a) VOCABULARY, text and graphic windows appear over the main text screen; (b) ANAPHORA, a graphic connects the pronoun to its antecedent; and (c) COMPREHENSION, students search for the line where the answer to a question is found. The software limits the text to be searched each time an incorrect choice is made.

# Hypertext/Hypermedia Information Presentation: Developing a HyperCard Template

Randall Boone and Kyle Higgins

*Hypertext* and *hypermedia* are relatively new terms for today's computer-using educators although the basic concept of non-sequential, computer-based text first was envisioned more than 40 years ago (Bush, 1945). Since this capability for microcomputers became widely available in 1986, interest in hypermedia has been growing rapidly throughout the educational community. This recent interest has resulted in a rapid increase in the number of magazine and journal articles, papers and presentations at educational conferences, and hypermedia educational software programs available for classroom use. Hypermedia as an educational tool is very different from traditional computer-assisted instructional software, offering a new format for providing instruction and information via a computer.

The first issue in discussing this subject is to clear up any confusion among three similar new terms being used in computer education: hypertext, hypermedia, and HyperCard (Atkinson, 1987). The first, hypertext, describes the concept of non-sequential text presentation. The next term, hypermedia, correctly designates a hypertext document that includes graphics, digitized speech, music, or video segments. HyperCard, on the other hand, is a specific software product developed by Apple Computer for the Macintosh. It is an operating system and authoring environment specially designed for creating applications based on the hypermedia concept.

The format of a traditional textbook leads the reader through a page-by-page progression from the beginning to the end. Additional information or clarification must be obtained from supplementary reference sources (e.g., a dictionary, thesaurus, encyclopedia, or another person). Hypermedia, on the other hand, provides immediate access through its computer format to supplemental information that the reader wants or needs without the interruption of seeking additional help outside of the immediate reading environment. A hypermedia textbook might include extra information in the form of additional text, computer generated speech, graphic representations, animated sequences, or combinations of text, speech, and graphics. Video segments may also be incorporated into hypermedia through videotape and laserdisc technology. This presentation system provides a reader an individualized way of accessing information, based on the person's needs or interests.

A hypermedia page might be thought of as a composite of several sheets of transparent film overlaying one another, each sheet containing its own unique information. The top layer sheet in the hypermedia page provides the initial information to be viewed and also serves as a menu for accessing information available on the underlying pages. The secondary text or graphics from the underlying pages is viewed by the reader in special windows that appear either alongside or overlaying the original page. From a secondary page or window the reader has the option to return to the original screen without the window, or further pursue new information in additional windows. These enhancements are typically accessed through the use of a computer mouse. The mouse controls cursor movement and selection of computer functions without the need for a keyboard. Selecting a word, for example, could give a choice of the word's definition or pronunciation, or provide a picture associated with the word (see Figure 1). Further selections on the second layer pages or on any subsequent layer could take the reader to additional areas of information.

Exploration of hypermedia can be left entirely to the reader or be controlled in varying degrees by a presentation sequence programmed into the hypermedia document itself. Readers of hypermedia, then, have the option to browse through reading material in a totally open-ended manner corresponding to their interests and needs, or to use the guided exploration.

The idea of hypertext as described by Nelson (1974, 1978, 1981) included different types of hypertext forms, from simple links between chunks of related text, to a more loosely structured text navigation system connected to a vast knowledge library including all pertinent information about a subject. Jonassen (1986) described three forms for implementing hypertext: (a) node-link, with chunks

**Randall Boone** and **Kyle Higgins** are Project Coordinators with the Experimental Education Unit at the University of Washington in Seattle.

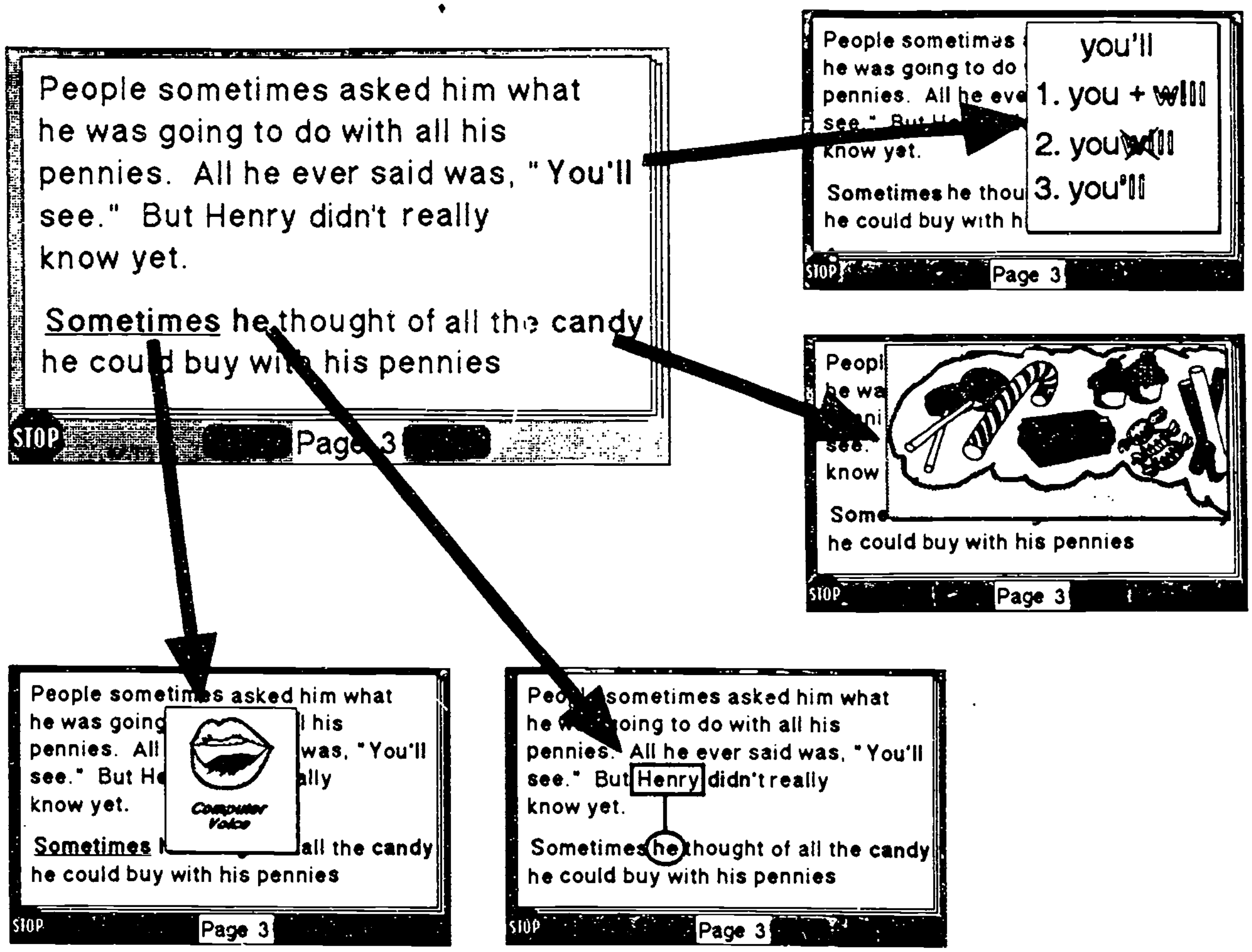



Figure 1. Cursor selection of the bold face words on the original text page (top left) reveals different types of hypertext/hypermedia enhancements in this educational hypermedia lesson: (a) *you'll,* a text window, depicts the structural analysis of the contraction; (b) *candy,* a graphic window, reinforces sight vocabulary with a visual representation of candy; (c) *he,* a graphic overlay, depicts the semantic and syntactic relationship of the pronoun to its referent word, Henry; and (d) *sometimes,* a computer generated voice says the word.

of text linked together providing direct access from any piece of text to another; (b) structured, in which the hypertext form serves as a meta-database, controlling access to each of several databases of related information; and (c) hierarchical, similar to structured hypertext, but with content arranged with general concepts broken down into more detailed concepts.

Hypertext/hypermedia, as it evolves, may take on many different forms. Some may prove more effective for particular types of reading material or instructional purposes. A form that is good for recreational or informational reading might not work well as a tutorial or as reference material. With new products described as hypermedia beginning to appear in the educational marketplace it is necessary for classroom teachers and other educators to become familiar with this new instructional mode in computer assisted learning.

Visions of hyperbooks (Moursund, 1988), hypertext and other forms of hypermedia (Dede, 1987) perhaps foretell the future focus of computer education, but computer-using educators need not wait until the future to use hypermedia. It is available today in a number of instructional programs and hypermedia authoring systems. *Guide* (Owl International Software, 1986), *HyperCard* (Atkinson, 1987), *LinkWay* (Kheriaty, 1989), *SuperCard* (Appleton, 1989), *HyperStudio* (O'Keefe, 1989), *Tutor-Tech* (Techware Corporation, 1988), *Hyper-*

*Screen* (Brackett, 1990) and *Toolbook* (Asymetrix Corporation, 1990) are some of the products designed to produce hypertext or hypermedia documents by persons with varying degrees of computer knowledge and programming proficiency.

Guide. Guide is a menu-driven authoring system for hypertext. Creation of a hypertext document begins with the entry of text in a format very similar to that of a word processor. Window overlays, replacements, and links between different parts of the text are incorporated into the document by menu-driven selection procedures. Guide's system of menus is very easy to use, giving powerful programming capability to relative novice computer users. Both text and graphics can be incorporated into Guide windows along with sound and videodisc control. Recent releases of the program will allow a record of user responses to be stored. Guide runs on both the IBM PC and the Macintosh. It is available from Owl International Software.

HyperCard. HyperCard is a hypermedia authoring system for the Macintosh available from Apple Computer. Although more difficult to use than Guide, it is much more powerful as a hypermedia authoring tool. HyperCard includes its own programming language with full high-level computer language capabilities. Although using HyperCard requires programming skills for creation of sophisticated hypermedia documents, it is much easier and less time consuming than development of similar material in a more conventional programming language. HyperCard comes free with the purchase of a Macintosh.

LinkWay. This product is IBM's version of HyperCard. It incorporates the mouse-controlled format of the Macintosh into the operation of the IBM and compatible computers. LinkWay relies on the use of icons for linking information in the text. These icons indicate that different types of additional information are available to the reader. A special speech adapter is necessary for adding computer speech capabilities to the hypermedia documents created with LinkWay.

SuperCard. This product took the HyperCard idea and provided several additional capabilities not available in HyperCard. SuperCard gives a hypermedia author an improved graphics tool, a special animation capability, and the ability to create buttons in shapes other than the rectangles provided in HyperCard. It is produced for the Apple Macintosh computer, yet unlike HyperCard, SuperCard comes from an independent software developer, Silicon Beach Software.

HyperStudio. HyperStudio is an adaptation of HyperCard for the Apple GS computer with 1.25 megabytes of RAM. Available from Roger Wagner Publishing, HyperStudio is a hypermedia authoring tool providing access to the color video and enhanced audio capabilities of the Apple GS machines. Lesson design is similar to that of HyperCard, but most programming is done through a menu-driven authoring system. Complete sound digitizing hardware is included with the software. This product provides easy to use yet sophisticated hypermedia capabilities for a computer that is very common in public schools.

Tutor-Tech. This is a hypermedia authoring product available for the Apple II line of computers. Lessons are created in a page by page fashion using multiple fonts and a built-in graphics tool. Buttons are available for controlling text presentation and viewing the hypermedia enhancements. No programming experience is necessary to build lessons with Tutor-Tech. Student lessons can be controlled through the keyboard as well as a mouse. Tutor-Tech is available from Techware Corporation.

HyperScreen. HyperScreen, a hypermedia product also for the Apple II line of computers, requires an alternate input device such as a mouse or a joystick. It is similar in many ways to Tutor-Tech in its reliance on the capabilities of the Apple II line of computers. Clip art and sound resources are also available for HyperScreen from Scholastic.

Toolbook. Toolbook is another IBM compatible hypermedia product. It requires the Microsoft Windows 3.0 graphical user interface. Toolbook, from Asymetrix Corporation, is currently the most HyperCard-like of the hypermedia programs for the IBM compatible machines.

HyperCard for the Macintosh and HyperStudio for the Apple GS appear to be the most widely used by educators of the full-featured hypermedia systems for microcomputers. Although most teachers with a reasonable amount of computer experience can be successful in creating a respectable piece of hypermedia software using the menu-driven programming features of HyperStudio, the same is not true of HyperCard.

HyperCard includes its own programming language with full high-level computer language capabilities. Based on a metaphor of note cards, HyperCard programming involves the creation of cards or screens of information which are ordered in files called stacks. HyperTalk, the programming language provided, is used to control presentation of the cards and operations within the stacks.

### A Hypermedia Template in HyperCard

Developing a template to accomplish similar tasks is a familiar strategy for computer users and programmers. Once a template is built in a spreadsheet, database, or word-processing program, one has only to enter new information for each new job. Construction of a hypermedia document template likewise makes sense for teachers who want to provide their students with computer assisted instruction through the hypermedia format. Using HyperCard, this can be a relatively easy task.

Instructions for creating a simple hypermedia template and subsequent hypermedia lessons follow. This is not a HyperCard tutorial. Exact step by step instructions are too lengthy for this article. Those who are somewhat familiar with HyperCard or who have some programming experience and a HyperCard manual, however, should have little trouble. It should be kept in mind that, as in any programming task, many ways exist to solve a particular problem. Those included here may not be the most efficient or elegant, but they do work. The document design and preparatory steps outlined here should also be of help when using other hypermedia authoring systems.

Windows, Buttons, and Links

HyperCard, with its metaphor of note cards in stacks, gives a familiar visualization to programming in this authoring environment. One card in a HyperCard stack represents one full screen on the Macintosh. For a hypermedia document, each screen (or card) may be thought of as one page in the document. Buttons, cursor-sensitive areas, are created on the cards to link them together. The buttons also serve to call windows of varying sizes to overlay a current screen. These windows may contain either text, graphics, or text and graphics together. Through this system of cards, windows, and buttons, a hypermedia document is linked together.

The Template

This template contains ten cards which allows for ten screens of original text. Each card contains links to two graphic windows and two text windows as well as links to the next original page and the previous original page. The last page reconnects to page one (see Figure 2).

The ten pages (cards) of original text are connected in a sequential order through page-turning buttons. Additional layers of information for each page are available through four windows, two graphic and two text.

This template produces what is perhaps more correctly called a limited or guided hypermedia document. While enhancements to the original text via the text and graphic windows on each page are available, there are no referential links between the separate pages. These links would connect or reference related facts or ideas scattered throughout the text. This is a very reasonable option and has been left out only to keep the template simple.

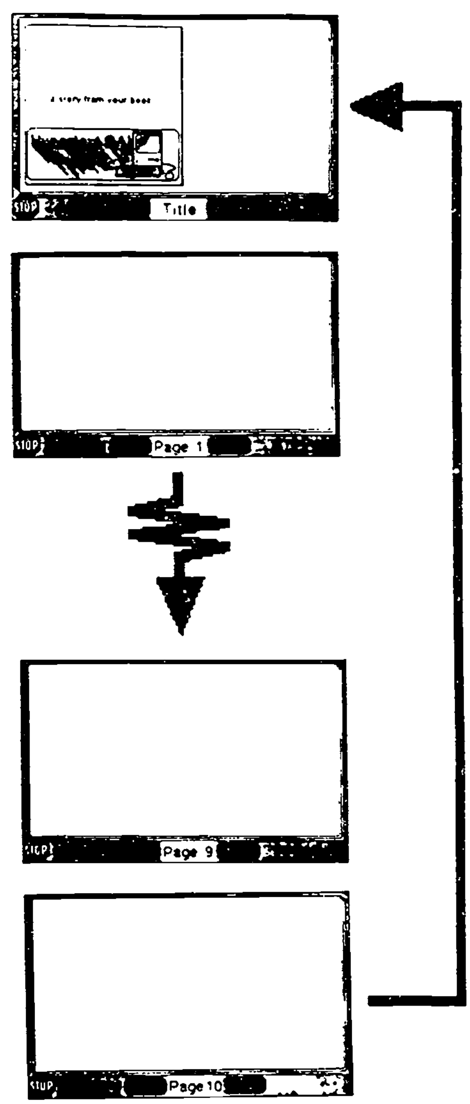



Figure 2. Ten original pages are linked sequentially with the last page returning the reader to the beginning. All pages have double links to page forward or backward.

**Getting Started.** HyperCard programming is accomplished mainly through menu selection of options and immediate mode commands. Starting from scratch is as easy as: (a) selecting NEW STACK from the menu bar; (b) creating a background; and (c) creating the number of cards necessary through menu selection of NEW CARD.

**Background.** Every page in a hypermedia document should bear some similarity to the others in terms of the look and feel of its operational features. This provides a familiar context for reading

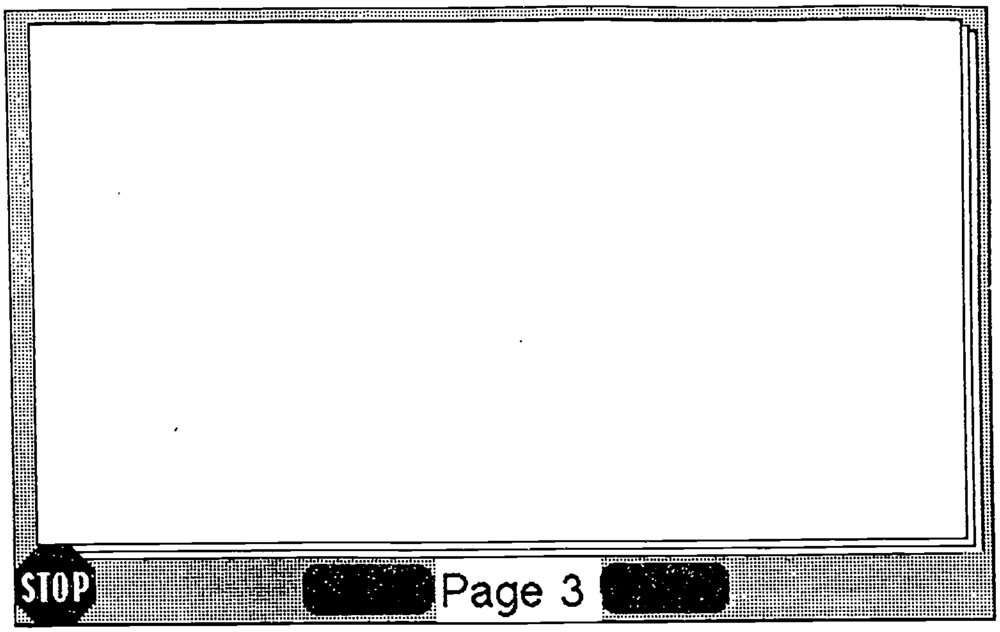



**Figure 3.** A common background for every page in a hypermedia lesson might include features such as (a) right and left page-turning arrows, (b) a centered page number, (c) a stop button to quit the program, and (d) a white background of simulated stacked papers for the original text of the document.

and learning. A HyperCard stack will have at least one background that is shared by many or all the cards. It can be designed using the built in graphics tool provided in the system but must be done while in the "background" mode. Figure 3 shows a representative hypermedia background. The right and left arrow buttons and the stop button, along with the graphic simulation of stacked pages, are features of every card in this stack. Only the white area where the text for that page will appear, changes from card to card.

**Cards.** Each time a new card is created in a HyperCard stack, it is assigned an ID number unique to that stack. This number is necessary for keeping track of the cards in the stack. For example, the script (HyperTalk code) for a page-turning button must include the card ID number of the destination page (e.g., GO TO CARD ID 2345). It is necessary then to make a listing of these card ID numbers as the cards are created. This is done by menu selection of OPTIONS and then further selection of CARD INFO.

As the first 10 cards, corresponding to the 10 original text pages, are created, their ID numbers must be noted and matched to a page number (e.g., Page 1, CARD ID 2834; Page 2, CARD ID 3730; etc.). This information will be used often as you navigate through the template. When the template is duplicated, the card ID numbers remain the same, so Page 1 in the original template and Page 1 in the 100th copy of the template have the same card ID numbers.

**Text Windows.** Fields are the HyperCard primary function for displaying text. Fields can be in the background of the stack, and thus appear on every card, or can be specific to a particular card.

This template will use CARD FIELDS exclusively, those specific to one card. Card fields are numbered consecutively from one, up to the number of fields created. Text for the fields is entered in word processor fashion on the screen when the field is active. Again, it is necessary to keep track of what information goes into which field. One way to accomplish this easily is to associate the FIELDS with correspondingly numbered BUTTONS (e.g., Field Button 1 accesses Card Field 1). The information in the card field, then, should be related to the word associated with the like-numbered button. Although fields are available in several modes, the SHADOW box, in a non-scrolling mode, seems best unless a large amount of text is needed in the field.

Graphic Windows. There is no graphic window function in HyperCard as there is for text. This must be simulated. The simulation is accomplished in the following manner:

1. Copy the text portion of a page using the "marching ants" tool in the TOOLS menu.
2. Create a new card from the EDIT menu. This will put a blank card on the screen with nothing but the BACKGROUND visible.
3. Paste the text from the original page onto the new page.
4. Using the graphics tools create an empty box where you want the graphic window to appear. A shadow box in the upper right corner is a good spot.
5. Copy the graphic you want from the SCRAPBOOK and paste it into the empty box you just created.
6. Note the CARD ID number of the new page.
7. Return to the original page.

The graphic window simulation is effected by a BUTTON script which calls the new card to replace the original. Since the only thing different in the two cards is the graphic box, it appears that the box is an overlay to the original page rather than a full page replacement. Similarly, to hide the graphic window, the script calls the original page back. This appears to make the window disappear (see Figure 4).

Buttons. Buttons are the real workers in HyperCard. The scripts, or HyperTalk programming code, associated with the buttons are very powerful. Buttons are created from the OBJECTS menu and the NEW BUTTON command. Buttons can be different sizes or fully transparent. A transparent button, overlaying any word, phrase, graphic, or graphic part, becomes a very powerful hypermedia function. Unfortunately, buttons come only in the traditional rectangular shape familiar in most Macintosh graphic applications although they are fully adjustable in size and dimension. The scripts associated with the buttons are activated by the mouse click operations of mouseUp (releasing the mouse button) or mouseDown (clicking the mouse button down). MouseUp is the most widely used.

---

### Template Directions

A hypermedia document template is now ready to be built following these directions.

#### Create the Cards

1. Open HyperCard.
2. Go to FILE menu and select NEW STACK; name it; unselect the COPY CURRENT BACKGROUND box; select NEW.
3. Go to EDIT menu and select BACKGROUND.
4. Go to TOOLS menu and use these MacPaint-like graphic tools to create a background. Plan this out ahead to save time.
5. Get the MESSAGE BAR with COMMAND-M; type SET USERLEVEL TO 5, (this puts you into scripting mode).
6. Go to OBJECTS menu and select CARD INFO; make note of the card ID number. (This is the card identification number for Page 1 of the hypermedia document). Click OK.
7. Go to EDIT menu and select NEW CARD. (A new card identical to the previous one will appear.)
8. Go to OBJECTS menu and select CARD INFO as before and note the card ID number. (This is the card identification number for Page 2).
9. Repeat steps 7 and 8 until you have 10 cards. Be sure to note the CARD ID NUMBER each time you create a new card and list it somewhere with its corresponding page number.

#### Make Additional Cards to Simulate Graphic Windows

Each original text page will have two graphic windows and two text windows. For ten pages of original text this means 20 additional cards will be created for the graphic window simulations. Be sure to list the CARD ID NUMBERS for the two new cards next to the page to which they will be connected.

| | |
|---|---|
| (e.g., Page 1 id#2834 | window 1 id#6338<br>window 2 id#6573 |
| Page 2 id# 3730 | window 1 id#7030<br>window 2 id#7249 |

Follow steps 7 and 8 in the instructions for creating cards until 20 additional cards are created and noted as shown above.

#### Create the Fields for Text Windows

1. Get the message bar with COMMAND-M; and type GO TO CARD ID (then the number for Page 1 from your list, e.g., *GO TO CARD ID 2834* and press return).
2. Go to the OBJECTS menu and select NEW FIELD; double click on the field when it appears on the screen; type FIELD 1 as the name; select SHADOW; click on FONT; choose font and size; then select OK.
3. Move and resize the field on the page.
4. Repeat Steps 1 and 2 above, but naming the second field FIELD 2.

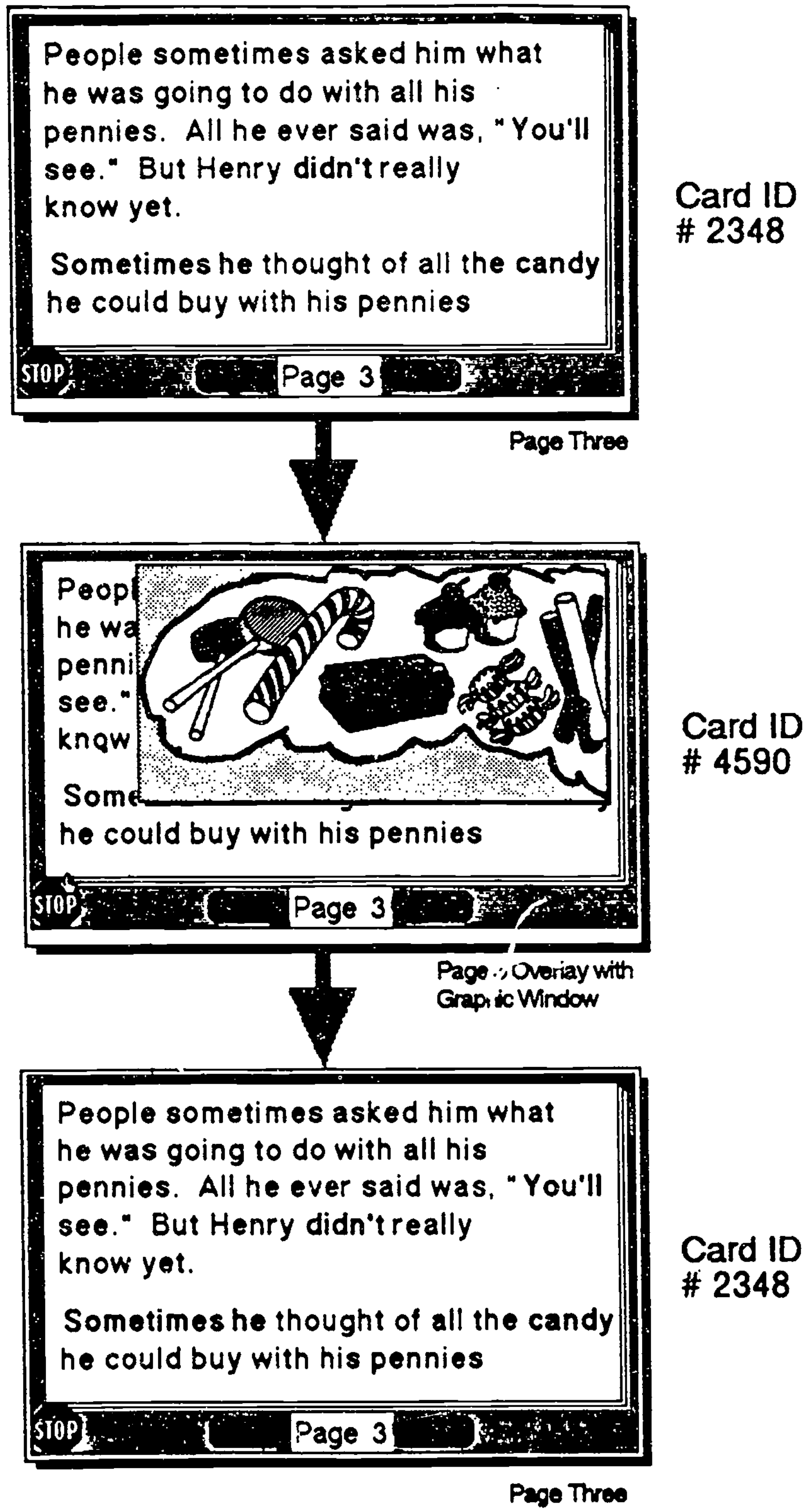



**Figure 4.** A graphic window for Page Three (card ID #2348) is simulated by a three step process: (a) making a copy of Page Three on another card (card ID #4590), (b) pasting the graphic desired as a window onto the copy of Page Three, and (c) replacing Page Three with the copy to simulate the window appearing and vice versa to make the window disappear.

5. Do this for each of the 10 original text pages in the template. Use the instructions in Step 1 to move from page to page.

Create the Buttons

1. Get the message bar with COMMAND-M; and type GO TO CARD ID (then the number for Page 1 from your list, e.g., *GO TO CARD ID 2834* and press return).
2. Go to OBJECTS menu and select NEW BUTTON; double click on the button; name the button GRAPHIC 1; choose TRANSPARENT and AUTO HILIGHT; then click on the SCRIPT box.
3. Between the script lines *ON mouseUP* and *END mouseUP* type in the following script:
   GO TO CARD ID (ID # of window 1 of page 1)
   WAIT UNTIL THE MOUSECLICK
   GO TO CARD ID (ID # of page 1)
   Line 1 calls the graphic window page.
   Line 2 holds the page until the mouse is clicked again.
   Line 3 calls the original page back into view.
4. Repeat Steps 2 and 3 above, but naming the button, GRAPHIC 2, and changing the CARD ID NUMBER in Line 1 of the script to that of Window 2 of Page 1.
5. Go to OBJECTS menu and select NEW BUTTON; double click on the button; name the button FIELD 1; choose TRANSPARENT and AUTO HILIGHT; then click on the SCRIPT box.
6. Between the script lines *ON mouseUP* and *END mouseUP* type in the following script:
   SHOW CARD FIELD 1
   WAIT UNTIL THE MOUSECLICK
   HIDE CARD FIELD 1
   Line 1 calls the text window.
   Line 2 holds the window until the mouse is clicked again.
   Line 3 hides the text window.
7. Repeat Steps 2 and 3 above but naming the button FIELD 2, and changing the FIELD NUMBERS in Lines 1 and 3 of the script to FIELD 2.
8. Resize and stack these buttons somewhere convenient on the page.
9. Do this for each of the 10 original text pages in the template. Use the instructions in Step 1 to move from page to page.

Create Page Turning Buttons

1. Get the message bar with COMMAND-M; and type GO TO CARD ID (then the number for Page 1 from your list, e.g., *GO TO CARD ID 2834* and press return).
2. Go to OBJECTS menu and select NEW BUTTON; double click on the button; name the button NEXT PAGE; choose ROUND RECTANGLE and AUTO HILIGHT; then click on the SCRIPT box.
3. Between the script lines *ON mouseUP* and *END mouseUP* type in the following script:
   GO TO CARD ID (ID # of the next page)
4. Repeat Steps 2 and 3 above but naming the button PREVIOUS PAGE, and changing the CARD ID NUMBER in the script to that of the page just preceding. In the case of Page 1 which has no preceding page, you may want to put the CARD ID of Page 10. This connects the start and the end of the document in a loop.
5. Position and resize these buttons in appropriate spots on the page.
6. Do this for each of the 10 original text pages in the template. Use the instructions in Step 1 to move from page to page. Buttons can be copied and pasted from page to page.

The template is finished. From the Macintosh Finder, duplicate the template and use the new copy to begin constructing a hypermedia document. With this template and some creative ideas, an effective piece of instructional or informational software can be built.

---

## A Hypermedia Document

Document building is broken down into nine basic steps. Each step is listed with annotations, suggestions, and discussion below.

1. **Enter Text of the Original Document.** HyperCard has two text modes. There are the text fields which remain dynamic, much like text in a word processor document, and there is the graphic mode of text presentation. The original text should be entered on the cards in the graphic mode using the TOOLS menu. Care must be taken in entering this text as it is not an editable file, but rather a graphic. Enter the text in an extended typeface but without any boldface or italics. To choose a font or style, first select the text function from the TOOLS menu. COMMAND-T presents a selection window for font, size, and type style. Make the appropriate selections and return to fill the page with text. Continue page by page until the document has been entered. Take care not to split meaningful units of text or syntactic structures between pages.

2. **Decide Which Words Will Be Hyper-enhanced.** Based on the intent of the hypermedia document, a decision must be made as to which words or pictures (if you decide to add pictures to the original pages) will have a link to a window. A hypermedia lesson from a content area text or

basal reader might use the new vocabulary words, important people or events, timelines, etc. These decisions are the basis for the instructional design of CAI lessons or the focus of an informational document.

3. Decide the Type of Enhancements. Graphic windows, explanatory or clarifying text, graphic or text combinations, or computer generated speech or music are all options for enhancements. Text enhancements will be assigned FIELD buttons, and graphic or graphic/text enhancements will use the GRAPHIC buttons. Speech can be added to either of the button types or used alone.

4. **Boldface the Words Which Will Be Buttons.** Return to the text mode of the graphics tool. Use COMMAND-T to return to the font and style window. Choose the same font and size as before, but in boldface, non-extended type style. (Boldface and regular spacing between letters take up the same space horizontally as non-boldface with extended spacing between letters.) Returning to the page of original text, the words which have been chosen for buttons are darkened by typing over them in the boldface style. This is a key for the reader that a window exists for that word.

5. **Position Buttons and Size Them Over the Words.** The four buttons that were created in the template are stacked somewhere on each original text page. To relocate them over the boldface words, the BUTTON mode from the TOOLS menu first must be activated. It is the middle-top square next to the BROWSE (finger pointing) mode box. Selecting a button now causes the "marching ants" to mobilize. The button can be moved by the CLICK AND DRAG method to the proper word where it can be resized by grabbing a corner and adjusting it. The name of the button now overlays the word. Double click on the button and unselect SHOW NAME and click on OK. The button name is now invisible. Returning to BROWSE mode (click on the finger box under the TOOLS menu) makes the entire button disappear. It is now active and ready to work.

6. **Enter Text into Text Fields.** The two FIELD buttons on each page are now linked to two corresponding but empty text fields. To enter text into the fields, the FIELD mode from the TOOLS menu first must be activated. It is the box on the top-right, next to the BUTTON mode box. Now get the message bar (COMMAND-M), enter SHOW CARD FIELD 1, and press return. Card Field 1 will now show on the screen.

To enter text, activate the BROWSE box in the TOOLS menu and place the cursor into the top-left corner of the FIELD box. Enter your text into the field. The field may be re-sized by activating the FIELD box again and grabbing a corner of the field. This may be necessary to make the field size fit the amount of text. When finished, activate the BROWSE box on the TOOLS menu and type into the message bar HIDE CARD FIELD 1. Follow the same process for Card Field 2.

7. **Create Graphic Windows.** There is no graphic window function in HyperCard as there is for text. This must be simulated. First, copy the text portion of the original text page using the "marching ants" tool in the TOOLS menu and the EDIT menu COPY command. Next, check your list for the CARD ID number of Window # 1 for this page. Get the message bar (COMMAND-M) and enter GO TO CARD ID (the number from the list). An identical page, though empty of text, appears.

Paste the text from the original onto the new page with the EDIT menu PASTE command. Using the graphics tools create an empty shadow box where you want the graphic window to appear. The upper right corner is a good spot. Copy the graphic you want from the SCRAPBOOK (clip art or your own design) and paste it into the empty box you just created. Return to the original page by entering in the message bar, GO TO CARD ID (the number of the original page).

8. **Putting Sounds into Hypermedia.** HyperCard handles playing sounds, voices, and music very well. The Macintosh SND (sound) resource can be activated from a HyperCard stack with the PLAY command followed by the SND name or number. ResEdit (Pope, 1986), a resource editor from Apple Computer, allows SND resources to be easily added or deleted from stacks. A device such as the MacRecorder (Farallon Computing, 1987) creates SND resources through a microphone or a standard audio output device. It might be noted that SND resources require lots of disk space.

A word of caution for users without hard disk drives. The SND resources, when read from a 3.5 inch disk and channelled through the HyperCard PLAY command, can be full of distortion. This distortion seems to be related to the slower read time on the 3.5 inch medium. The distortion can be circumvented by adding a WAIT command directly after the PLAY command in the script. The longer the sound being played, the longer the WAIT command should be.

9. **Final Check:** Browse through the stack, stopping on each page and utilizing every button on the page. Make sure the windows are linked to the proper words and that transitions are smooth.

## Conclusion

Hypermedia appears to hold many possibilities for educational use, from a highly structured document for exploring just about any subject, to a more specific, directed teaching tool such as study guide for a content area text or a basal reader supplement. The hypermedia format of layered text accessed in a non-sequential fashion by the reader, provides dynamic, interactive instruction very different from traditional computer assisted instructional programs.

Although most hypermedia development is centered around the Macintosh computer, not yet a common machine in the public schools, computer-using educators have already begun to explore the seemingly endless possibilities that hypermedia opens up. Findings from recent studies at the University of Washington indicate that hypermedia study guides are an effective tool for high school remedial and learning disabled students (Higgins, 1988; Boone and Higgins, in press). Preliminary findings from a related study with elementary school students support the use of hypermedia computer assisted reading material as a supplement to teacher directed instruction for low achieving students (Higgins and Boone, 1990).

Whether the subject matter is from a high school content area text or an elementary school basal reader, the hypermedia format appears an effective instructional mode for students of varying ages and ability levels. It is a new and exciting concept in the field of computer use in education. □

## References and Suggested Readings


Appleton, B. *SuperCard* [Computer program]. San Diego, CA: Silicon Beach Software, 1989.

Asymetrix Corp. *Toolbook* [Computer program]. Bellevue, WA: Author, 1990.

Atkinson, B. *HyperCard* [Computer program]. Cupertino, CA: Apple Computer, Inc., 1987.

Boone, R., and Higgins, K. Hypermedia Applications for Content Area Study Guides. *Journal of Reading, Writing, and Learning Disabilities International*, in press.

Brackett, G. *HyperScreen* [Computer program]. New York: Scholastic, Inc., 1990.

Bush, V. As We May Think. *Atlantic Monthly*, 1945, *176*(1), 101-108.

Dede, C.J. Empowering Environments, Hypermedia, and Microworlds. *The Computing Teacher*, 1987, *15*(3), 20-24.

Farallon Computing, Inc. MacRecorder [Computer program]. Berkeley, CA: Author, 1987.

Higgins, K. *Hypertext Computer-Assisted Instruction and the Social Studies Achievement of Learning Disabled, Remedial, and Regular Education Students.* Unpublished doctoral dissertation, University of New Mexico, Albuquerque, 1988.

Higgins, K., and Boone, R. *Hypermedia CAI: A Supplement to an Elementary School Basal Reading Program.* Manuscript submitted for publication, 1990.

Jonassen, D.H. Hypertext Principles for Text and Courseware Design. *Educational Psychologist*, 1986, *21*(4), 269-292.

Jonassen, D.H. *Hypertext/Hypermedia.* Englewood Cliffs: Educational Technology Publications, 1989.

Kheriaty, L. *LinkWay* [Computer program]. Atlanta, GA: International Business Machines, 1989.

Marchionini, G. (Ed.) Special issue of *Educational Technology* on Hypermedia, November 1988.

Moursund, D. HyperWhat?? *The Computing Teacher*, 1988, *15*(6), 4.

Nelson, T.H. *Literary Machines.* Swarthmore, PA, 1981. (Available from the author.)

Nelson, T.H. Electronic Publishing and Electronic Literature. In E.C. DeLand (Ed.), *Information Technology in Health Science Education*. New York: Plenum, 1978.

Nelson, T.H. *Dream Machines.* South Bend, IN: The Distributors, 1974.

O'Keefe, M. *HyperStudio* [Computer program]. El Cajon, CA: Roger Wagner Publishing, Inc., 1989.

Owl International. *Guide: Hypertext for the Macintosh* [Computer program]. Seattle, WA: Author, 1986.

Pope, G. *ResEdit* [Computer program]. Cupertino, CA: Apple Computer, Inc., 1986.

Techware. *Tutor-Tech* [Computer program]. Altamonte Springs, FL: Author, 1988.



Preparation of this paper was supported by U.S. Department of Education Grant 84.024J to Thomas C. Lovitt. The authors gratefully acknowledge the assistance of James Thurston in the preparation of this manuscript.


The directions for using HyperCard in this article are based on the HyperCard 1.0 version and its upgrades. HyperCard 2.0 is now available offering several improvements including multiple windows that are resizable, menu creation, and multiple text fonts and sizes within a single field.