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ABSTRACT

This report presents information on the first year of a program designed to develop hypermedia computer-assisted instructional (CAI) materials to support students with disabilities in a regular classroom reading program. The first section describes hypermedia; compares electronic versus traditional text; explains the concept of "layers of information" underlying hypertext; and discusses hypertext documents, hypertext CAI, application to a basal reading series, hypertext in content areas, and hypertext software such as authoring programs. The second section provides a report of the first year of a 3-year study using hypermedia CAI to provide individualized instruction in reading within a regular classroom environment. Particular attention was given to use with low-achieving students. The study involved eight regular education classrooms (K-3) containing 175 students, including 6 students with disabilities. Hypermedia lessons were developed to supplement the Macmillan Basal Reader Series using the HyperCard authoring system for the Macintosh computer. Results of the first year's research support the instructional effectiveness of such materials. (Contains 31 references.) (DB)

Hypertext CAI: Mainstreaming Handicapped Students in a Regular Classroom Reading Program

U.S. Department of Education
Office of Special Education

Year 1

MONOGRAPH

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Hypertext CAI: Maintaining Handicapped Students in a Regular Classroom Reading Program

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Hypertext: A New Vehicle For Computer Use in Reading Instruction

Hypertext: A New Vehicle For Computer Use in Reading Instruction

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.

Electronic vs. Traditional Text

Text, when presented in the traditional print on paper format, leads the reader through a predetermined, page-by-page progression from the beginning of the document to the end. The reader is limited to information contained in the particular text being read. Additional information or clarification must be obtained from supplementary reference sources (e.g., a dictionary, thesaurus, encyclopedia, or another person). Hypertext, on the other hand, provides immediate access through its computer format to supplemental information that the reader wants or needs. This new information may be presented as additional text for clarification or extension of a topic or an idea, or in the form of computer generated speech, graphic representations, animated sequences, or combinations of text, speech, and

graphics. Strictly speaking, the term hypermedia correctly designates a hypertext document that includes graphics or computer speech. For the purposes of this article, however, the word hypertext refers to documents that may include text, graphics, and computer speech.

Hypertext offers the reader a dynamic reading environment including access to special enhancements (e.g., the additional text, computer speech, and graphics) all within the familiar context of the computer. These enhancements are typically accessed through the use of a hand-controlled device called a mouse. The mouse controls cursor movement and selection of computer functions without the need for a keyboard.

Layers of Information

A hypertext 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 hypertext page provides the initial text to be read and also serves as a menu for accessing information available on the underlying pages. The secondary text from the underlying pages is viewed by the reader in special text windows that appear either alongside or overlaying the original text. From a secondary text page or window the reader has the option to return to the original text screen without the window, or further pursue new information in additional windows.

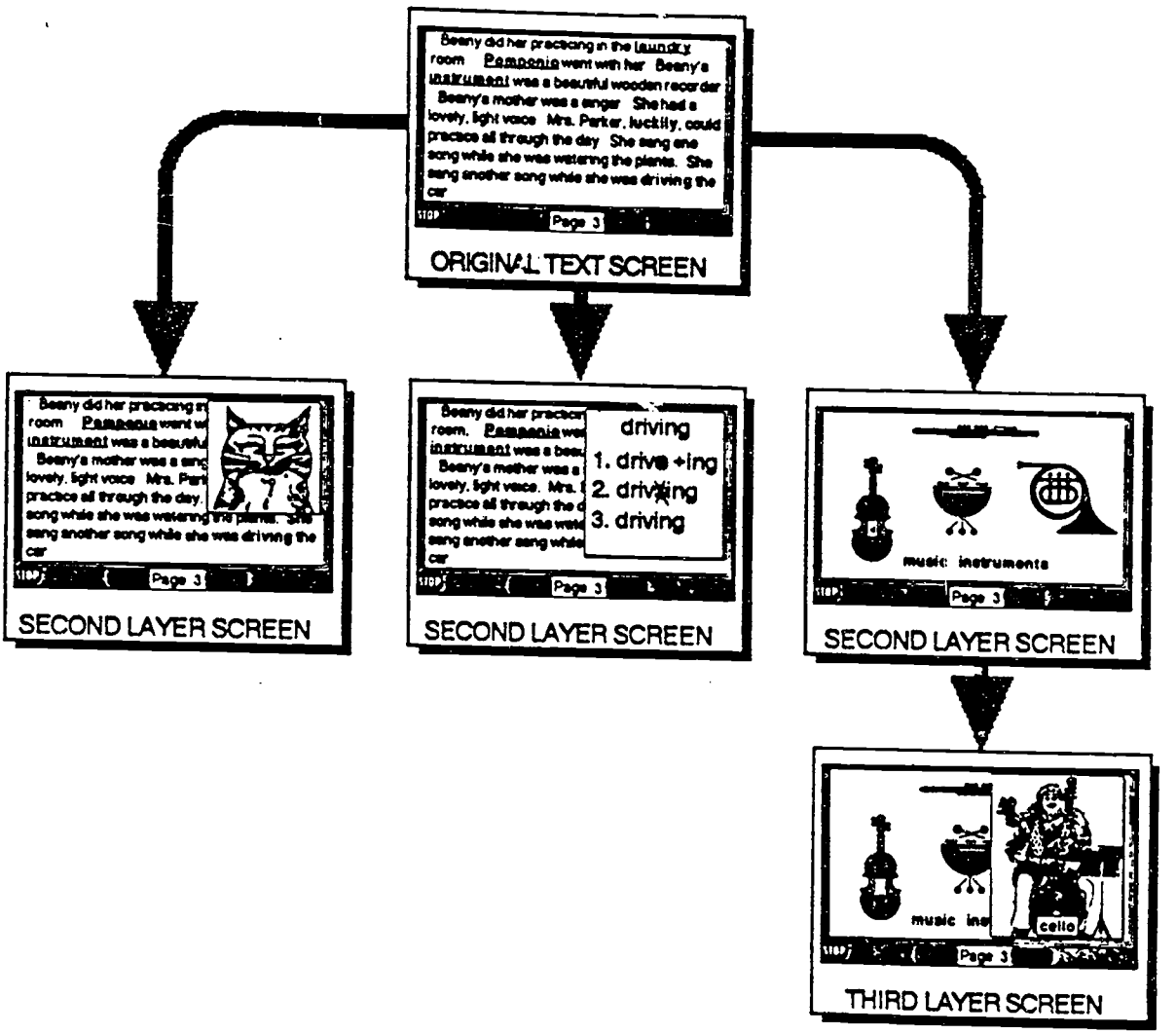

Figure 1. A flow chart detailing the layered structure of a hypertext page.

A hypertext flow chart. The computer screen shown at the top of the flow chart in Figure 1 is the original text layer of a hypertext page. At the second level of the flow chart are screens which are linked to specific words in the top level screen. These linked words are often referred to as buttons when discussing hypertext.

The screen on the left. This screen is linked to the word "Pomponio." That is, the picture of the cat, Pomponio, appears in a window when the word "Pomponio" is chosen by cursor selection. This second-layer window may be viewed until the reader clears it from the screen with additional cursor selection.

The middle screen. This also shows a second-layer window and is linked to the word "driving." Unlike the window in the previous page, this window is text rather than graphics. Cursor selection clears the new window returning the reader to the previous layer.

The screen on the right. This is a complete replacement screen rather than a window, which is linked to the word "instrument." It is different from the other two second-layer screens in that it contains buttons, or links, to a third layer.

The screen at the right-bottom. This screen shows a third-layer page which is linked to a musical instrument picture shown in the second-layer screen. Cursor selection on the picture of the cello produces a window containing a picture of someone playing a cello and the sound that a cello makes. Similarly, selection of any of the other three pictures would produce a corresponding window.

Hypertext Documents

In a hypertext document, words, letters, blocks of text, pictures, and parts of pictures contain links to more information than that which appears on the surface layer page or screen. Selecting specific areas of a hypertext page with the cursor reveals appropriately related layers of information to the reader. Selecting a word, for example, could give a choice of the word's definition or pronunciation, or provide a picture associated with the word. Further selections on this second layer

page or on any subsequent layer could take the reader to additional areas of information. This layering effect is virtually limitless.

An educational hypertext document might include thesaurus and dictionary information, encyclopedic references, references to related information within the same document, help with unknown words, tutorial strategies for building comprehension, or associated reading material categorized by subject, author, time period, genre, reading level, etc.

In addition to this expansion of information, movement through hypertext pages can be left entirely to the reader to move freely throughout the document, or be controlled in varying degrees by a presentation sequence programmed into the hypertext document itself. Readers of hypertext, then, have the option to browse through reading material in a totally open-ended manner corresponding to their interests and needs, or to use a guided exploration built into the hypertext document.

Hypertext Computer Assisted Instruction

Consideration of hypertext as a new mode for computer assisted instructional (CAI) material can provide a useful point of departure for looking closely at the possibilities for hypertext in education . While a hypertext equivalent of a high school content area textbook or an elementary basal reader will include very different types of help and information, the same hypertext conventions may be used in both. The look and feel of all hypertext materials can be kept very similar while the purpose or instructional objectives vary widely. This uniformity of design provides students with a familiar context for learning both across the

curriculum and regardless of age or ability level.

Students wrestle with textbooks every day; not just in and out of lockers, but with unlocking the meaning hidden within the syntax and semantics of the printed page. In elementary school, these books are most often basal readers, books with a common pedagogy and scope and sequence of skills for learning to read. After elementary school, the common textbook is the content area text (e.g., science, social studies, history). Hypertext CAI based on basal readers or content area texts can provide a new vehicle for interactive reading instruction offering different levels of text enhancement.

Basal Readers in Hypertext

A research project currently under way at the University of Washington is involved in the development and testing of hypertext reading materials based on an elementary basal reader series. Over the three years of the federally funded project the lessons will cover three levels of instructional features: (a) level one, text with enhanced surface structures; (b) level two, text with enhanced syntactic and semantic structures, and (c) level three, text with built in comprehension strategies.

Enhanced surface structures. Many students either do not have the experiential background that is necessary for understanding what they read, or do not access the information they do possess for successful comprehension. In a hypertext document, related pictures, animated graphic sequences, simple definitions, synonyms, and computer generated speech, are included to supplement the student's existing knowledge. These enhancements, as shown in Figure 2, provide a poor reader with the additional information needed for better comprehension.

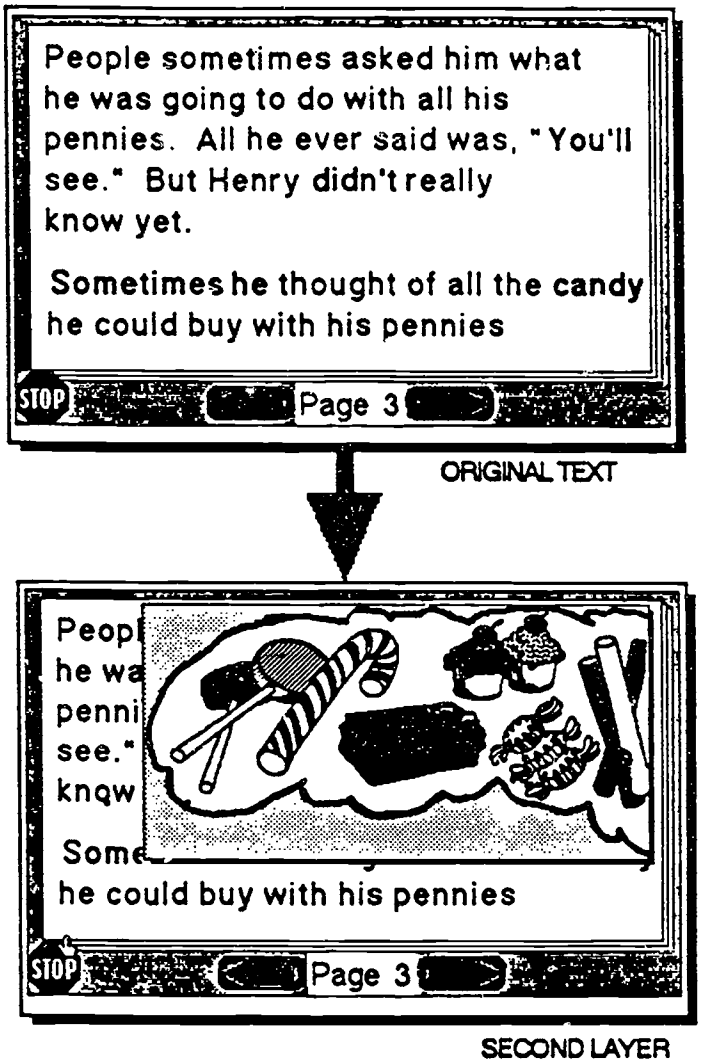

Figure 2. A picture linked to the word "candy" in a window overlaying the text screen. Cursor selection of the boldfaced "candy" produces the graphic window shown in the second layer. Additional cursor selection on the graphic window causes the window to disappear.

Enhanced syntactic and semantic structures. Enhancements at this level of hypertext include strategies for decoding unknown words and for understanding the relationships between words and phrases in the text. The use of phonics, structural analysis, and context clues provides immediate help for decoding words unfamiliar in print to the reader. The tutorial sequence shown in Figure 3 illustrates the connection of a pronoun to its referent in the text. This type of graphic representation shows the relationship of words and phrases in a reading passage.

This level of hypertext CAI provides an educational scaffold made up of strategies for understanding and decoding text. This scaffold may become less necessary as an external intervention in the student's reading process, and become a more internalized, automatic function. The hypertext reading lesson provides as much or as little external intervention as the individual needs.

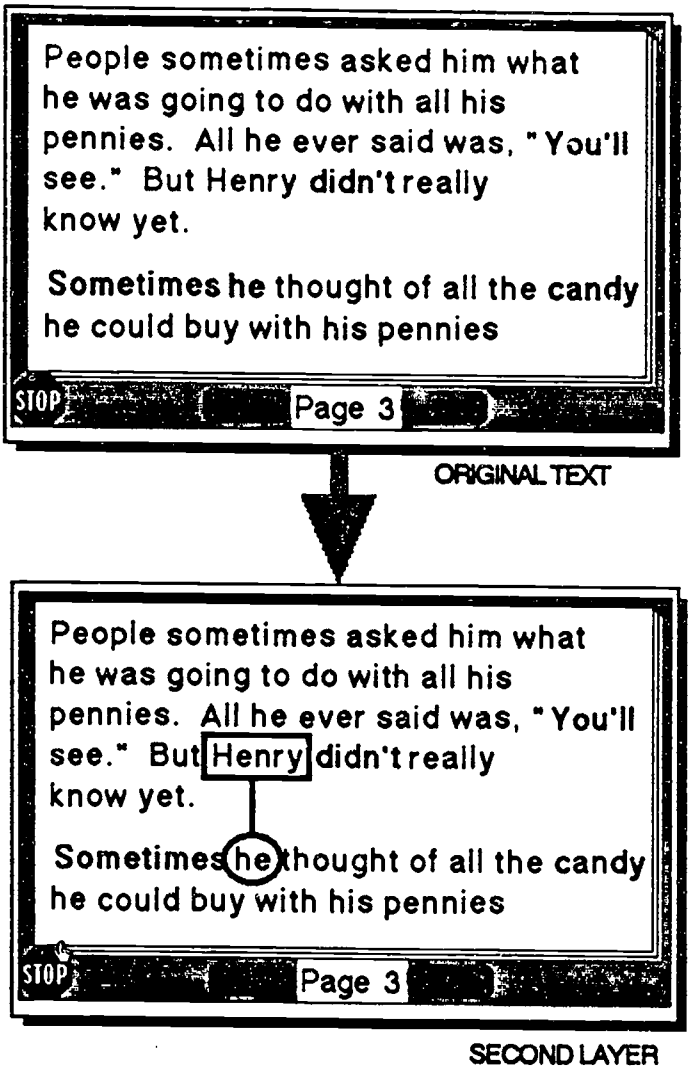

Figure 3. The relationship between the words "he" and "Henry" grpahically illustrated. Cursor selection of the boldfaced "he" produces the graphic overlay shown in the second layer. Additional cursor selection on "Henry" causes the graphic to disappear.

Enhanced deep meaning structures. This level emphasizes leading the reader through one or more process strategies for improving comprehension. The scaffold concept applies at this level as well. Such techniques include literal and inferential questions (see Figure 4), paragraph summaries, main idea matching, or re-reading for specific detail, all strategies similar to those used in a teacher-directed reading activity. The hypertext lesson presents the same instructional strategies as a teacher directed lesson, with appropriate interaction and reinforcement.

Hypertext in a Content Area

Content area textbooks such as science, history, and government are prime candidates for adaptation to a hypertext instructional format. The large quantity of reference information available in these disciplines limits the scope of a general textbook for sake of readability. The multiple layers of a hypertext medium provides space for volumes of additional information while retaining an easy to read general format for the text.

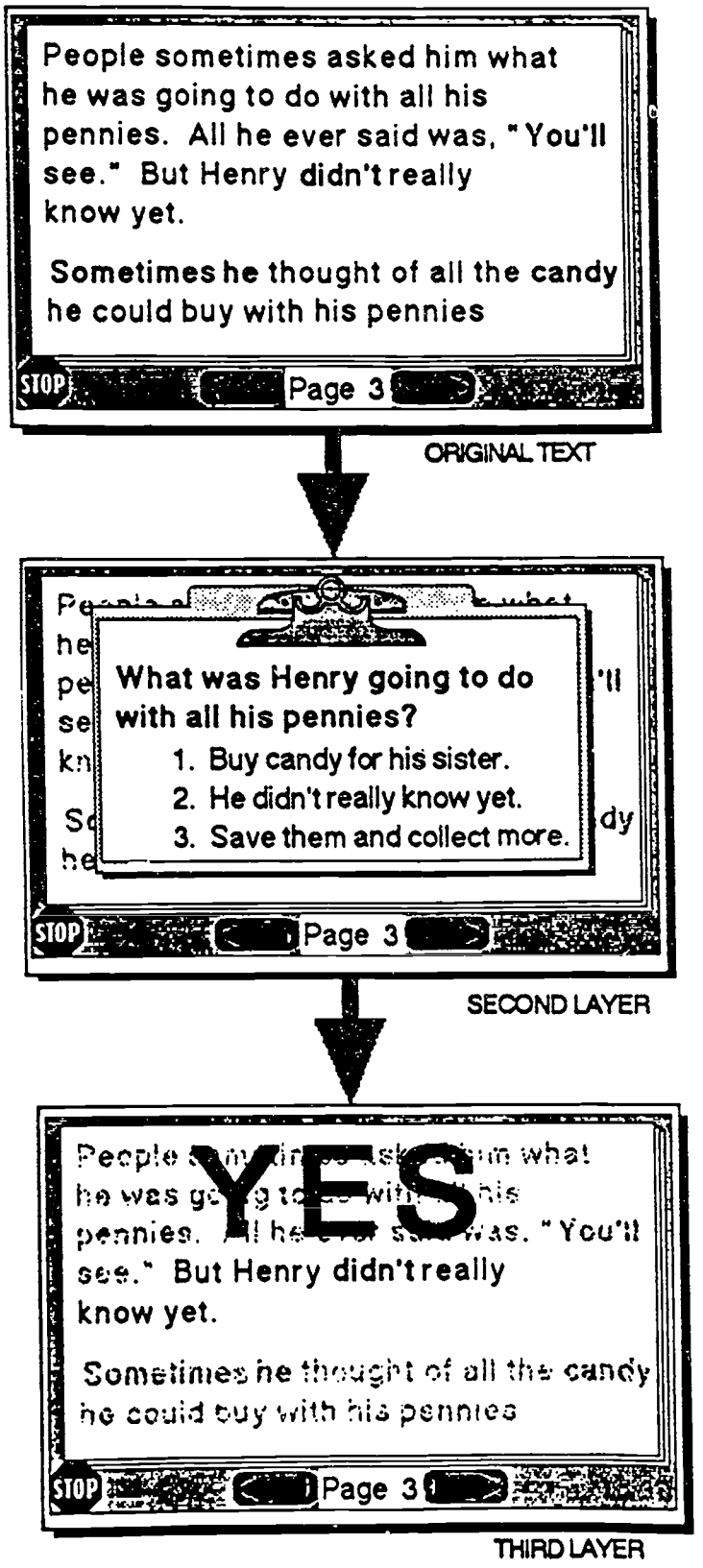

Figure 4. Questioning for comprehension occurring before student continues to the next page. Choosing the correct answer from a second layer window provides the student with a reinforcement page (third level) affirming the correct choice, and showing where in the text the answer is found. An incorrect answer prompts the student through a series of stops to find in the text where the answer is found.

Also available are features simply not possible in traditional print on paper. A hypertext American History lesson, for example, might include an actual recitation of the Gettysburg Address while showing a series of pictures surrounding the event. A geography lesson could take the format of a spatially oriented database in which a map of the United States would reveal information about each state through cursor selection on the state itself. This could be replicated to counties and on to cities, providing information pertinent to each level (e.g., country, state, county, city). The ideas are many.

Hypertext Software

Looking to the future, visions of *hyperbooks* (Moursund, 1988) and other forms of hypermedia (Dede, 1987) are receiving serious attention in educational literature. These predictions perhaps foretell the future focus of computers in education, but hypertext is not limited to the future. It is available to computer using educators today in ready to use instructional programs in subject areas as diverse as art, history, science, world geography, and political science. Most of these programs are produced as HyperCard stacks for the Macintosh computer.

Authoring Programs

Also available are several hypertext authoring programs which provide a level of programming ease and versatility that puts development of educational software back in the hands of educators. These products, *Guide* (Owl Software), *HyperCard* (Apple Computer), *Linkway* (IBM), *SuperCard* (Silicon Beach Software), *HyperStudio* (Roger Wagner Publishing), and *Tutor-Tech* (Techware Corporation) are specifically designed to produce hypertext documents and other

similar applications 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. The program does not provide for a record of user responses to be stored. Guide runs on both the IBM PC and the Macintosh. It is available from Owl Software.

HyperCard. HyperCard is a hypertext authoring system for the Macintosh available from Apple Computer. Although more difficult to use than Guide, it is much more powerful as a hypertext 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 hypertext documents, it is much easier and less time consuming than development of similar material in more conventional programming language. HyperCard comes free with the purchase of a Macintosh.

Linkway. This product is essentially 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 heavily 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 hypertext documents created with Linkway.

SuperCard. This product took the HyperCard idea and provided several additional capabilities not available in HyperCard. SuperCard gives a hypertext 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 a very reasonable adaptation of HyperCard for the Apple GS computer. Available from Roger Wagner Publishing, HyperStudio is a hypertext authoring tool providing access to the color video and enhanced audio capabilities of the Apple GS machines. Lesson design and programming are similar to that of HyperCard. Complete sound digitizing hardware is included with the software. This product provides easy to use yet sophisticated hypertext capabilities for a computer that is very common in public schools.

Tutor-Tech. This is the only hypertext 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 hypertext 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.

Summary

Hypertext appears to hold many possibilities for educational use, from a highly unstructured document for exploring just about any subject, to a more specific, directed teaching tool such as a study guide for a content area text or a basal reader supplement. The hypertext 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.

With the increasing interest in educational hypertext applications, more and more computer software labeled hypertext is becoming available for classroom use. These materials will likely take on many different forms and functions as hypertext products evolve in the classroom and in the marketplace. It is important, then, for an educator to evaluate hypertext software just as critically as any other instructional tool planned for use in the classroom.

Although most hypertext 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 hypertext opens up. Findings from a recent study at the University of Washington indicate that hypertext study guides are an effective tool for high school remedial and learning disabled students (Higgins, 1988). Preliminary findings from a related study with elementary school students support the use of hypertext computer assisted reading material as a supplement to teacher directed instruction for low achieving students (Higgins & Boone, 1989).

Whether the subject matter is from a high school social studies text or an elementary school basal reader, the hypertext 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

Dede, C.J. (1987). Empowering environments, hypermedia and microworlds. The Computing Teacher, 15(3), 20-24.

Higgins, K. (1988). 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.

Higgins, K. & Bcone, R. (1989). Hypertext CAI: A supplement to an elementary school basal reading program. Manuscript submitted for publication.

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

LIST OF HYPERTEXT/HYPERMEDIA SOFTWARE AVAILABLE FOR MICROCOMPUTERS

Guide (1986)
Owl International, Inc.
14218 N.E. 21st Street
Bellevue, WA 98007

HyperCard (1987)
Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014

Linkway (1989)
International Business Machines Corp.
P.O. Box 2150
Atlanta, GA 30055

SuperCard (1989)
Silicon Beach Software
9770 Carroll Center Road, Suite J
San Diego, CA 92126

HyperStudio (1989)
Roger Wagner Publishing, Inc.
1050 Pioneer Way, Suite P
El Cajon, CA 92020

Tutor-Tech (1988)
Techware Corporation
P.O. Box 151085
Altamonte Springs, FL 32715

Hypermedia CAI: A Supplement to an Elementary School Basal Reading Program

Hypermedia CAI: A Supplement to an Elementary School Basal Reader Program

Skepticism concerning the efficacy of educating students with mild handicaps in non-mainstream environments (Wang & Birch, 1984) has resulted in a great deal of attention being given to the issue of educating these students within the regular education classroom (Wang, Reynolds, & Walberg, 1986; Will, 1986; Hallahan, Kauffman, Lloyd, & McKinney, 1988). This attention has led to a call to more fully accommodate these students in the regular education classroom (Lilly, 1986; Reynolds, Wang, & Walberg, 1987; Stainback & Stainback, 1984; Wang, Reynolds, & Walberg, 1986). An outcome of this concern has been a recommendation by the Teacher Education Division of the Council for Exceptional Children (1987) for further research into appropriate strategies for the delivery of systematic and organized intervention for students with handicaps in the regular classroom and the curriculum-based assessment of such interventions.

This study involves the use of a technological instructional strategy--hypermedia computer assisted instruction (CAI)--that provides individualized instruction in reading within a regular classroom environment. Particular attention is given to the reading progress of low achieving students, as they appear to be the most at risk for being referred to special education classes.

Maintenance in the Regular Classroom

If maintenance of learners with handicaps in the regular classroom is to be successful, it is the regular classroom teacher who will be responsible for assisting these students in becoming effective and efficient learners. Increasing instructional time for the students without increasing the demands on the teacher and creating a system which offers access to new curriculum or enhances an already established curriculum are important concerns within this setting.

One means of successfully integrating additional instructional time is through supplemental use of computer assisted instruction. There is evidence that CAI, which requires only a modest amount of teacher time to implement, can provide increased academic achievement for certain learners with handicaps (Hasselbring, 1982; Hallworth & Brebner, 1980). The effectiveness of CAI depends on the appropriateness of the curricula materials it presents for the student population it serves. Much of the traditional CAI software is not directly related to the other instructional materials used in the classroom (e.g., basal readers and content texts). Because teachers prefer to use computer software which relates directly to what they are already doing instructionally (Mokros & Russell, 1986; Naiman, 1987) traditional materials need to be adapted to the CAI format.

Other more traditional techniques that have been used effectively by teachers to meet the needs of mainstreamed students with handicaps include: (a) reducing content demands, (b) developing parallel alternative curricula, and (c) using adapted textbooks. These techniques require a considerable amount of time spent in materials preparation. Regardless of method, successful instructional

procedures in the framework of a mainstreamed classroom are those which: (a) can be quickly learned by teachers, (b) can be easily integrated with ongoing lessons without disrupting the normal routine and delivery of instruction, and (c) are sufficiently powerful to influence students with handicaps in mainstreamed classrooms.

Reading

The elementary classroom places heavy demands on learners with handicaps in terms of reading skills. One of the main reasons for students being labeled as handicapped learners is a deficit in reading ability (Ysseldyke & Algozzine, 1983). The inability of these learners to benefit from conventional instruction is well documented (Wiens, 1983). Poor readers appear to be less adept at comprehension monitoring, and they approach the text in a passive manner (Bransford, Stein, & Vye, 1982; Paris, 1981). These students display less efficient text scanning strategies (Garner & Reis, 1981). less sensitivity to text structure (Pearson & Camperell, 1981), and are less likely to elaborate the encoding of text (Levin, 1973; Merrill, Sperber, & Mc Cauley, 1981; Pearson & Camperell, 1981).

The use of CAI to increase reading and comprehension competency can provide help for students with learning handicaps and other at-risk students in areas in which they are experiencing difficulty (Higgins & Boone, in press). Research indicates that students often do not learn to read because they are not actively engaged in reading (Ysseldyke & Algozzine, 1983). The microcomputer medium can maximize the active participation of the student in reading, as well as provide a

consistent curriculum-based assessment of student progress within the mainstreamed environment.

Hypermedia

Hypermedia, a new educational idea for computer text and information presentation, provides a flexible format for adapting materials currently in use by teachers to the CAI medium. Text, when presented in the traditional print on paper format, limits the reader to information contained only in the particular text being read. Additional information must be obtained from supplementary reference sources (e.g., a dictionary, thesaurus, encyclopedia). Clarification and elaboration are often provided by the teacher.

When text is presented on a computer screen in a hypermedia format, it loses its fixed nature and becomes more flexible and manipulable. This 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 which provide the supplementary information, clarification, and elaboration needed by the reader, all within in a familiar context and a single medium.

Individualized tutorials or information access based on a reader's needs or interests are possible in hypermedia. Findings from a recent study indicate that hypermedia study guides are an effective tool for students with learning disabilities and remedial students in a mainstreamed high school social studies classroom (Higgins, 1988; Higgins & Boone, in press).

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 (see Figure 1). The top layer sheet in the hypermedia page provides the initial text to be read and also serves as a menu for accessing information available on the underlying pages. The secondary text from the underlying pages is viewed by the reader in special text windows that appear either alongside or overlaying the original text. From a secondary text page or window the reader has the option to return to the original text screen without the window, or further pursue new information in additional windows.

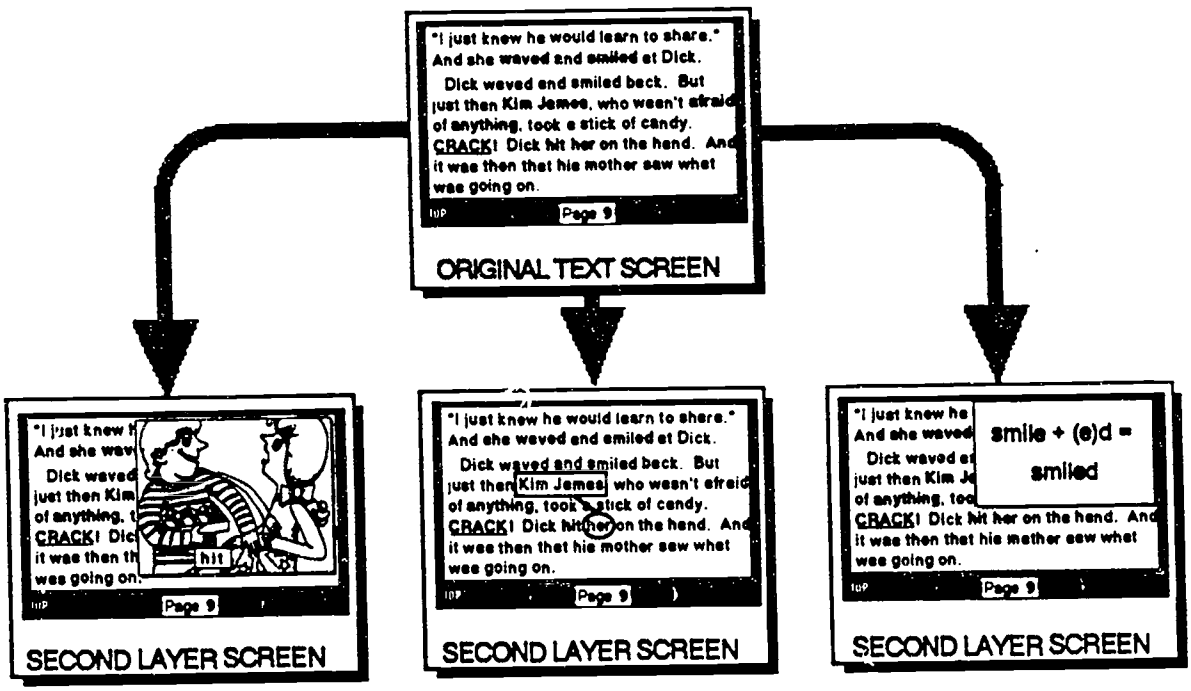

Figure 1. A hypermedia flow chart.

A hypermedia flow chart. The computer screen shown at the top of the flow chart in Figure 1 is the original text layer of a hypermedia page. At the second level of the flow chart are screens which are linked to specific words in the top level screen. These linked words are often referred to as buttons when discussing hypermedia.

The screen on the left. This screen is linked to the word "hit." That is, a picture of the boy hitting the girl appears in a window when the word "hit" is chosen by cursor selection. A second-layer window may be viewed until the reader clears it from the screen with additional cursor selection.

The middle screen. This shows a second-level graphic overlay linked to the pronoun "her." Unlike the window in the previous page, this overlay graphically illustrates the connection between the pronoun "her" and its antecedent "Kim James." Cursor selection on the antecedent word clears the overlay, returning the reader to the previous layer.

The screen on the right. This is also shows a second layer window and is linked to the word "smiled." This window is different from the first window in that it contains text rather than graphics.

The research project

This longitudinal research project addresses two areas at the forefront of current inquiry and practice in the field of Special Education: (a) maintaining students with handicaps within the regular education environment, and (b) the impact of technology on students with handicaps. The research centers on the development and testing of state of the art microcomputer software designed to aid

students with handicaps and other at-risk students in the acquisition of successful reading skills in a regular elementary school setting.

The software provides reading lessons in a hypermedia format designed as supplementary material for a basal reader series. The lessons are based on selected segments from each basal textbook. The hypermedia reading material offers easily accessible, additional information about the text along with decoding and comprehension strategies within the context and physical structure of the reading selection itself. Scope and sequence of skills and pedagogical techniques in the hypermedia lessons are kept constant with the basal text teaching guidelines.

The software is being developed in three levels of increasing sophistication for each grade level (K-3) over a three year period. The lessons will include three levels of instructional features: (a) level-one, text with enhanced surface structures; (b) level-two, text with enhanced syntactic and semantic structures; and (c) level-three, text with enhanced comprehension and self-monitoring structures.

Software developed for the first year includes surface level enhancements to the basal reader text. The emphasis at this level is to provide as much additional information as possible for the student to access through the hypermedia format. 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.

The second year lessons build on the existing software from year one, adding enhancements of syntactic and semantic structures to the same text passages. All level-one features are kept intact as well as the instructional design

and feel of the lessons. The new features graphically depict the relationship between pronouns and anaphora with their referent words.

Software developed for the third year builds on the second year software, adding enhancements for comprehension and self-monitoring strategies. All level-one and level-two features are included in this level also.

METHOD

Students and Setting

Eight regular education classrooms (K-3) involving 175 students in both experimental and control settings are participating in the research (see Table 1). Two classrooms at each grade level are randomly assigned to the experimental and control conditions.

The student sample includes both nonhandicapped students and mainstreamed students with mild handicaps including (a) first grade, one orthopedically impaired student, (b) second grade, two students with learning disabilities, and (c) third grade, three students with learning disabilities. Handicapped students included in the research were selected for mainstreaming according to policy set by the participating school district. Students with learning disabilities and students who are orthopedically impaired are classified according to Washington State criteria. Orthopedic impairment is defined as a lack of normal function of muscles, joints, or bones due to congenital anomaly, disease, or permanent injury, and such condition adversely affects educational performance. A learning disability for students in grades one through six is defined as intellectual functioning above that specified as mentally retarded and with a severe discrepancy

between intellectual ability and academic achievement in one or more of the following areas: (a) oral expression, (b) listening comprehension, (c) written expression, (d) basic reading skill, (e) reading comprehension, (f) mathematics calculations, and (g) mathematics reasoning. A severe discrepancy is determined by applying the regressed standard score discrepancy method to the obtained intellectual ability and achievement test scores using the full scale intellectual ability score and the academic achievement test score which can be converted into a standard score with a mean of 100 and a standard deviation of 15.

Socio-economic status and IQ information were not available from the school district. Metropolitan Achievement Test (1985) scores were available for only second and third grade students. The students attend an elementary school in a middle-class suburb of Seattle, Washington. All research activities take place in the regular education classrooms. Every student in the four experimental classrooms receives the hypermedia CAI intervention as a part of his/her regular reading instruction.

Materials

Basal Reader. The Macmillan Basal Reader Series-R (1983) is the adopted text for the participating school district. Selections from each book in the series (K-4) provide the basic text for the hypermedia CAI lessons. A corresponding hypermedia computer lesson was constructed for approximately 45% of the basal reader lessons for grades kindergarten through fourth. Lessons were grouped together by story content (i.e., a story in the basal containing three separate lessons has three hypermedia lessons also). Stories selected for the hypermedia lessons

were taken equally from the beginning, middle, and last sections of the books in a random fashion.

Computer Equipment. Eight Apple Macintosh Plus computers with external 3.5 inch disk drives are being used in the experimental classrooms, two per room. Students operate all computer functions through the mouse, a hand held input device. Keyboards are not attached to the computers.

HyperCard. *HyperCard* (1987) from Apple Computer is a combination operating system and authoring environment for the Macintosh computer, and currently is the most widely used hypermedia authoring system for microcomputers. It is the development system for the software used in this research.

Hypermedia CAI. Hypermedia as an educational tool is quite different from traditional CAI software which often focuses on drill and practice of isolated skills. In a hypermedia CAI lesson, words, letters, blocks of text, pictures, and parts of pictures contain links to more information than that which appears on the surface layer screen. This additional information may be presented as digitized speech, graphic representations, animated sequences, or clarifying text. By selecting specific areas of a hypermedia page with the cursor, appropriately related layers of information become accessible. Selecting a word, for example, could give a choice of the word's definition or pronunciation, or provide a picture associated with the word.

In addition to this expansion of information, movement through hypermedia pages can be left entirely to the reader to move freely throughout the document, 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 a guided exploration built into the hypermedia document.

Hypermedia CAI lessons used in this research are designed for a modified or guided exploration of the text by students. Words chosen for hypermedia enhancements include the basal vocabulary words and words relating to the phonic and structural analysis skills from the teacher's guide for that lesson. Boldface type and underlining of words indicate to students that hypermedia enhancements are available for those words, however, students are not required by the software to access these in any particular order or fashion. As illustrated in Figure 2, cursor selection of the boldface words on the original text page (top left) reveals different types of hypermedia enhancements in an educational hypermedia lesson: (a) clock, a graphic window reinforces sight vocabulary with a picture from the basal reader showing a clock; (b) closed, a text window depicts the structural analysis of the word closed; and (c) tape, a computer generated voice says the word. The software records the user's button selection sequence and the amount of time spent viewing a particular window or screen of text.

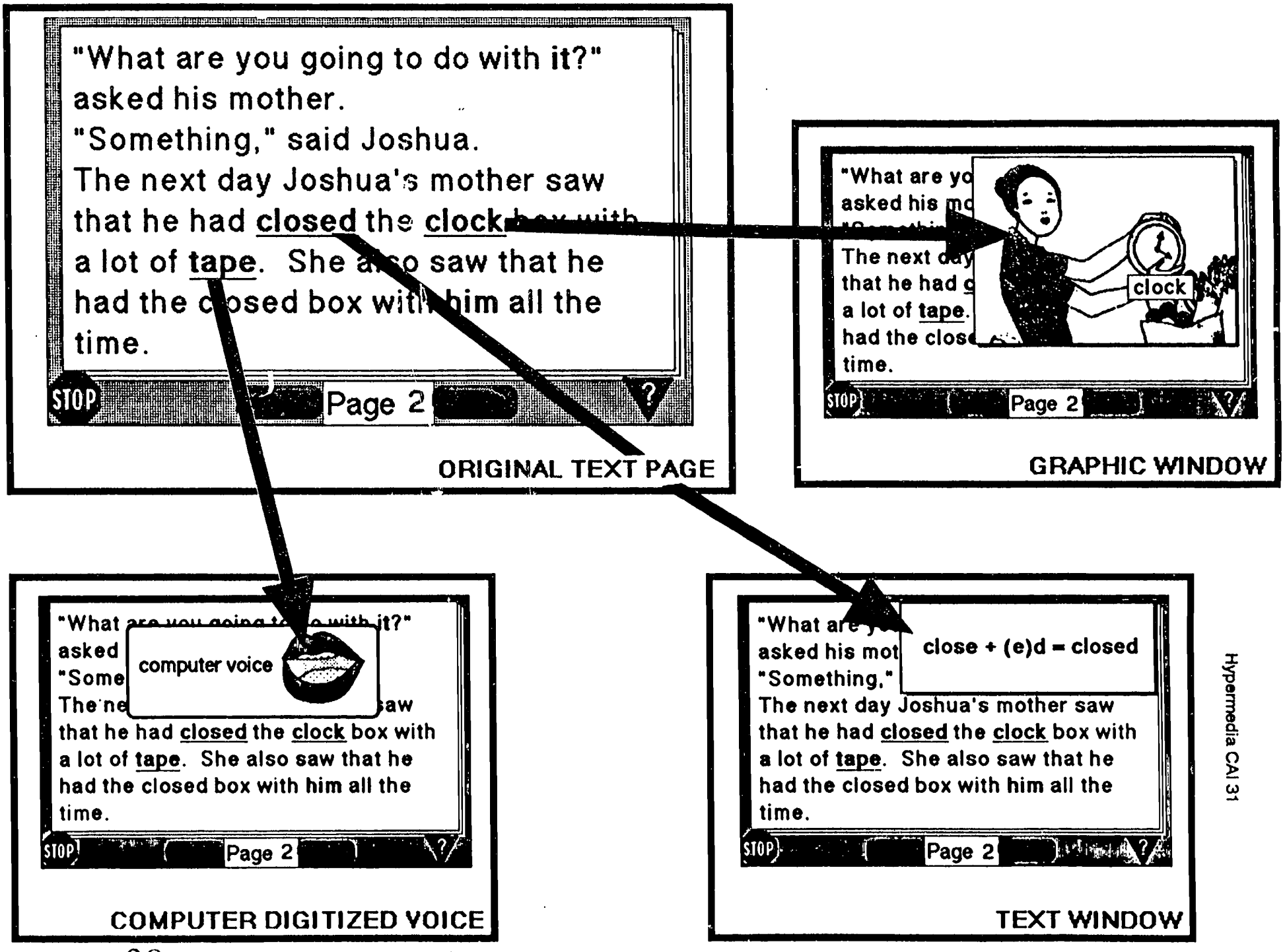

Figure 2. Hypermedia CAI enhancements.

Tests. The Macmillan standardized reading achievement test (1983) was administered to all students as a pretest and posttest measure using different forms of the same test. The tests were administered in October (pretest) and again in June (posttest).

Statistics. T-tests were performed on the data collected for the experimental and control groups to determine if the differences in means for the two groups were statistically significant. Improvement scores were computed as the difference between a student's pretest percentage score and the posttest percentage score for each section of the test (e.g., vocabulary, comprehension, total reading).

One-way ANOVAs were used to compare the results from two treatment groups defined by instructional sequence: (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.

Procedure

No artificial or intrusive pedagogy was required to implement the intervention into the experimental classrooms. The experimental design was kept consonant with the typical elementary classroom routine surrounding reading instruction. The hypermedia computer lessons were integrated into the normal working pattern of the students as they moved from the teacher directed reading groups to more independent activities and vice versa. There was no global classroom interruption or out of the ordinary protocols for the teacher or students to follow.

Training of the students in the use of the computer was conducted in the K-3 classrooms. The first session was a "get acquainted with the computer session" in which students learned the basic mechanics of using a Macintosh Plus computer. The second session was designed to acquaint the students with the hypermedia software. In this second 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.

After the students were taught to use the computer and the accompanying software, the computer lessons became an independent activity. A management schedule for computer use was developed by each teacher to fit her individual classroom management and instructional schemes. Students rotated through the computer based lessons much as they went through the teacher directed reading lessons. Each classroom had two computers for the entire day, every day. Students were assigned the computer lessons in one of the following instruction sequences: (a) teacher directed reading activity followed by a hypermedia CAI lesson, or (b) a hypermedia CAI lesson followed by a teacher directed reading activity. The speed at which the reading groups moved through the basal texts determined the number of hypermedia CAI lessons each student completed during

the course of the study.

Computer lessons were timed by an internal clock in the computer. Students were required to stay at the computer and review the lesson more than once if necessary to use the entire time allotted for the lesson. Lesson duration varied across grade levels: kindergarten lessons, 7.5 minutes; first and second grade lessons, 10 minutes; third grade lessons, 15 minutes. Hypermedia lesson length was determined by the increasing length of the basal reader stories as grade level rose, and observation of student interaction with the software during the pilot testing phases.

Students in the control classrooms had no access to the Macintosh computers or the hypermedia CAI software. The teachers in these classes used the Macmillan Basal Reader Series-R as the basis for their reading instruction program. Pretests and posttests were given at the same time in the control classrooms as in the experimental.

RESULTS

Data from Year One were examined by treatment grouping (experimental vs. control) and instructional sequence grouping (intervention either before or after teacher-directed activity). Students were ability grouped within classrooms as high, medium, or low based on three separate criteria: (a) reading group placement by teacher, (b) achievement test results, and (c) reading rate. The groups labeled as low based on each of the three definitions were considered most likely to include the students who were at risk to be referred for special education services.

Statistically significant differences between the experimental and control groups and the before-teacher-instruction and after-teacher-instruction groups are detailed in the following tables.

Experimental Vs. Control. While almost no difference is shown between experimental and control groups at any of the four grade levels when comparing entire classes, there is evidence that the intervention was a significant educational help for students defined as low by the definitions of reading group placement, achievement test results, and/or reading rate.

Low students in both kindergarten and second grade experimental classrooms outperformed their counterparts in the control classes in letter identification and total reading at the kindergarten level (see Table 2) and in comprehension in the second grade (see Table 4). There is also evidence that the low students in the first grade experimental class were benefitted by the intervention. Students in the control first grade class defined as medium and high had significantly higher improvement rates regardless of the defining criteria: (a) reading group placement, (b) achievement test results, and (c) reading rate. In the same class however, only students defined as low by reading rate did significantly better than the experimental students. Briefly, the low students in the experimental class had more similar reading gains to the low students in the control class than did the students defined as medium or high (see Table 3).

No significant differences between experimental and control students were found at the third grade level in the low reading groups (see Table 5). In the medium and high reading groups, however, students in the experimental class

showed significantly higher scores in vocabulary (medium reading group) and comprehension (high reading group).

Before Vs. After Teacher Instruction. Results concerning the efficacy of the intervention either before or after a teacher-directed reading lesson are inconclusive except for the first and second grade students in the low reading groups and third grade students in the high reading group. These students who received the intervention before their teacher directed reading activity on the same lesson generally had higher gains in reading than did those who received the same intervention following the teacher directed reading activity.

DISCUSSION

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 favorable possibilities for educational use with lower achieving students in elementary school classrooms. The most significant reading gains achieved by the experimental students were in kindergarten, first, and second grades. This success may reflect the correlation of a heavy vocabulary emphasis in the hypermedia lessons for the first year of the study with a similar emphasis on vocabulary development in the lower reading groups and in the earlier grades.

One of the most interesting findings from the study came from the first grade classrooms. The evidence that the low students in the first grade experimental class were benefitted by the intervention is based on the lack of a significant statistical difference between their reading gains and those of the low

students in the control classroom. While students in the control first grade class defined as medium and high had significantly higher improvement rates regardless of the defining criteria no difference was found between students defined as low by reading group placement or achievement test results. The low students in the experimental class had similar reading gains to the low students in the control class. One interpretation of this finding is that the intervention made a difference educationally for the low students in the experimental class thus keeping them more on a parity with the low students in the control class. A postulation may be made that the intervention provided the low students in the experimental class with a level of instruction that kept them on a more even par with similar students in the control class.

There is little conclusive evidence from the first year's data to suggest a favored instructional sequence, before or after teacher-directed instruction, for the hypermedia lessons. While low achieving students in first and second grades and third graders in the high reading group best utilized the intervention as an advance organizer, no differences were found at other levels. Once formal reading instruction has begun (after kindergarten) it would appear that the less sophisticated readers in first and second grades benefitted more from the pre-reading instruction supplied by hypermedia lessons used before the teacher-directed reading activity. It is possible that as the focus of reading instruction changes in third and fourth grade reading materials (the third grade high reading group) from word attack and vocabulary skills to more sophisticated comprehension tasks, the hypermedia pre-reading instruction may provide an added advantage to the students.

SUMMARY

Hypermedia appears to hold favorable possibilities for educational use as 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. Programs that provide hypermedia capabilities or emulation on machines other than the Macintosh include: (a.) Guide by Owl Software (1986) -- Macintosh and IBM, (b.) Linkway by IBM (1989) -- MS DOS compatible, (c.) Hyperstudio by Roger Wagner Publishing (1989) -- Apple GS, (d.) Tutor Tech by Techware Corporation (1988) -- Apple II, and (e.) Hyperscreen by Scholastic (1990) -- Apple II and GS.

Findings from this 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. Findings from a related study indicate that hypermedia study guides are an effective tool for high school remedial students and students with learning disabilities (Higgins, 1988; Higgins & Boone, in press). Whether the subject matter is from an elementary school basal reader or a content area textbook, the hypermedia format has proved 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 special education.

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Tables

Table 1: Description of Subjects by Group

	K Experimental	K Control	1st Experimental	1st Control	2nd Experimental	2nd Control	3rd Experimental	3rd Control
Numbers:								
male	12	16	12	13	10	9	9	9
female	7	8	13	11	13	11	9	10
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)
Special Education Students:	0	0	0	1 orthopedically impaired	2 learning disabled	0	2 learning disabled	1 learning disabled

Note. Scores expressed as percentage correct.
Range of test scores in ( ).

Table 2: Description of Kindergarten Subjects by Reading Group

	K Experimental			K Control		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Numbers:						
male	4	3	5	6	5	6
female	1	4	2	2	3	2
total	5	7	7	8	8	8
Age:						
mean	6.6	6.7	6.8	6.6	6.3	6.5
Race:						
Anglo	4	7	5	5	7	8
Hispanic	0	0	1	1	0	0
Black	0	0	0	0	0	0
Asian	1	0	1	2	1	0
SES:	UN	UN	UN	UN	UN	UN
IQ:	UN	UN	UN	UN	UN	UN
MAT reading mean:	UN	UN	UN	UN	UN	UN
Pre-McMillan achievement mean:	68 (51-76)	86 (81-90)	96 (92-99)	72 (62-79)	84 (80-86)	91 (90-98)
Post-McMillan achievement mean:	92* (86-99)	95 (88-100)	97* (92-99)	88 (80-94)	89 (77-98)	94 (89-97)
Pre-reading rate mean:						
corrects	16 (12-20)	22 (17-38)	26 (22-36)	18 (13-35)	18 (6-32)	22 (17-28)
errors	5 (2-6)	3 (1-6)	1 (0-2)	2 (0-3)	3 (0-5)	2 (1-3)
Post-reading rate mean:						
corrects	25 (17-31)	28 (22-38)	26 (19-36)	28 (22-37)	20 (9-29)	29 (19-38)
errors	2 (0-5)	1 (0-4)	1 (0-1)	2 (1-4)	3 (1-4)	2 (1-4)

Note. * $p<.05$

Table 3: Description of First Grade Subjects by Reading Group

	1st Experimental			1st Control		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Numbers:						
male	8	3	1	1	7	5
female	5	3	5	2	6	3
total	13	6	6	3	13	8
Age:						
mean	7.6	7.4	7.5	7.9	7.2	7.7
Race:						
Anglo	13	6	3	2	12	6
Hispanic	0	0	0	0	0	0
Black	0	0	0	0	0	0
Asian	0	0	3	1	1	2
SES:	UN	UN	UN	UN	UN	UN
IQ:	UN	UN	UN	UN	UN	UN
MAT reading mean:	UN	UN	UN	UN	UN	UN
Pre-McMillan achievement mean:	31 (0-52)	52 (28-68)	86 (66-96)	40 (33-47)	42 (38-53)	59 (43-73)
Post-McMillan achievement mean:	79 (58-98)	94 (87-100)	97 (93-100)	96 (94-98)	98* (92-100)	99* (93-100)
Pre-reading rate mean:						
corrects	51 (24-121)	92 (62-139)	128 (94-171)	26 (12-39)	72 (38-75)	84 (46-138)
errors	6 (1-10)	4 (2-6)	3 (1-4)	3 (2-4)	2 (1-8)	1 (0-3)
Post-reading rate mean:						
corrects	76 (55-128)	122 (105-155)	131 (95-188)	55 (53-57)	92 (61-110)	119 (77-175)
errors	2 (0-4)	1 (0-1)	2 (0-4)	5 (3-6)	1 (0-5)	0 (0)

Note. * $p<.05$

Table 4: Description of Second Grade Subjects by Reading Group

	2nd Experimental			2nd Control		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Numbers:						
male	5	2	3	2	2	5
female	2	5	6	3	4	4
total	7	7	9	5	6	9
Age:						
mean	8.4	8.2	8.5	8.7	8.4	8.4
Race:						
Anglo	5	5	8	4	6	8
Hispanic	1	0	0	0	0	0
Black	0	1	0	0	0	0
Asian	1	1	1	1	0	1
SES:	UN	UN	UN	UN	UN	UN
IQ:	UN	UN	UN	UN	UN	UN
MAT reading mean:	46 (8-88)	75 (36-98)	97 (84-99)	60 (28-86)	69 (58-77)	94 (90-99)
Pre-McMillan achievement mean:	63 (50-73)	82 (71-88)	96 (91-98)	62 (54-67)	74 (58-90)	93 (89-99)
Post-McMillan achievement mean:	93* (88-98)	91 (83-96)	97 (91-100)	85 (72-92)	91 (83-96)	97 (94-100)
Pre-reading rate mean:						
corrects	85 (50-116)	98 (72-138)	129 (81-162)	94 (59-122)	99 (49-112)	130 (95-163)
errors	3 (0-6)	2 (1-4)	1 (0-3)	3 (2-9)	2 (1-6)	2 (1-3)
Post-reading rate mean:						
corrects	103 (56-143)	112 (75-150)	131 (87-167)	107 (80-125)	116 (75-135)	130 (93-153)
errors	1 (0-3)	1 (0-2)	1 (0-4)	1 (0-1)	1 (0-3)	1 (0-1)

Note. * $p<.05$

Table 5: Description of Third Grade Subjects by Reading Group

	3rd Experimental			3rd Control		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Numbers:						
male	5	2	2	4	0	5
female	1	5	3	3	5	2
total	6	7	5	7	5	7
Age:						
mean	9.7	9.2	10	9.6	9.3	9.3
Race:						
Anglo	6	7	5	5	5	6
Hispanic	0	0	0	0	0	0
Black	0	0	0	1	0	0
Asian	0	0	0	1	0	1
SES:	UN	UN	UN	UN	UN	UN
IQ:	UN	UN	UN	UN	UN	UN
MAT reading mean:	55 (34-73)	73 (34-97)	92 (86-97)	67 (13-97)	77 (63-86)	82 (61-97)
Pre-McMillan achievement mean:	79 (71-83)	85 (71-95)	94 (92-95)	70 (35-91)	87 (87-91)	93 (85-96)
Post-McMillan achievement mean:	90 (83-97)	94* (88-98)	97* (95-98)	89 (72-98)	95 (92-98)	97 (88-99)
Pre-reading rate mean:						
corrects	94 (80-102)	135 (102-158)	129 (97-150)	113 (66-183)	148 (103-173)	123 (91-177)
errors	4 (1-11)	5 (1-14)	3 (0-4)	3 (2-4)	1 (0-4)	1 (0-2)
Post-reading rate mean:						
corrects	104 (93-139)	164 (94-220)	136 (108-158)	113 (70-181)	152 (115-188)	130 (112-160)
errors	4 (1-10)	1 (0-2)	1 (0-4)	2 (1-3)	0 (0)	2 (0-3)

Note. * $p<.05$