Determining Effects of Text-To-Speech Synthesis in a Multimedia Learning Environment on Science Achievement for Students with Learning Disabilities in Reading

by

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DETERMINING EFFECTS OF TEXT-TO-SPEECH SYNTHESIS IN A
MULTIMEDIA LEARNING ENVIRONMENT ON SCIENCE ACHIEVEMENT
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(ABSTRACT)

The purpose of this study was to explore the effect of text-to-speech in a
multimedia learning environment on science achievement for students with
learning disabilities in reading. The researcher examined how student
achievement on unit tests was related to their participation with the experimental
treatment. A secondary purpose of the study was to determine whether students
prefer the combination of digitized audio and text, or text alone.

The researcher used a quasi-experimental, counter-balanced, post-test-
only design for the study. Qualitative information was collected using post
experiment individual and small group interviewing techniques.

The sample used in this study was selected from students enrolled at The
Forman School, a private school specializing in the education of students with
learning disabilities. Specifically, the sample consisted of students with dyslexic
reading problems. This independent school is located in Connecticut and
currently uses multimedia in daily instruction. The sample consisted of 22
students enrolled in life science classes. The students' ages ranged from 13-19
years and the grade levels ranged from 9-12. Intact, pre-grouped students were
randomly assigned to the experimental groups.

The main thrust of the study was to examine the effect on achievement of the type of instruction (with and without text-to-speech synthesis) applied. The experimental group consisted of students who received modified multimedia instruction (treatment), including the text-to-speech synthesis. The control group consisted of students who received standard multimedia instruction; a series of texts and graphics without text-to-speech synthesis. Both lessons were identical in content and appearance, with the exception of the text-to-speech synthesis modification.

At the end of the first unit, the multimedia instruction treatment for each group was reversed. The control group from the first treatment became the experimental group of the second treatment (receiving the text-to-speech synthesized lesson) and vice versa. Each unit of instruction differed in content, so the treatments were relatively independent of each other. A t test served as the primary means of analyzing the data relative to the research hypothesis.

The findings of the study were summarized as follows:

1. The treatment group students' science achievement scores were not significantly higher than the control group students' science achievement scores when students' post-test scores were used for comparison.
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Chapter One

Introduction and Rationale

Nature of the Problem

Recently, the education community has responded to the learning problems of students with learning disabilities by devising methods and associative techniques that transcend currently used educational processes (Koscinski & Gast, 1993; Raskind, 1993; Williams, 1990). Historically, American public school academic classes have been taught by teachers lecturing and students reading. Students complete tasks on their own, usually with little guidance from the instructor (Brown, 1982). Students in a classroom setting spend approximately 1-3 hours per week, per class, listening to someone talk or watching demonstrations while they attempt to take notes. Sometime later in the instructional process, the students are typically required to duplicate, through a test or examination, what the teacher has told them or shown them. For the student with learning disabilities, this task may be overwhelming, or impossible, simply because written instructions may be incomprehensible and/or the verbal instructions may seem garbled to them (Gearheart & Gearheart, 1989; Koscinski & Gast, 1993).

Instructors are always interested in having day-to-day classroom operations run as smoothly as possible and a learning environment in which students can learn in an organized and effective manner. Many students with learning disabilities have an average or better I.Q. level but are unable to perform at or above grade level. Students with learning disabilities who experience frustration with their learning often have a disruptive effect on group-learning or classroom harmony. When students receive instructions and lessons in a manner
incompatible with their learning ability, they often fail for the wrong reasons. If the instruction set and lesson presentation are to be germane to all students' learning styles, the lessons should be presented in an organized, contiguous method regardless of the input and synthesis ability of the individual student. No presentation system is perfect, but instruction is most effective when the methods used are designed to meet the needs of a wide range of learning abilities in a classroom (Gearheart & Gearheart, 1989).

Background of the Problem

In 1969, the Learning Disabilities Act legally described children with learning disabilities as exhibiting one or more of the following disorders in listening, thinking, talking, reading, writing, spelling, or arithmetic. This included conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. Though students with learning disabilities may also have other physical, emotional, or mental handicapping conditions, the learning disability cannot be the result of these other disabling conditions (Mercer, 1991, p. 38; Wallace & McLoughlin, 1990, p. 5-6).

Persons with specific learning disabilities are capable of learning, but process information/stimuli differently (Carlisle, 1993, p. 97; Mercer, 1991, p. 276-278; Rack, Snowling & Olson, 1992, p. 29-31). Using a computer model to represent the functioning of the learning process in a student with a learning disability, it could be said that the input, output, processing, and retrieval processes are adversely affected, and while the central processing unit is intact, it is running on a different operational system. Therefore, many of the same commands given to their classmates may be lost or misread by students with
learning disabilities (Gearheart & Gearheart, 1989; Koscinski & Gast, 1993). Can we lessen the effects of the deficiencies, and therefore increase their performance (Raskind, 1993, p. 186)?

**Characteristics of children with learning disabilities.** Although persons with learning disabilities are unique human beings, with unique combinations of disabilities, there are still some common exhibited traits. Until recently research on learning disabilities has been focused on younger learners. Characteristics of a child with learning disabilities include problems in four specific areas of attention: time-on-task, focus of attention, selective attention, and certain short-term memory problems including the encoding of information. Students with learning disabilities tend to be more impulsive than other students as well as more field-dependent than other students (Bender, 1991; Gearheart & Gearheart, 1989; Mercer, 1991; Wallace & McLoughlin, 1990; Westman, 1990). The sum of the possible problems and interactions for the child with a learning disability were illustrated by Mercer (1991) with the matrix of possibilities and interactions included in Chapter Two (see Figure 2.1).

**Adolescents with learning disabilities.** The characteristics of the adult and adolescent with learning disabilities are similar to those of children with learning disabilities. Similar to elementary school students with learning disabilities, adolescents with learning disabilities typically score below the tenth percentile on achievement tests in reading, written language and/or mathematics. Furthermore, they tend to perform poorly in other achievement areas as well (Mercer, 1991, p. 51). Many students with learning disabilities display social-
skills deficiencies, including problems in giving feedback, accepting negative feedback, negotiating, and coping with peer pressure. In addition, adolescents with learning disabilities may experience problems with accepting and abiding by the demands of the settings (i.e., work, school, team sports, etc.) in which they live, which are necessary for their success (Bender, 1992; Gearheart & Gearheart, 1989; Mercer 1991; Wallace & McLoughlin, 1988; Westman, 1990).

Finally, the most important and disconcerting factor, is the academic skill development of adolescents with learning disabilities tends to level off during their middle school to junior high school years. The cumulative-academic-deficit (sometimes called the academic plateau) can inhibit their academic performance in the later secondary school years. This plateauing seems to occur during middle school years because of the relationship of the disability to the reading level of the student versus the reading level of the instruction being given (Bender, 1992; Gearheart & Gearheart, 1989; Mercer, 1991; Westman, 1990). (A more detailed discussion of the subject, appears in Chapter Two, pages 22-24.)

Mainstreaming and inclusion. The current trend in ability grouping, both in practice as well as in law, is to include all students into the “mainstream” of education. The Vocational Education Act of 1963 (Public Law 88-142), Public Law 94-142--The Education of all Handicapped Children Act, the Rehabilitation Act of 1973, sections 503 and 504 combined with amendments of 1976 Public Law 94-482 and the Individuals with Disabilities Education Act (IDEA) of 1990, mandated the states to identify and educate, in the least restrictive environment, students with disabilities of all kinds, including students that fit the U. S. Office of Education's description of children with learning disabilities. Specifically,
children were to be, and are presently being, placed more frequently in the "least restrictive environment" of regular education classrooms. The problem here is that if the instructional rate is too rapid, students with learning disabilities can become frustrated. Even though a student learning disabilities may have normal-to-high intelligence, problems with the information processing of the materials to be learned could be a dilemma for both the teacher as well as the learner (Center, 1993, p. 4-5). The student's frustration with the learning process and with their own disabilities can manifest itself in inappropriate behaviors (Bender, 1992; Center, 1993, p. 4-5; Gearheart & Gearheart, 1989; Gettinger and Fayne, 1982; Mercer 1991; Slate & Saudargas 1986; Wallace & McLoughlin, 1988; Westman, 1990). Since hyperactivity is a common trait among students with learning disabilities, it stands to reason that these children are more likely to be hyperactive, to have deficits in attention and cognitive problems, and therefore, to have more problems with appropriate classroom behavior than other students (Alabiso & Hensen, 1977; Bender, 1992; McKinney & Feagans, 1982).

Multimedia and hypermedia instruction for students with learning disabilities. Multimedia is thought of as the combination of audio/visual and computer-generated information, with a computer and monitor. Hypermedia refers to the nonsequential or nonlinear linking of multimedia (Myers, 1993, p. 2). Multimedia instruction has proven to have a distinct advantage in helping students with learning disabilities do remedial work (Raskind, 1993; Koscinski & Gast, 1993; Barba & Armstrong, 1992; Knowles, 1992; Williams, 1990; Gay & Mazur, 1989; Gearheart & Gearheart, 1989; Harwell, 1989). Hypermedia has the ability to allow the learner to be "an active participant" in the learning process, which is a

Individual multimedia workstations can allow students to maintain their own pace and place of learning within a group classroom setting. The learning interface can be individualized to match the learning characteristics of each participant (Ayersman, 1993; Becker, 1990; Clark, 1989; Darrow, 1993; Grabowski et al, 1989; Grabowski, 1989; Megarry, 1988; Cognition and Technology Group at Vanderbilt, 1990). Students with learning disabilities, when assisted by multimedia workstations, can gain success in education that is imperative for their success in later life (Gearheart & Gearheart, 1989; Harwell, 1989; Koscinski & Gast, 1993).

Purpose of the Study

The purpose of this study was to determine if the use of a text-to-speech feedback in a science multimedia instructional program facilitates science achievement scores of secondary school students with learning disabilities. A secondary purpose of this study was to determine if students prefer the combination of digitized audio and text, or text alone.

Significance of the Study

If school districts are investing in multimedia software for instruction in the classroom, are there any features that can be beneficial to the student with learning disabilities, without being detrimental to the rest of the students? This study was conducted in light of the expressed and mandated need of the education community to reach special population students more effectively considering the current trends in school district purchasing patterns (Ayersman,
Ayersman (1993) stated that Computer Aided Instruction (CAI) can be used to reach the “uniquely different segments of the learner population” (p.2). Specifically he reminds us that not all students have done equally as well from learning with computers; “Specific groups of students (i.e., low ability) have been the ones to benefit the most from CAI” (p. 2). He goes on to state “... this multi-modal approach to learning can benefit students who have often been neglected by more traditional forms of instruction” (p. 2).

Students with learning disabilities have problems in encoding and decoding information for storage, processing and retrieval (Mercer, 1992, p. 277). Ausubel (as cited in Sprinthall & Sprinthall, 1990) suggests that “concept formation depends on which characteristics a person chooses to focus upon ... The dual-code theory of information processing emphasizes a multi-modality approach to instruction which allows the information to be received and then reinforced utilizing more than one of the five senses. Since [these] students can have imaging and/or verbalizing preferences, this dual-coding is doubly beneficial” (p. 293).

Students receiving instructional software with color, sound, and animation performed better than those students who received instructional software with black and white images without sound and animation (Havita & Reingold, 1987). Barba and Armstrong (1992) examined hypermedia-assisted instruction with and without interactive video, and found that, depending on the disability, the linking of modalities can have obvious advantages. Raskind (1993) writes that text-to-speech synthesizing word processors “can be powerful tools
for those whose oral language skills are superior to their written language abilities” (p. 189). This idea of technology compensating for human shortcomings is not new in special education; prosthetics have been used for many years, but the currently used name for this application of new technology is called “assistive technology” (Ayersman, 1993).

The literature in learning disabilities suggests that if you can reach students in a manner that is not inhibited by their learning disabilities, you can educate them more closely to a normal classroom rate (Ayersman, 1993; Barba & Armstrong, 1992; Milhiem, 1990; Raskind, 1993; Center for Special Education Technology, 1990). A new teaching method—one that circumvents their disabilities—might also combat the students’ negative perception of learning and thus allow them to learn with more enthusiasm (Gearheart & Gearheart, 1989; Harwell, 1989; Koscinski & Gast, 1993).

Though treating a negative self-concept, especially for students with learning disabilities, is not a focus of study, keeping students interested in learning is a goal of good teaching. Since students with learning disabilities have plateaus in their learning as a consequence of their disabilities, exposing them to other modes of learning might compensate for their reading difficulties (Ayersman, 1993; Barba & Armstrong, 1992; Gearheart & Gearheart, 1989; Harwell, 1989; Koscinski & Gast, 1993; Milhiem, 1990; Office of Special Education Programs, 1992). Since much of the information taught is written, students with reading deficiencies suffer the most.

Research Question

This study addresses the following research questions:
1. To what effect does the use of a text-to-speech synthesis feedback in a science multimedia instructional program facilitate the science achievement scores of secondary school students with learning disabilities?

2. Do these students prefer the combination of digitized audio and text, or text alone?

Assumptions

The following assumptions were made with regard to this study:

1. Participating teachers followed the established syllabus while implementing the treatment.

2. The variability of the students' limitations (i.e., learning style, I.Q., degree of disability) were equally distributed across groups by random assignment and would have an equal impact on both treatment and control groups.

3. The participants honestly reviewed and responded to the multimedia program presented to them.

4. Instruments used to measure the students' achievement were tested and proven to be reliable.

5. The researcher was effective in training participating teachers in the proper procedures for implementing the software and instructional package.

6. The teachers of both the treatment and control groups were qualified to present and instruct the science subject matter used.

Limitations

The following was a limitation of this study:

1. The special school from which the subjects were chosen was used because this school's population offered access to a relatively homogeneous grouping of
students with learning disabilities. Finding a similar pool of subjects in the general population, that is, in regular public schools, would be problematic, since learning disabilities exist naturally in only about 4% of general school age children (Chalfant, 1985). Thus, the source from which students with learning disabilities in reading were to be drawn had to have a sufficiently large number of students with learning disabilities in the population.

Delimitations

Delimitations were necessarily imposed on this study because of time, financial, and access constraints.

1. The study was confined to students in grades 9-12.
2. The sample was drawn from one school which expressed an interest and a willingness to participate in this study.
3. Delivery of each unit was limited to 7 days in length.
4. The science content of the units was limited to that contained in the Life Story curriculum (Sunburst Wings for Learning, 1993).

Operational Definitions

Dyslexia. A student's severe difficulty in learning to read, including behavioral manifestations of central nervous system deficits or dysfunctions, gender or inherited causation, maturational lag, and inability to read through regular classroom methods (Mercer, 1991, p. 497).

Educational hypermedia/multimedia. The combination of hypermedia information with computer-generated information for instructional or display purposes.
Digitized audio. Audio that is digital in nature, rather than analog; therefore, it can be readily utilized by computer programs for sound reproduction used in applications such as music and voice.

Text-to-speech synthesis. Text displayed on screen that is subsequently processed by an algorithm to convert it to digital audio, which can then be artificially “spoken” by a computer through a speech synthesizer. “Text-to-speech [synthesis] systems translate ASCII characters (text) into phoneme characters ...[these characters are] then converted into the digital data needed to make sounds” (Anderson-Inman, Adler, Cron, Hillinger, Olson, Prohaska, 1990, p. 360).

Hypermedia. The nonsequential or nonlinear links involving multiple forms of media such as full motion video, audio, still frame pictures, and animation (Myers, 1993, p. 2)

Hypertext. The connection of ideas in a nonsequential and nonlinear fashion, usually used in a hypermedia context. “The process of creation, storage, and retrieval of nonlinear ideas and information.” (Fraase, 1990, p. xxvii)

Learning disability. According to the literature, the following definitions are currently most accepted (Bender, 1992; Mercer, 1991; Westman, 1990; Gearheart & Gearheart, 1989; Wallace & McLoughlin, 1988):
Specific learning disability[ies] is a chronic condition of presumed neurological origin which selectively interferes with the development, integration, and/or demonstration of verbal and/or nonverbal abilities. Specific learning disabilities exist as a distinct handicapping condition in the presence of average to superior intelligence, adequate sensory motor systems, and adequate learning opportunities. The condition varies in its manifestations and in degree of severity. The condition can affect self-esteem, education, vocation, socialization, and/or daily living activities. Association For Children and Adults with Learning Disabilities (as cited by Mercer, 1992, p. 43).

Learning Disability is a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, and mathematical abilities. These disorders are intrinsic to individuals and presumed to be due to central nervous system dysfunction. Even though a learning disability may occur concomitantly with the other handicapping conditions (such as sensory impairment, mental retardation, social and emotional disturbance) or environmental influences (such as cultural differences, insufficient or inappropriate instruction, psychogenic factors), it is not the result of those conditions or influences. (As Cited by Hammill, Leigh, McNutt, & Larsen, 1981, p. 336).

*Reading difficulties.* The student's reading achievement is significantly lower than what would normally be expected, given the student's age,
intellectual ability, and school experience. The student might be experiencing difficulty in any aspect of reading; for example, comprehension, and decoding ability (Gearheart & Gearheart, 1985, p. 17).
Chapter Two  

Review of Related Literature

Introduction

The contents of this chapter provide support for the experimental treatment used in this study: assistive technology—specifically text-to-speech voice synthesis in multimedia instruction. This chapter details the experimental treatment and provides support for it from the literature. It elaborates on the information provided in Chapter One, which gave examples of the various learning systems available in the computer-aided instructional environment for special needs learners with reading deficiencies. Furthermore, this chapter presents an overview of pertinent educational theories in learning disabilities, instructional technology, multimedia in related learning environments, assistive technology, and computer applications, including a technical discussion of the differences and advantages of using text-to-speech synthesis over digitized audio in text-based multimedia applications. Finally, the specific research on the effects of speech synthesis on the instruction of students with learning disabilities is reviewed in detail.

Definitions of “Learning Disability”

Definitions of “learning disabilities” are abundant, and there is little agreement on any one definition. This lack of agreement exists for two main reasons: 1) the different theories about why learning disabilities exist, each having different reasons for what causes the disability, resulting in different definitions, and 2) since most schools use federal money for some part of their
special education budget, the funding system is tied to the federal government's definition of who may receive aid for special needs, which includes children with learning disabilities.

The National Advisory Committee on Handicapped Children (NACHC) developed the following definition which was accepted by the federal government in the Learning Disabilities Act of 1968:

Children with special learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written languages. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling, or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include tolerating problems which are due primarily to visual, hearing, or motor handicaps, to mental retardation, emotional disturbance, or environmental disadvantage (U. S. Office of Education [USOE], 1968, as cited in Mercer, 1991, p. 38; Wallace & McLoughlin, 1988, p. 5-6).

The Special Education Act -Public Law 94-142 of 1975 stated that learning disabilities are included under federal funding of special education, but did not provide a definition. In 1977, the Federal Register sought to define the term for standardization reasons, and released a definition designed to define and identify students who could receive funding under Public Law 94-142. It reads almost identical to the NACHC definition listed above:
"Specific learning disability" means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to write, spell, or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, or emotional disturbance, or of environmental, cultural, or economic disadvantage (USOE, 1977, 65083, as cited by Mercer, 1991, p. 39).

In 1986 the need for further refinement of the definition process was prompted by the Association of Children with Learning Disabilities (now the Learning Disabilities Association of America) who proposed their own:

Specific learning disabilities is a chronic condition of presumed neurological origin which selectively interferes with the development, integration, and/or demonstration of verbal and/or nonverbal abilities. Specific learning disabilities exist as a distinct handicapping condition in the presence of average to superior intelligence, adequate sensory motor system, and adequate learning opportunities. The condition varies in its manifestations and in degree of severity. The condition can affect self-esteem, education, vocation, socialization, and/or daily living activities (as cited in Mercer, 1991, p. 43).
In 1987, the Interagency Committee on Learning Disabilities (ICLD) proposed a definition to Congress differing from the NJCLD definition only slightly in relation to the emphasis on social skills. The differing statement is: "Learning disabilities ... refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities, or of social skills" (ICLD, 1987, p. 222, as cited by Mercer, 1991, p. 43). This is the most straightforward definition of a learning disability.

The most recent law to attempt to clarify the definition of a "specific learning disability" was the Individuals with Disability Education Act (IDEA) of 1990. The Act is an updated version of the Education for All Handicapped Children's Act of 1975 (P.L. 94-142). The new definition includes criteria for determining whether or not a child may have a specific learning disability. The criteria are:

(1) when provided with learning experiences appropriate for his or her age and ability, the child does not achieve what would be expected for someone of his or her age and ability in

- oral expression, or
- listening comprehension, or
- written expression, or
- basic reading skill. or
- reading comprehension, or
- mathematics calculation, or
- mathematics reading,
(2) the team finds that there is a "severe discrepancy" between the child's intellectual ability and what he or she is actually achieving in one or more of these listed areas. (National Association of State Directors of Special Education, p. 34-35)

Neither IDEA nor its regulation define the term "severe discrepancy," this was left to each state's law or interpretation.

Characteristics of learners with learning disabilities. Most of the research in learning disabilities until recently has been focused on the elementary school child (Bender, 1992; Mercer, 1991; Westman, 1990; Gearheart & Gearheart, 1989; Wallace & McLoughlin, 1988). Bender (1992) provided a brief list of common, but not inclusive, characteristics of a learning disabled child:

Students with learning disabilities typically:

... demonstrate problems in three areas of attention, [those being] time-on-task, focus of attention, and selective attention.

... demonstrate certain memory problems which involve encoding information for memory storage. Typically these students do not demonstrate long-term memory problems.

... tend to be more impulsive than students who are not [learning disabled].

... tend to be more field-dependent than other students (p. 154).

A display of the possible problems and interactions for the learner with a
learning disability were illustrated by Mercer with this "matrix of possibilities and interactions," in Figure 2.1 (1991, p. 53). The possible interactions of the various combinations allows each learner to be different, and therefore, educational strategies must be different for each learner. One added dimension to Mercer's matrix (noted in the reading but not shown on the diagram) is severity. Each child could have differing amounts of each of the categories, thereby making each "affliction" 3-dimensionally unique from one another (Bender, 1992; Mercer, 1991; Westman, 1990; Gearheart & Gearheart, 1989).
Figure 2.1

Mercer's matrix of characteristics of learning disabilities.
Learning disabilities specific to reading and learning. The kinds of learning disabilities differ with the individual who has the disability, since no two disabilities are alike. There are general guidelines for classifying disabilities, to help guide the educator in whatever specific area the learner will need assistance. The following general categories are used in diagnosis: discrepancy factor, academic learning difficulty, language disorders, perceptual disorders, meta-cognitive deficits, social-emotional problems, memory problems, motor disorders, attention problems, and hyperactivity (Mercer, 1991, p. 45-49). Although all of these categories are influential in determining effects on a learner, this study only focuses on the effects of the first three: discrepancy factor, academic learning difficulty, and language disorders.

The discrepancy factor is present in most of the definitions of learning disabilities and is considered to be the “common denominator of learning disabilities” (Mercer, 1991, p. 45). The discrepancy factor is the difference between the estimated ability and the academic performance of a student. A significant difference between the two is an indication that there might be a learning disability. Both Mercer (1991) and Bender (1992) specify in their discussions that the discrepancy factor may be present in one or more skill areas. These skill areas include: basic reasoning skills, reading comprehension, math calculation, math reasoning, written expression, oral expression and listening comprehension (Mercer, 1991, p. 53). The difference is measured using a combination of achievement test batteries and intelligence tests.

Academic learning difficulty is the most widely accepted characteristic of learning disabled individuals. It is loosely defined as a student's difficulty comprehending one or more specific subject areas. The 1977 identification
criteria are "basic reading skill, reading comprehension, written expression, mathematics calculation, and math reasoning" (Mercer, 1991, p. 45). This learning difficulty can manifest itself with a subject area that is difficult to comprehend, such as in a student's statement of despair: "I can't learn math." A student's poor performance in math, especially when he/she is putting forth effort and studying hard, may indicate an academic learning difficulty (Mercer, 1991; Bender, 1992).

The final category is language disorders involving difficulties in both the written and spoken language. This characteristic is very prevalent in students with learning disabilities, affecting 50 to 90 percent of these learners by some estimates, although these estimates are uncertain in part due to language limitations in younger children. This dysfunction is extremely important to learning because the methods of instruction used in education rely so heavily upon the written and spoken language (Bender, 1992; Gearheart & Gearheart, 1989; Mercer, 1991; Wallace & McLoughlin, 1988; Westman, 1990). How can an individual learn if he or she can't read, or comprehend speech well?

Reading and reading comprehension problems are a central component of language disorders. "The student's reading achievement is significantly lower than what would normally be expected, given the student's age, intellectual ability, and school experience" (Gearheart & Gearheart, 1985, p. 17). This difficulty could be manifested in any aspect of the reading process, for example: comprehension, decoding ability, eye movement, etc. (Balota, Flores d'Arcais, & Rayner, 1990, p. 159; Gearheart & Gearheart, 1985, p. 17).

*Cumulative deficit and academic plateau.* During the middle school and early secondary grades, the reading deficiency arrests the academic skill
development of adolescents with learning disabilities. The farther they progress in their schooling, the farther they fall behind their peers. The "cumulative-deficit," this academic plateau, can inhibit academic performance in the latter secondary school years, as academic growth stops. This deficit usually occurs at the sixth to seventh grade level, because of the relationship of the reading level of the learning disabled student versus the reading level of the instruction being given. Students do not seem to be able to progress rapidly beyond these academic plateaus (Bender, 1992; Mercer, 1991; Westman, 1990; Gearheart & Gearheart, 1989). If a handicapped student is operating at a 75% efficiency rate, falling behind 25% the first year may not be a severe problem but, after four years falling behind at this same rate, the student would be one full year behind. By the time the student reaches high school, this translates into being 3-4 years behind, producing a deficit that is not readily overcome (Bender, 1992, p. 174-177). Adding to this problem is the usual reading level of textbooks, which are typically several years above the grade level of intended use (Bender, 1985; Bender, 1992; Johnson & Varidan, 1973). Bender (1992) illustrates the problem of plateauing in high school with the following scenario:

"... a student with learning disabilities is in a ninth-grade history class, the student's reading comprehension is fourth-grade level, and the text is written at a twelfth-grade level. Clearly, this student has virtually no opportunity to master this class unless major modifications are made in some fashion" (p. 174).

Plateauing in the secondary school is a limiting factor, and the
recommended treatments for students with learning disabilities in the current
textbooks for teachers is broken into four categories: remedial, corrective,
learning strategies, and compensatory treatments. Yet, of the most commonly
recommended specific treatments, the ones “with most research and/or expert
support” (Mercer, 1991, p. 50), few are in the compensatory categories. In most
teacher’s texts for grades 7-12, there are no compensatory recommendations.
Only when you look at the instructional recommendations for adult learners, are
there any suggestions for compensatory instruction which include “… aids, such
as tape recorder, calculator, computer” (p. 50). How can one possibly get these
learners beyond the plateau effect without effective teaching methods? Are
students with learning disabilities supposed to lose 1-2 years while learning to
read and write at the high school level, and then lose another 1-2 years at the post
secondary level? (Balota, et al., 1990; Bender, 1992; Gearheart & Gearheart, 1989;
Mercer, 1991; Westman, 1990)

Mental processing and comprehension in reading. The population with
learning disabilities is inherently unique and, similarly, each learner with a
disability is unique. As with all individual human traits, such as hair color, eye
color, height-weight ratio, and personality, learning disabilities also differ for
each person. Language disorders, and specifically reading disorders, are based
upon the lack of ability to understand or apply the rules of that language. There
are five components in language: phonology, morphology, syntax, semantics,
and pragmatics. These components of language are not formally taught, and
many of the rules of language are learned before a student comes to school
(Gearheart & Gearheart, 1992). Students learn by listening to and using language.
A problem exists when a student cannot use the language rules at the level of his or her peers; this problem is the disability. In Conners and Olson's recent study of listening skills in relation to reading skills between dyslexic students, normal students, and students with a reading level equal to that of the dyslexic students, the dyslexic students were found to have lower written/verbal and listening skills than their peers, equal reading skills with their reading performance matched group, and higher listening skills than the performance matched group. Furthermore, they go on to state “most dyslexics in our sample were uniquely deficient in word recognition... [the] first step [for remediation] for these subjects is to significantly improve their word recognition. Recent research with computer-based reading and speech feedback... has shown substantial gains for dyslexic readers.” (Conners and Olson, 1990, p. 577). The link between dyslexic readers and listening/reading skills is based on word recognition. If a student does not have the reading skills- (i.e. the visual word recognition skills), might not a listening- word recognition treatment aid their overall word recognition skills and performance?

Multimedia, hypermedia and instruction for the learning disabled. As previously discussed, multimedia is commonly thought of as the combination of audio/visual and computer-generated information, with a computer and screen for instructional or display purposes. Hypermedia is the nonsequential or nonlinear linking of multiple forms of media such as full motion video, audio, still frame pictures, and animation (Myers, 1993, p. 2). Multimedia and hypermedia are random, having instant access in linear and non-linear pathways (Fraase, 1989). This fact is a direct advantage for the child with learning
disabilities where the pathways of learning may be uniquely, and sometimes vastly, different for each child (Gearheart & Gearheart, 1989; Harwell, 1989; Koscinski & Gast, 1993).

Multimedia instruction has proven to have an advantage in assisting students in remedial work (Koscinski & Gast, 1993; Barba & Armstrong, 1992; Gay & Mazur, 1989; Knowles, 1992; Raskind, 1993; Williams, 1990). Anandam and Kelly (1981, p. 239) stated that interactive video, a form of multimedia, has "changed the student from a passive observer to [an] active participant." This "change" is a good idea and should be kept in mind when designing multimedia and hypermedia for diverse audiences, such as students with learning disabilities (Milhiem, 1990).

Multimedia workstations can allow students with special needs to maintain their own pace for learning within a standard classroom setting. The learning instruction may be individualized to match the learning characteristics of each person (Ayersman, 1993; Becker, 1990; Clark, 1989; Cognition and Technology Group at Vanderbilt, 1990 [Vanderbilt]; Darrow, Darrow, & Yates, 1993; Grabowski, Clark, Yacci, Pask-McCartney, & Slee, 1989; Megarry, 1988). While each person naturally applies his or her unique needs, talents, and perspectives to all situations encountered in life, the school setting allows students to solve problems and experience true-life situations vicariously, in a safe environment. Students with learning disabilities, with their special needs, can be assisted by multimedia workstations (Gearheart & Gearheart, 1989; Harwell, 1989; Koscinski & Gast, 1993). The computer, therefore, can be a prosthetic for the child with a learning disability; specifically, it may enable students with reading disabilities to keep pace with their peers through the use
of software (Darrow, 1993; Raskind, 1993; Williams, 1990; Center for Special Education Technology, 1990).

Ayersman (1993) stated that computer-aided instruction can be used to reach the "uniquely different segments of the learner population." Specifically he reminds us that not all students have done equally well learning from computers: "Specific groups of students (i.e., low ability) have been the ones to benefit the most from CAI" (p. 2). Furthermore, he goes on to state "[t]his multi-modal approach to learning can benefit students who have often been neglected by more traditional forms of instruction" (p. 2).

Different types of instruction, including instructional technology, if done well, will yield similar, positive results (Thompson, Simonson & Hargrave, 1992). Recently researchers in CAI, hypermedia, and other instructional technologies have focused their attention of "learner attributes" compared with different presentation modes (Ayersman, 1993; Thompson, Simonson & Hargrave, 1992). Learner attribute research examines how specific types of learner traits interact with different methods of instruction, and though no significant difference can be shown with many learner traits, learning disabilities are not considered "learner traits" or "preferences" (Clark, 1983, 1985; Thompson et al, 1992; Vanderbilt, 1990). The attributes of students with learning disabilities define the interference of the input, processing, and output functions of the brain in a person (Harwell, 1989). The modes of input, or channels, are the key link in the use of multimedia instruction with students with learning disabilities (Ayersman, 1993; Carlisle, 1993; Darrow et al, 1993; Koscinski & Gast, 1993; Thompson, et al., 1992; Vanderbilt, 1990).
**Assistive technology.** Assistive technology serves the learner with a disability by allowing the learner to cope with or lessen the effects of the specific disability, without being concerned with a complete remediation of the disability. "Assistive technologies" used for learning disabilities are a recent development. Because the advent of high-powered personal computers and related software technologies in the speech synthesis area, has taken form in the past five years, many of the applications and related solutions were not previously viable. The ability to generate speech from text-based documents opens a world of possibilities for sight-impaired or reading disabled learners (Anderson-Inman, et. al., 1990; Ayersman, 1993; Darrow, et. al., 1993; Raskind, 1993). According to Raskind (1993), assistive technology is not designed to remediate or fix disabilities, but rather is to be used as a strategy to compensate for or "circumvent" the disability; furthermore, he points out that experts in the field of learning disabilities have "all but ignored assistive technology" (p. 185).

*Research on Text-To-Speech Synthesis and Digitized Audio*

Weiner (1991) reviewed Jones, Torgesen & Sexton; Torgesen, Waters, Cohen & Torgesen; and Olson & Wise's speech/text/audio /computer based instructional studies and suggested the following three potential advantages to having speech output in educational software: 1) "... involving students more actively in the instructional process by utilizing their sense of hearing as well as sight;" 2) "... providing an alternative channel of communicating with students who are visually impaired or have visual-perception problems;" and 3) "... conveying certain kinds of semantic information usually carried by complex emphasis patterns in speech" (p. 101). Furthermore she states "that digitized
speech should be considered for inclusion in reading software intended for use by mildly handicapped learners."

As mentioned in Chapter One, Havita and Reingold (1987) found that students receiving instructional software with color, sound, and animation performed better than those students receiving instructional software with black and white images without sound and animation. Barba and Armstrong (1992) examined hypermedia-assisted instruction with and without interactive video. They found there was no significant difference for the general population students, but there was a significant difference for the low verbal ability group. This difference was attributed to the effects of the multi-modal presentation of information (interactive video) to a group of learners who “obviously rely on visual information to understand concepts” (Ayersman, 1993, p. 12). Depending on the disability, the linking of modalities can have obvious advantages. Raskind (1993, p. 189) writes that text-to-speech synthesizing word processors “can be powerful tools for those whose oral language skills are superior to their written language abilities.”

Current literature in the field of teaching reading to students with learning disabilities show the decoding fluency of poor readers could be increased substantially with the use of reading software (Roth & Beck, 1987). Jones, Torgesen and Sexton (1987) increased students with learning disabilities' fluency in grapheme-phoneme correspondence and word-analysis skills by 30%. The increase followed 15 minutes of computer practice per day, over a period of ten weeks. In a study of error rates in a CAI (drill and practice) program with students with learning disabilities testing text versus text and speech, McGregor, Drossner and Axelrod (1990) found an average reduction of errors by 3-8%, with
a high reduction rate of 19% (p. 195). In another study by Wise and Olson (1994) using computer speech for the remediation of spelling problems, phonological decoding and word recognition have improved (17%). In the same study the increase in ability to spell correctly was only "marginally increased" (p. 217). In Borgh and Dickson's (1986) related study in voice speech synthesis to a word processor, 68% of the 48 students involved increased their "lower level editing skills" (represents the sum of typing error, spelling and punctuation correction) and 46% of the students increased their "higher level editing skills" (the sum of changes at the single word, multiple word or phrase and whole sentence levels) (p. 13). Barron and his colleagues (1992) found nonreaders phoneme detection (awareness) rate can be improved when given computer speech feedback. The lower ability students had 3-times the significance level as the higher ability group, further supporting the previous research on lower ability achievement with computer aided instruction. ". . . the only significant increase in rhyming skill were made by children with low letter-sound knowledge. Their performance increased to the level of the high letter-sound group. . . (p. 200)"

Speech synthesis and audio have been used with word processors and with remediation reading and related problems, yet there are few studies using "large scale" speech synthesis feedback for instruction. Now that text-to-speech synthesis is at an "acceptable level of quality, this should change" (Anderson-Inman, Adler, Cron, Hillinger, Olson, & Prohaska (1990). If the rate of word recognition can be increased and the rate of spelling errors decreased, the work of Anderson-Inman et al. (1990), Darrow, M., Darrow, J., Yates (1993), Dickson (1986), and Wiener (1991) clearly indicates the need to apply text-to-speech synthesis in a multimedia learning environment with students with learning
disabilities, such as dyslexics.
Chapter Three

Methodology

Introduction

Details of the experiment are discussed in four sections. The first section of this chapter focuses on the design of the study and includes five subdivisions: hypotheses, sample, research design, instrumentation, and data analysis. The procedures followed in organizing and conducting the study are outlined in the second section. This section clarifies how the study was implemented in the school and how the data was collected and provides a detailed explanation of how the unit plan, treatment group materials, and control group materials were developed. The third section focuses on the development and validation of the post-test only unit cognitive measures used in this study. Processes for creating, field testing them, and assessing the instruments are described and reliability estimates are reported.

In the fourth section the procedures used in collecting the non-experimental data are provided. Data collection techniques, methodology, guiding theories, and the procedures for the integration of said data with the experimental results are examined.

Design of the Study

The purpose of this study was to examine the effectiveness of text-to-speech synthesis in a multimedia learning environment on students with specific learning disabilities in reading. The researcher examined whether students' achievement was related to the mode of presentation (with text-to-speech--audio or without text-to-speech--audio) of information in the experimental treatment.
The researcher used a quasi-experimental, counter-balanced, post-test only design for the study (Campbell & Stanley, 1966, pp. 50-52).

**Hypothesis**

Based on the review of literature and research questions posed in Chapter One, the following research hypothesis was stated:

Students learning disabilities studying a multimedia science unit with a text-to-speech synthesizer (treatment group) will have higher overall science achievement levels than students studying the unit without a text-to-speech synthesizer (control group), controlling for prior overall science knowledge and comprehension by random assignment.

**Sample**

The sample was selected from students enrolled in The Forman School, a private school in Fairfield Connecticut, specializing in the education of the students with learning disabilities, specifically those with dyslexic reading problems. This independent school was chosen for two reasons: 1) They pooled the subjects in a convenient and homogeneous grouping. 2) There were consistent data available in the form of standardized test results and psychological examinations of the sample population. Because of the narrow range of population being studied, and their rarity, such groupings do not occur in regular public schools, making access to the population problematic. Because of the heterogeneous nature of learning disabilities in general, this school evaluates students for admission to their educational programs. Formal batteries
of cognitive, achievement, and other psychological tests were used to determine if a student has learning disabilities. In this way a homogenous pool of subjects could be identified.

The sample consisted of 22 students chosen from the general population of The Forman School. Students chosen were randomly assigned to the control and experimental groups. The researcher assured the students that confidentiality would be maintained and that only group data would be used in the determination of the results, and then notified students and parents of the location and time requirements of the experiments. Table 3.1 shows the breakdown of the sample, control and treatment groups.

The researcher first proposed the study to the school's officials and administrators, who then decided which teachers' classes in their schools would be available for this type of study. The school's administrators introduced the researcher to the classroom teachers. The researcher then sought the active participation of the individual teachers. The treatment was randomly assigned to one half of each of these classes. The other half served as control group students. Table 3.2 lists the I.Q., grade and reading levels of the treatment and control groups.

The students' ages ranged from 13-19 years and the grade levels from 9-12. They had been tested with the Wechsler Intelligence Scale for Children, Revised (WISC-R) and the Peabody and WRAT standardized Reading Level Test. The tested I.Q. range of the students used in the study was 79-128 with a mean of 109.4 (Table 3.2). The tested reading levels of the students ranged from range 6-16. The Forman School offered caution with respect to the interpretation of grade reading level data (see Appendix A for The Forman School's official
statement regarding reading test data provided).

To comply with the university requirement of ethical treatment of subjects, mandatory for subjects under the age of eighteen, the researcher applied for permission to conduct the study. The study design, procedures, and timeline were reviewed and approved for one calendar year by the Virginia Tech Internal Review Board. (See Appendix B for a complete set of Internal Review Board documentation.)
Table 3.1

*Number of Students in Sample*

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>12</td>
</tr>
<tr>
<td>Two</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
</tr>
</tbody>
</table>
Table 3.2

*Mean Students’ I.Q., with I.Q., Grade, and Reading Level Ranges*

<table>
<thead>
<tr>
<th>Group</th>
<th>I.Q.-M</th>
<th>I.Q.</th>
<th>Grade</th>
<th>Reading levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>112.42</td>
<td>79-128</td>
<td>9-12</td>
<td>6-16</td>
</tr>
<tr>
<td>Group 2</td>
<td>104.43</td>
<td>79-128</td>
<td>9-12</td>
<td>6-16</td>
</tr>
<tr>
<td>Total sample</td>
<td>109.47</td>
<td>79-128</td>
<td>9-12</td>
<td>6-16</td>
</tr>
</tbody>
</table>
Research Design

This study employed a quasi-experimental, counterbalanced design as described by Campbell and Stanley (1963, pp. 50-52). This design was deemed appropriate because with the naturally occurring low numbers of learning disabled subjects available, this design compensates for the lack of a large number of subjects. The cross-testing ability of the counterbalanced design also allows for stronger statistical power from a small sample.

The main thrust of the study was to examine the effect on achievement by the type of instruction (with text-to-speech synthesis and without text-to-speech synthesis) applied. The control group consisted of the group of students receiving standard multimedia instruction, which includes texts and graphics without text-to-speech synthesis. The experimental group consisted of the group of students receiving the modified multimedia instruction (treatment), including the text-to-speech synthesis. Both lessons were identical in content and appearance with the exception of the text-to-speech synthesis modification.

At the conclusion of the first unit (7 days of treatment), the treatment for each group was reversed. The control group from the first treatment became the experimental group for the second treatment (receiving the speech-synthesized lesson) and vice versa. Also instructional content switched to a second unit so that the two treatments were relatively independent of each other (Table 3.3).
<table>
<thead>
<tr>
<th>Group</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Ts1</td>
<td>X</td>
<td>To2</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>To1</td>
<td>X</td>
<td>Ts2</td>
<td>X</td>
</tr>
</tbody>
</table>

Time ➔

Ts1- Treatment Group 1 with Text-to-speech Synthesis -- Unit One
To1- Control Group 1 without Text-to-speech Synthesis -- Unit One
Ts2- Treatment Group 2 with Text-to-speech Synthesis -- Unit Two
To2- Control Group 2 without Text-to-speech Synthesis -- Unit Two
X- Post-test only
P- Multimedia Pre-treatment

*Figure 3.1*

*Research Design for Testing*
Instrumentation

Measurement is the observation of the aspects of objects or people that renders itself irrelevant to the reality of life; observation by definition is a glimpse of reality. The perspective of the observer is skewed by his or her position in relation to what is being studied. Realizing the limitation of measurement, one must design the viewing apparatus to record what was meant to be recorded with the highest accuracy and reliability possible. (Pedhazur, Pedhazur & Schmelkin, 1991, pp. 17-18).

Threats to internal validity. According to Kirk (1982, pp. 20-23) threats to internal validity in a quasi-experimental study are history, maturation, testing, instrumentation, statistical regression, selection, mortality, interactions with selection, ambiguity about the direction of causal influence, diffusion or imitation of treatments, compensatory equalization of treatments, compensatory rivalry by respondents receiving less desirable treatments, and resentful demoralization of respondents receiving less desirable treatments. Random assignment helped rule out maturation, selection, and selection maturation problems in this study. This study was drawn from intact classes, from which students were randomly assigned. The post-testing of both the treatment and control groups helped to rule out maturation, history, and testing because both groups would receive similar experiences at approximately the same time. Instrumentation and interactions with selection are controlled by random assignment and with proper instrument design, content validity and reliability testing. A table of specifications was applied to all treatments and instruments and a panel of experts was used to control for the above confounding variables. (The exact
procedure used is explained in Validation of Instruments section.) Mortality and statistical regression were not controllable variables, but it is assumed that with random assignment, if these threats occur, their effect will be spread evenly across the groups. Finally, compensatory equalization of treatments, compensatory rivalry by respondents receiving less desirable treatments, and resentful demoralization of respondents receiving less desirable treatments were not factors in this study because there was no compensation given to the treatment groups, and both control and treatment groups were designed to be equivalent.

The counterbalanced design assists in overcoming any differences between the two groups that may still exist after random assignment during the subject data collection (collapsing) process. A problem that may arise by using the same sample as the control and treatment group is Effect of Exposure (Ary, Jacobs, and Razavieh, 1990). Having the groups switch treatments midway through the study can pre-sensitize the subjects to the second treatment. To control for the Effect of Exposure that could result from the second treatment all subjects received a familiarization pre-treatment, a third introductory-type unit. All treatments were equivalent in rigor so content, rather than quantity of information, is varied.

*External validity.* External validity is the ability to generalize findings to and across various populations (Kirk, 1982). This study was designed to test a narrow (unique) group of subjects typifying a narrow (unique) population that may benefit uniquely from this treatment. No attempt was made to generalize to other populations. Any inference to other related populations is limited to the
discussion of "Recommendations for Further Research."

**Data Analysis**

The researcher used *Minitab*, (release 8.21 for the Macintosh) software to analyze data and compute descriptive and inferential statistics. *T test* procedures were used to test for the main effects of the treatment. The level of statistical significance was set at .05 (alpha) for all procedures used in the study.

**Organization of the Study**

The researcher designed the study to integrate with existing school curricula while causing as little disruption as possible. The following procedures and considerations were made to accomplish this goal:

**Choosing a unit.** Once the site and instructors were identified, the researcher sought input from the classroom teachers to identify two appropriate units of subject matter for this study. It was imperative that all participating teachers consent to the same unit being presented during the same time frame.

The researcher spoke with all classroom teachers from the sites. During these discussions, the teachers provided the researcher with information about the types of science units from the *Life Story* multimedia package that fit with their curriculum and the time needed to teach them. The information collected from the sites was synthesized to identify two units to be mutually agreed upon by participating teachers and the researcher. A letter was sent to the participating teachers identifying the units agreed upon, and giving general instructions on
implementing the study, physical classroom requirements, and a tentative timeline (see Appendices C and D).

*Developing a unit plan.* Once the units were identified, the researcher sought teachers' input regarding the specific strategies to teach the concepts in these units. These strategies were designed to maintain a consistent and uniform presentation in keeping with the *Life Story* curriculum. Content-based unit tests were used to assess student achievement. The researcher used organizers in the *Life Story* curriculum as the primary content organizers. Using the multimedia presentations, thorough unit lesson plans and tests were developed by the researcher with input from the site teachers. After a series of revisions involving the site teachers, the final unit lesson plans were accepted by mutual consent. These plans and tests were validated by a panel of two (2) experts at Virginia Tech and one (1) at Radford University. All three reviewers had degrees in physical science as well as advanced degrees in education. Reviewers compared unit plans and tests against the unit objectives and content matrix (Table of Specifications) in the multimedia program *Life Story*. To assist with validation, a table of specifications was made of the curriculum content and the levels of learning within the learning package. Content validity and reliability were confirmed using this table of specifications to reflect a balance between objectives taught and testing criteria. The panel of experts was then asked to compare the lessons and the test to the table of specifications. (See Appendix E for a listing of the members of the panel and Appendix F for the general instructions to the reviewers and the list of recommendations for corrections of the test.)
The test had an average of 12 items and was written in 14 point, Roman type to aid readability by subjects. Copies of the test were given to the sites for distribution to the students. (See Appendix G for copies of the test and Appendix H for copies of the unit plans.)

*Developing treatment materials.* Once the unit plan was finalized, the researcher modified the *Life Story* multimedia program into the two packages, control and treatment, for the two units of instruction. The treatment required software drivers (*Hypercard X-Commands*) to simulate vocal speech from the written words contained in the on-screen text within the instructional package. MacIntalk II and MacIntalk Pro text-to-speech synthesis programs from the Apple Computer Corporation were used in the development of the text-to-speech synthesis treatment. These software drivers fit into the software internal programming so that the end user cannot tell the difference in the operation of the software, other than the added text-to-speech synthesis capabilities. The text-to-speech synthesis command was controlled by a set of play buttons similar to the existing *Life Story* video playback buttons. Upon entering a new data screen having a text field, other than titles and labels, the text-to-speech synthesizer would automatically *read* the text to the student. The text-to-speech synthesis playback buttons' commands included were "Read the Text" and "Stop". All buttons were located in a similar location on the screens and were operated by a mouse click. (see Appendix I for a diagram of both sets of buttons.)

The voice and speed control were set to the average reading speed of the learners, as supplied by the administrators at the site. An average student
reading speed of seventy (70) words per minute was calculated and validated by a reading expert at Virginia Tech. The speed was specifically chosen to accompany the students' ability to read, not to replace it. "Victoria, High Quality," a female voice of medium pitch and intonation, was chosen because of its high quality and realistic sound.

*Life Story.* The *Life Story* multimedia courseware, by *Sunburst/Wings for Learning* was used in this study. This instructional program covers science topics such as cells, chromosomes, DNA, evolution, heredity, genetic code helices, nucleotides, bases, hydrogen bonds, x-ray diffraction, microscopes and processes of scientific inquiry. These topics were set within the story of the race for the discovery of DNA. The manufacturer was very supportive of this research project and provided the software and support for the *Life Story* program. The program was selected for its high quality, its fit into existing curricula, and its adaptability to both group and individual instruction.

The researcher with assistance from two Virginia Tech instructional technologists, Mr. Michael Leahy and Mr. Ed Schwartz, modified the computer program. They installed the speech drivers, which enabled the computer to simulate verbal speech from the written text contained within the multimedia learning package. The text-to-speech synthesis was manually triggered by the student upon opening the new card (screen), and pressing a button titled "Read Words,” releasing the mouse button. A click-on type button was designed to display on the screen, enabling the user to replay the audio. The main program was run off the computer's hard drive and accessed the CD-ROM for graphics and other voluminous data.
The researcher provided each treatment and control group teacher with specific instructions about the use of the software, the *Life Story* introductory unit, and how to record students' progress and absences. These general guidelines and sample forms are presented in Appendices J and K. The unit plans for both the treatment and control are shown in Appendix H.

*Developing control group materials.* In order to maintain consistency between implementation for each of the groups and units, the researcher developed a suggested daily plan for the teachers to follow. The students were run through the instructional sequence on an individual basis. They were proctored by the computer lab director and her assistant. All students were exposed to the treatment in a consistent, controlled and contiguous manner. All lessons were 50-60 minutes in length and administered at approximately the same time every day, on consecutive days (except for holidays). The control and treatment groups' daily student instruction log is shown in Appendix J. The general guidelines and other forms were the same as with the treatment group teachers' guidelines and forms (Appendices J and K). All materials necessary to implement the units and unitize the learning package *Life Story* were provided to the teacher by the researcher. Appendix K shows the materials provided to each control group teacher.

*Training control and treatment group teachers.* The researcher presented the scientific activities and implementation guidelines to all treatment and control group teachers during a 2-4 hour workshop. The workshop was delivered in conjunction with a one day visit to the site to familiarize teachers with the
software and solve any logistical questions raised about the operation of the hardware.

During the workshop, teachers were shown how to run both versions of the software package *Life Story*. The researcher demonstrated and indicated presentation techniques and other plans and procedures related to implementing the experiment. All teachers were trained on how to present the software package *Life Story* and how to manage the classroom in a similar way. In addition, teachers were instructed on how to administer the post-tests for recording student achievement. Teachers left this meeting with a complete set of materials to use during the implementation process.

*Conducting the study and collecting data.* Teachers administered the introductory unit before they started teaching the first treatment unit. After the unit was presented, the post-test for that unit was given. Students were given a code number, used to identify testing and protect students' identity. Only the site officials had the list of students' names with their corresponding numbers.

As specified in the teachers' procedures, both control and treatment group teachers implemented the experiment at the same time. Because of scheduling restrictions, teachers could not start and finish teaching the units at the same time as proposed in the procedures. Instead, students completed the Units in an independent study fashion requiring that they work on it one hour per day during 7 contiguous days. This self-instruction mode, provided to students with study questions for each lesson (showed in Appendix J) lent itself well to the computer-aided instruction of the program. The daily log in Appendix K shows that the total class hours were the same, and the instruction was given at
approximately the same hour in the day. Table 3.3 shows the related data for each of the groups and the hours of instruction.
Table 3.3

*Total Length of Instruction for Treatment and Control Groups. in Unit One and Unit Two*

<table>
<thead>
<tr>
<th>Group</th>
<th>No. Days</th>
<th>Total Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>7</td>
<td>8.3</td>
</tr>
<tr>
<td>Control</td>
<td>7</td>
<td>8.3</td>
</tr>
</tbody>
</table>

| Total Time | 14       | 16.6               |
Site teachers delivered all post-test materials to site administrators who sent them to the researcher for processing. All teachers were contacted approximately 10-15 times during the course of the study, once each after the start of each unit to verify that everything was progressing well. All teachers were sent a summary of the results for their class, the group results, and letters thanking them for their involvement in the study.

Assessments of instruments. There were no assessment instruments included with the Life Story curriculum package; both of the post-tests were developed and validated by the researcher for use in this experiment.

Development of the unit test. The researcher developed the science test for this study based on the unit plan included with the Life Story learning package. The instrument was titled Life Story Unit Test One (Test one) and Life Story Unit Test Two (Test two). All items on both tests were short answer/fill-in-the-blank as per the standard at the site. All items were directly related to the concepts presented in the unit plan. (See Appendix G for Unit Tests based on Life Story's.)

Once the drafts of the tests were created, they were presented to a panel of experts for evaluation (see Appendix E for a list of and credentials of expert panel members.). A Table of Specifications was created by the researcher to compare and rate the information in the unit plan to the test forms. A Specification Matrix was created by the researcher and presented with the test for evaluation. Levels of educational objectives (Bloom, 1956), content and percentage of time spent on presentation of specific subject information were the three variables in the matrix. The experts evaluated the test form in comparison
with the matrix and the unit plan. The forms used for the evaluation of the draft test were shown in Appendix F. A summary of the experts' comments were shown in Appendix M.

The test form was revised based on the experts' comments and suggestions. Each test item was categorized by its ability to measure specific concepts and the learning level for the way each concept was recalled. Each question was evaluated in terms of four factors: content; readability for grades 7-10; type of knowledge tested; consistency of rigor and length. Reading levels were derived using the Flesch-Kincaid reading tests.

Rating Content:

All test items were drawn from the three lessons presented in the multimedia learning package Life Story, Theme # 1 (Units on Evolution, Heredity, and Genetic Code); Theme #2 (Units on Process of Science, Microscopes , and X-ray Diffraction); Theme #3 (Units on Cells, Chromosomes and DNA). A copy of the outline of the lesson was included for reviewers' convenience. Content was rated as either Acceptable (A) or Not Acceptable (N). If not acceptable, the question was discarded or rewritten. (See Appendix M for reviewer’s comments.)

Rating Readability:

All test items were deemed readable and understandable to typical 7th-10th grade students by the panel of experts. Suggestions for changes from the panel, with regard to readability, were written directly on the test form. It was assumed that questions were acceptable (in the reviewer's opinion) wherever
they did not change. (See Appendix F for copies of the general instructions for reviewers.)

*Rating Type of Knowledge:*

The questions were evaluated by the same panel of experts with respect to the type of information the students were asked to recall. Using Bloom's Cognitive Domain of the Taxonomy of Educational Objectives, the first three levels of information recall were used; Knowledge, Content, Application (Bloom, 1956). Each test item was rated according to whether it tested Knowledge, Comprehension, or Application. Bloom (1956) defined these as:

*Knowledge (K):* this category includes memorization behaviors; recall or recognition.

*Comprehension (C):* Behaviors in this category are those that show understanding, not just memorization. Being able to explain or interpret is an indication of comprehension.

*Application (A):* Application involves being able to use, or apply, an abstract concept to a specific situation.

The type of knowledge was rated and noted on the attached form by marking a K (Knowledge), a C (Comprehension), or an A (Application) in the appropriate columns. The majority of the questions tested knowledge.

*Consistency:*

The themes or major lessons; Theme #1 (Units on Evolution, Heredity, and Genetic Code); Theme #2 (Units on Process of Science, Microscopes, and X-ray
Diffraction); Theme #3 (Units on Cells, Chromosomes and DNA), were rated for consistency in length, rigor, and amount of effort to finish. The rating was: Yes or No. Theme #'s 1 & 2 are consistent with Theme #3. and reviewers' comments were listed. (See Appendix M for copies of reviewers' comments.)

The final evaluation of the questions was with regard to all of the reviewers' comments. Each question was rated three ways, acceptable, acceptable with modifications, and unacceptable. Finally, the overall test forms were rated on equivalency. This was done to assure that the test be equivalent in both rigor, complexity and length. Appendix M shows the breakdown of reviews, comments, and test items.

Based on the reviewers' comments, the test form was revised again in preparation for the pilot study, see Appendix N for a copy of test one and test two used for the pilot. Field testing of the test forms, software operations, teachers' unit plans and experimental instructional sets were all done during the pilot study. This field testing procedure is described in the next section.

Validation of instruments. The validity and reliability of both sets of instruments were found to be acceptable through a review of experts and pilot testing. Test one and test two (both forms) were subjected to review by the panel of experts. These individuals assessed whether the questions on the instruments did, in fact, reflect the content of the Life Story unit plan. Furthermore, they categorized questions as to the type of knowledge being tested: Knowledge level and Comprehension level. (See Appendix M for a summary of the experts' reviews.)

A pilot study was implemented using students with learning disabilities
(reading problems) at the Forman School (the study site). Students in the pilot were not used in the main study. The pilot study was conducted to ascertain four main things:

a) The effectiveness of the computer program.
b) The quality (of presentation) of the instructional units as prepared.
c) The quality (user friendliness) of the procedural instructions written for experiment proctors.
d) The feasibility of the instructional/experimental data collection system.

Seven students with documented learning disabilities (dyslexic/reading problems) currently enrolled at The Forman School were selected for the pilot study. These students were solicited from the general student population and were selected as a representative sample of the type of student at the school. They were asked to read and follow the instructions for the first unit and were then asked to take the unit test. A similar set of students with the same profile was asked to work through the second unit. Both questionnaires and personal interviews of participants were used in the pilot study. Both groups of students were given questionnaires and were personally interviewed for any suggestions on improving the total program. The main thrust of the questioning was on text-to-speech synthesis, the flow of the program, and the instructions that accompany the program. Their instructors were interviewed as well.

Several changes were made to the program and to the instructional set as a result of this pilot study. First, the test form was modified to increase the point size of the type to 14 point. Second, extra spacing was added between questions to allow more room to write. Third, test directions were simplified and added in
writing to the top of each test (Note: during the pilot the directions were read to the students). Fourth, the number of questions was reduced from 25 to 10-12 for each test. These changes were imposed by The Forman School to assure that the tests and procedures were reasonably consistent with their standards and classroom procedures.

Reliability of instrumentation: Pilot Reliability was not estimated using the Kuder-Richardson KR-21 Formula (Kirk, 1982) because of the small number of students available in the study. In consultation with the Test Scoring Analysis Service at Virginia Tech, it was determined that the sample for the pilot was too small to be used for reliability estimates. This was a site-imposed limitation. All questions were based directly upon the textual information presented in the program Life Story; no information was added. The researcher used the revised instruments for this experiment based upon student and site teacher feedback.

Data collection and recording. The scores from the post-tests were recorded on student data sheets, provided to the instructor by the researcher. There were four sets of raw data: group one scores with and without text-to-speech synthesis (TTSS), and group two scores with and without synthesized text-to-speech. Both sets of data with text-to-speech were combined. The data sets without the text-to-speech were also combined. This created a larger data set—those with synthesized text-to-speech and those without. Figure 3.2 illustrates this data collection.

Students' test scores for both units (treatment and control) were first recorded on short answer sheets, graded by an independent person, and then cross-listed by student's code number. This information was entered in a
spreadsheet by the researcher and then downloaded into the statistics package Minitab, release 8.21 for the Macintosh.
Units 1 2

Group 1
w w/o
w/o w

Group 2

Totals

W W/O

Note: Variables represent post-test scores.

Figure 3.2

Data Collection.
Non-experimental Data Collection

The researcher collected two additional sets of data with live interviews; one set from students and the other from teachers.

Student data. Student data were collected using two techniques. First, several of the student learning sessions were videotaped. This was done at random by the site teacher. Second, students were interviewed by the researcher after the unit tests were finished. This was done using both one-to-one interviewing and focus group techniques. Because of time constraints and student accessibility only 16 (81%) of the students were interviewed. A consistent set of questions was asked of all students (see Appendix O). Though questions were left open-ended to allow students the chance to express themselves, most answers were rated into four categories: Strongly Agree, Agree, Disagree, and Strongly Disagree. This was done to allow a bi-directional handling of the data. First, because of interview-first hand input from the subjects (partial transcription of the interviews were utilized), personal feedback and expressions were recorded; second, the answers were also recorded on an ordinal Likert-type scale, thus allowing survey data analysis techniques to be applied to the group as a whole. All interviews were audio tape-recorded with the students' assent.

Teacher data. One teacher, Ms. Leigh Rader, was responsible for approximately 95% of the implementation and daily running of the study (her assistant was responsible for the remainder and was unavailable for the interview). Ms. Rader was the only teacher interviewed. She was provided a
follow-up questionnaire prior to the researcher's visit (see Appendix F). Ms. Rader's answers to the questionnaire were used to guide the researcher during the interview. The interview was audio tape-recorded with the teacher's consent. Portions of the recording were professionally transcribed for accuracy.
Chapter Four

Findings

Introduction

A quasi-experimental, post-test-only design was used to test the effect of text-to-speech synthesis in a multimedia learning environment on science achievement. The subjects for this study were 22 students with learning disabilities in reading at the Forman School. In addition, qualitative data were collected from both the students and the teacher via audio taped interviews. Videotape was used to document the testing environment and provide further student data.

Students' Achievement

The 22 subjects were administered the post-test for units one and two of the instructional material. Table 4.1 displays the means and standard deviations for the post-test by treatment. The scores on the achievement tests for those using text-to-speech were compared to those not using text-to-speech using a t test. The alpha level for the analysis was set at $p=.05$.

Results of this t test are presented in Table 4.1. Three test scores had missing answers and were omitted from the analysis. Students' post-test scores served as the dependent variable in this analysis. The t test for the two groups was not significant ($t = 1.24$).

Although, the units had been tested for content, readability, knowledge, and consistency, summing the treatment across the units may have hidden the treatment effect, thus barring the use of a paired t test. A secondary set of t tests
were run on the subsamples 1) across individual groups between treatment to control for unit variability and 2) across groups between units to control for students' variability. None of these tests was significant in supporting the original t test and refuting the null hypothesis.

After looking at the sample distributions, the variance was found to be large. Additional descriptive statistics are presented below. Students' I.Q. scores (Wechsler Intelligence Scale for Children, Revised [WISC-R]) ranged from 79 to 131. The I.Q. score range was 52, with a mean of 109 and a standard deviation of 11.51, the reading level range was 2, with a mean of 2.05 (see Table 4.3), thus confirming the sample was an accurate representation of the general student population.

The reading level scores, of the students, obtained from the Forman School, ranged from 6th to 16th grade. These levels were not comparable, because the results came from different testing methods (Peabody and WRAT standardized Reading Level Test). Therefore, the reading levels were grouped for the analysis. The three categories are: High = 10th grade and above, Average = 7-9th grade levels, and Low = below 7th grade.
Table 4.1

Means and Standard Deviations for Unit Post-test Scores.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (w TTSS)</td>
<td>19</td>
<td>11.79</td>
<td>7.46</td>
</tr>
<tr>
<td>Control (w/o TTSS)</td>
<td>19</td>
<td>9.32</td>
<td>4.45</td>
</tr>
</tbody>
</table>
Table 4.2

$t$ Test of Text-To-Speech Synthesis Treatment

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Difference</td>
<td>2.47</td>
</tr>
<tr>
<td>$t$ Value</td>
<td>1.24</td>
</tr>
<tr>
<td>Probability Level</td>
<td>0.22</td>
</tr>
</tbody>
</table>

*Note: $N=19$*
Table 4.3

I.Q. and Reading Levels Descriptive Statistics for Total Sample

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>Variance</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.Q.</td>
<td>109.47</td>
<td>11.96</td>
<td>143.04</td>
<td>79</td>
<td>131</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>Variance</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Levels</td>
<td>2.05</td>
<td>.82</td>
<td>.68</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note: The reading levels are: 3 = High, 2 = Average, and 1 = Low.*
Group Information. Table 4.4 shows that students' mean scores improved for each group when the text-to-speech-synthesis treatment was employed. (Group 1, 2.29 point gain; Group 2, 2.72 point gain). Most students' scores improved from 1 to 10 points with the treatment, though four students had a decrease of 1 to 6 points. Three of the students with negative treatment effects were contained in Group 1 and may explain its higher variability. The variance for Group 1 jumped from a standard deviation of 3.05 to 7.57 between the control and treatment, as compared with Group 2 with a change from 6.13 to 7.00. This within-group variability is well displayed by having standard deviations almost as large as the score means. These scores were obtained using two different units. Thus, some of the between unit variances are represented by the above standard deviations.
Table 4.4  
*Mean Scores and Standard Deviations by Group and Unit for each Treatment.*

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.Q.</td>
<td>112.42</td>
<td>104.43</td>
</tr>
<tr>
<td>Reading Level</td>
<td>2.08</td>
<td>2.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Unit 1</th>
<th>Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>With (TTSS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>M</td>
<td>12.54</td>
<td>10.43</td>
</tr>
<tr>
<td>SD</td>
<td>7.57</td>
<td>7.00</td>
</tr>
<tr>
<td>n</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Without (TTSS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group 2</td>
<td>Group 1</td>
</tr>
<tr>
<td>M</td>
<td>7.71</td>
<td>10.25</td>
</tr>
<tr>
<td>SD</td>
<td>6.13</td>
<td>3.05</td>
</tr>
<tr>
<td>n</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

*Note:* Three of the 22 students had missing scores or reading levels, thus reducing the N to 19 students.  <sup>a</sup>This group contained a student without a given reading level.
Students and Teacher Preference

A secondary purpose of the study was to determine whether students and teachers prefer the combination of digitized audio and text, or text alone. Sixteen of the nineteen students who finished the experiment were interviewed. (See Appendix O for the interview questionnaire.) A statement was read to each student before the interview to assure them their answers would be held in confidence, and that answers would have no effect on their unit test grade, the research outcome, nor on their regular classroom grades. The last part of this statement encouraged them to answer with their honest opinions, for there were no right or wrong answers.

Responses on six of the questions were rated on a 1-4 Likert-type scale, with the responses limited to: 1= Strongly Agree, 2= Agree, 3= Disagree, and 4= Strongly Disagree. These data appear in Table 4.5. The questions solicit data on students’ perception of the usefulness of this mode of instruction (Q1 and Q2) and the extent to which they liked this instructional approach, as well as their acceptance of the program (Q3-Q6). The means of 2.06 obtained in question 1 and 2.19 in question 2 suggest that students felt this mode of instruction was somewhat helpful. The high standard deviation of 1.12 in question 1, indicates a higher variability in students’ perception of the help provided by the program than for other questions.

Responses to the three questions relating to students’ fondness for this mode of instruction were somewhat positive in nature. Specifically, mean responses were: “would encourage your friends to use this program” (Q3) 1.63;
"did you like the text-to-speech synthesis program” (Q4) 1.69, “would you pay twice as much for a textbook, for example, in college, to have the text-to-speech synthesis as an option to assist with reading” (Q6) 1.47. Although these students found the program only somewhat useful, they said they liked it enough to recommend it, use it again, and even buy it.

Students were also asked to specify any changes that could be made to improve the program. Their top five responses for improvements were:

1. Improve speech, make it faster-less choppy. (100%)
2. Use faster computers. (93%)
3. Provide selection-specific replay capability. (72%)
4. Implement a word highlighting system. (23%)
5. Provide an on-line thesaurus and dictionary, for every word in each passage. (21%)

The response to the question “would you use the text-to-speech synthesis program again (with the suggested improvements) if it was offered?” yielded a mean of 1.44 with a relatively low standard deviation.
Table 4.5

Summary of Student Responses from Post-Treatment Interviews on a 1-4 Likert Scale with Minimum and Maximum Responses.

<table>
<thead>
<tr>
<th>Question</th>
<th>N</th>
<th>M</th>
<th>Mdn</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q.1 Did It Help</td>
<td>16</td>
<td>2.06</td>
<td>2.00</td>
<td>1.12</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Q.2 Raise Grade</td>
<td>16</td>
<td>2.19</td>
<td>2.00</td>
<td>0.91</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Q.3 Encourage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friends</td>
<td>16</td>
<td>1.63</td>
<td>2.00</td>
<td>0.62</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Q.4 Like TTSS</td>
<td>16</td>
<td>1.69</td>
<td>1.00</td>
<td>0.95</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Q.5 Use again</td>
<td>16</td>
<td>1.44</td>
<td>1.00</td>
<td>0.81</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Q.6 Pay 2X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13</td>
<td>1.46</td>
<td>1.00</td>
<td>0.88</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: The responses were: 1=Strongly Agree, 2=Agree, 3=Disagree, and 4=Strongly Disagree. <sup>a</sup> Q6 was accidentally omitted in 3 interviews.
The site teacher, present during each student learning session, stated a preference when given a choice of using text-to-speech synthesis, especially for this type of "learning lab" instructional activity: "Self contained [learning] activities are best suited [for this type of technology]. . . . Our students can keep even with the information presented in the reading passages. . . . The biggest problem we have is the kids get down [behind in the reading] and get discouraged, then lose interest. . . . This [technology] might allow them to keep up and keep into it". She stated a reservation that this type of technology would not be as valuable in a large group setting, such as a standard classroom, because of the large amount of time it takes to maintain the labs and the related equipment (i.e. headphones, CD-ROMs, software glitches, etc.). She suggested this approach might be unrealistic in a typical school setting because of lack of technical support within the lab.

*Site Videotape Results*

Review of videotaped lessons confirmed students' diligence. The length of the treatment was compared with the amount of time students spent "on-task." The several students videotaped were "on-task" 85-90% of the time.

*Restatement of Research Hypothesis*

The hypothesis tested in this study was:

Students with learning disabilities studying a multimedia science unit with a text-to-speech synthesizer (treatment group) will have higher overall science achievement levels than students studying the unit without a text-to-speech synthesizer (control group), controlling for prior overall
science knowledge and comprehension by random assignment.

The data shown in Table 4.2 did not support this hypothesis \( (t = 1.24, p = 0.22) \). Both Reading Level and I. Q. had an effect on student achievement. The treatment group students' mean achievement (11.79) was higher than the control group students' mean achievement (9.32), but not significantly higher.

Summary

The results of this study provide evidence that there was no significant group effect on students' achievement scores with the treatment. Treatment group students did not have significantly higher achievement scores than did the control group students; therefore, the null hypothesis was not rejected. It is believed that reading levels and I. Q. had effects on the students' overall achievement score. While the research design used for this study allowed for a small sample, it precluded any further analysis.

The results of the interviews and subsequent survey support a secondary hypothesis that students like the text-to-speech synthesis technology and that they have a stated preference when given a choice of using it. The site teacher also had a stated preference for using this technology in specific self-contained learning environments.
Chapter Five

Conclusions and Recommendations

Summary of the Study

This study explored the effect of text-to-speech in a multimedia learning environment on science achievement for students with learning disabilities in reading. The researcher examined how student achievement on unit tests was related to the experimental treatment using a quasi-experimental, post-test-only design. A secondary focus of the study was to determine whether students preferred text with speech synthesis to plain text without speech synthesis. To this end, qualitative data were collected using individual and small group interviewing techniques after the main treatment was administered and both unit tests were given.

Procedures

Students for the study were chosen from intact, already grouped classes, and were then randomly assigned to the experimental groups. The sample was chosen with input provided by school officials. The researcher proposed the study to the school officials, who then decided which classes in their school would be available for this type of study. The school's officials introduced the researcher to the classroom teachers, and the researcher then sought the participation of these individual teachers.

The main thrust of the study was to examine the effect on achievement by the type of instruction (with and without text-to-speech synthesis) applied. The control group consisted of the group of students receiving standard multimedia
instruction—a series of texts and graphics without text-to-speech synthesis. The experimental group consisted of the group of students receiving the modified multimedia instruction (treatment), including the text-to-speech synthesis. Both lessons were identical in content and appearance with the exception of the text-to-speech synthesis modification.

At the end of the first unit (7 days of treatment), the treatment for each group was reversed. The control group from the first treatment became the experimental group of the second treatment (receiving the text-to-speech lesson) and vice versa. The instructional content was changed to a second unit, so that the treatments were relatively independent of each other with regard to content.

The hypothesis tested in this study was:
Students with learning disabilities studying a multimedia science unit with a text-to-speech synthesizer (treatment group) will have higher overall science achievement levels than students studying the unit without a text-to-speech synthesizer (control group), controlling for prior overall science knowledge and comprehension by random assignment.

A t test was used to analyze the data. Findings of the study were summarized as follows:

There was not a significant difference between the treatment and control group students' science achievement when post-test scores were used for comparison. Treatment group students did not have significantly higher achievement scores than did the control group students.
Conclusions

Based on the findings in this study, the researcher concluded that use of text-to-speech synthesis in a multimedia learning package does not increase achievement for students with reading disabilities. Students liked using the text-to-speech synthesis approach in this type of multimedia instruction. The findings parallel findings of somewhat similar studies done by Olofsson (1992), Leong (1992a), and Leong (1992b) which feature similar applications of text-to-speech synthesis technology with younger children (1-7th grade level) with deficiencies or disabilities in language learning in experimental or quasi-experimental settings. These studies did not show significance in the text-to-speech synthesis or "computer speech feedback." A plausible reason for the negative response given by the authors was the poor quality of the speech synthesis. The quality level of computer speech may have risen high enough in the past 5-6 years so as not to interfere with the experiment. This finding is inconsistent with studies conducted by Barrow, et al. (1992), Borgh & Dickson (1992), Hillinger (1992), Olson & Wise (1992), Raskind & Higgins (1995) and Wise & Olson (1994) involving younger students and remediation of reading disabilities in phonological awareness skills. In these six studies, reading or reading skills of general populations were investigated. In three of these studies, the general population students were compared to students with learning disabilities. All six of these studies found significant gains with lower ability readers.

The hypothesis was not supported by the $t$ test because the within group variance was extreme. The means for the treatment and control groups were 11.79 and 9.32, with standard deviations of 7.46 and 4.45. Four cautions are
offered in interpreting these results.

1) Within group variances were large (almost as large as the means).

2) The descriptors (I.Q. and reading levels), varied greatly; with ranges of
79-128, and 6th to 16th grade levels respectively, blurring their effect on student’s
scores.

3) The attempt at isolating a sample within a specialized school population
for students with learning disabilities was appropriate, but even within this
homogeneous population, there was too much variability for experimental
research requirements.

4) The instructional treatments’ length and intensity is sufficient to create
an effect, but the text-to-speech synthesis output could be improved to decrease
the effect of poor speech as a direct confounding variable.

Students preferred the multimedia with text-to-speech synthesis over the
multimedia alone. Furthermore, the students were very succinct in their opinions
about which population this technology would help. One student who was
adamantly against using the program and did not enjoy using the program—and
did not test well with the text-to-speech synthesis—stated “...[the text-to-speech
synthesis] don’t work [sic] for me, but I would recommend it to [my] friends who
have more problems [with] reading!” Another student stated: “I could not
finish the assignment without the [TTSS] program... When will it be out
[available to buy or use].”

Implications and Recommendations

The findings in this study have implications for software developers,
assistive technology educators and developers, learning disability educators and language training educators. The findings hint at a technological aid that is currently being overlooked for use with this specific population, especially with students with low I.Q. and poor reading skills. A device or treatment that can assist in closing the gap between their rate of learning and the rate of learning for normal students should be pursued with vigor. "Throughout the use of technology or any other educational strategy, educators must embed its employment within the context of meaningful dialogue and searching that allows persons with learning disabilities to understand the larger world, [and] their place in it..." (Poplin, 1995, pp. 138-9).

Although the findings of this study suggest that text-to-speech synthesis may not be effective with students with reading disabilities, caution should be used in interpreting this data and generalizing beyond this specific sample and educational environment used. Further studies are needed to confirm these results.

Based on the findings in this study, the researcher recommends the following:

1. Additional studies using the text-to-speech technology and students with learning disabilities in reading should be conducted. These studies should utilize a larger, more representative (preferably stratified) sample in order to generalize the results of the study to a broader population.

2. Future studies should be conducted using more homogeneous groupings within a heterogeneous student population setting, such as large
public school systems. Within this context, student reading disabilities could be identified, thus allowing for a more accurate observation of student effort. Then, grouping the scores of the identified students would create the homogeneous sample needed.

3. It is the conclusion of both the researcher and the site teacher that the setting, though controlled, did not represent a true setting of a heterogeneous grouped classroom, nor an experimental “lab” situation. This will continue to be a problem as the reality of the classroom is balanced with the demands of experimental research. This problem may be solved by a larger, better funded study that uses pretesting to group students in sample populations according to I.Q. and reading levels. This would result in homogenous samples with numbers large enough to clearly define the treatment effect, if any.

4. Those who develop multimedia with text-to-speech synthesis should make every effort (through hardware/software) to create “natural / normal” sounding synthesized speech, thus minimizing any confounding variables with hardware/software and the actual text-to-speech synthesis interaction with the student.

5. Since isolated sites with large numbers of appropriately grouped students with reading disabilities are not readily available, researchers might employ funding to create one. A summer learning camp could be used to group the students in realistic classroom settings. Researchers could pretest all student candidates during the school year, and then place or invite them to a summer camp or summer school, at reduced or no cost. Operating costs could be reduced by operating this camp in conjunction with preexisting summer programs (e.g. Upward Bound or summer school at specialty schools for the learning disabled,
such as The Forman School or the Kildonan School, university summer enrichment programs, etc.). Besides lowering costs, this "tag-a-long" approach has several advantages to external field research: 1) The school environment preexists and is detached from the experiment; 2) The number of personnel required to run the school or camp may be kept to a minimum; 3) The actual learning lab could be maintained and monitored by the researchers' trained staff, thus helping to eliminate other confounding variables.

6. During the pretreatment period, allow students who find text-to-speech synthesis disruptive to their learning style the option to opt out of the study. This opportunity should be given only after the students have tried the technology for at least a week, during which time some may overcome their initial fear or discomfort in using the text-to-speech synthesis.

7. Learner attributes such as reading level, I.Q., time-on-task, attitudes toward the treatment, and so forth, should be collected as part of the study, thereby increasing their accuracy and consistency to facilitate the analysis of their interaction with the treatment.

8. The with-in group variance associated with students having learning disabilities will continue to be a problem in experimental research designs. Single-subject case studies may be a more effective way of observing the effect of the treatment than the artificial groupings typically employed for quasi-experimental research. By studying several individual students in this manner over an extended time frame, a more accurate "group picture" might be obtained.
References


Gabrowski, B. L. (1989). Reflections on why media comparison studies continue to be conducted -- with suggested alternatives. Paper Presented at the 1989 Annual Convention of the Association for Educational Communications and Technology, Dallas, TX, Feb. 1-5, 9p.


Appendices

Appendix A: Forman School Reading Level Official Statement
Appendix B: Internal Review Board Request Documentation.
Appendix C: Classroom Requirements
Appendix D: Tentative Time Line
Appendix E: Panel of Experts
Appendix F: General Instructions to Review Panel and Survey Forms
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Appendix J: Students Self-Instructions for Each Lesson (Unit)
Appendix K: Daily Log of Student Instruction
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Appendix M: Unit Test Used for Pilot Test
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Appendix A

Forman School Reading Level Official Statement
Forman School Reading Level Official Statement

The following statement was provided by The Forman School administrators with the reading levels after the experiment was completed.

"Grade equivalencies for reading levels are an unreliable measure of a student's performance levels because the students in this sample were tested using different diagnostic instruments and at different ages.

Some of the test results are more recent than others. Also, individual tests measure different parts of the reading process (i.e. word recognition, passage comprehension, vocabulary, and broad reading skills)."
Appendix B

Internal Review Board Request Documentation
Institutional Review Board Request

JT Scholz

Justification of Project:

Purpose of the Study

The purpose of this study was to determine if the use of a text-to-speech synthesizer in a science multimedia instructional program would have an effect on science achievement scores of secondary school students with learning disabilities. The specific benefit of this research is for children with learning disabilities. Therefore research must be performed using the appropriate population.

With mainstreaming and inclusion of special education students becoming more commonplace in today's classroom, harmony in the classroom has become more elusive. Many students with learning disabilities are functioning at an average or better IQ level but are unable to perform at or above grade level. When students receive instructions and lessons in a manner incompatible with their learning ability, they may fail for the wrong reasons.

No presentation system is perfect, but instruction is most effective when those methods are designed to meet the needs of a wide range of learning abilities. Hypermedia has the ability to allow the learner to be "an active participant" during the learning process, which is a great instructional advantage.

Individual multimedia workstations allows students to maintain their own pace and place of learning within a group classroom setting. The learning interface can be individualized to match the learning characteristics of each person. Learning disabled students assisted by multimedia workstations may gain a level of success in education that is imperative to their later success in life.

Procedures:

Demographics
The sample used in this study will be selected from students enrolled at The Forman School, a private school specializing in the education of the learning disabled, specifically students with dyslexic reading problems. This independent school is located in Connecticut, and currently uses multimedia in daily instruction. The sample consisted of 25 students enrolled in life science classes. The students' ages ranged from 13-19 years and the grade levels from 6-12. Gender was random.

Procedures

The students were chosen from intact, pre-grouped classes, and were then randomly assigned to the experimental groups. The sample was chosen with input provided by school officials. The researcher first proposed the study to the school officials, who then decided which teachers' classes in their schools would be available for this type of study. The school's officials introduced the researcher to the classroom teachers, and the researcher then sought the participation of the individual teachers.

The main thrust of the study was to examine the effect on achievement by the type of instruction (with text-to-speech synthesis and without text-to-speech synthesis) applied. The control group consisted of the group of students receiving standard multimedia instruction, a series of texts and graphics without text-to-speech synthesis. The experimental group consisted of the group of students receiving the modified multimedia instruction (treatment), including the text-to-speech synthesis. Both lessons are identical in content and appearance with the exception of the text-to-speech synthesis modification.

At the end of the first unit (10 days of treatment), the treatment for each group will be reversed. The control group from the first treatment will become the experimental group of the second treatment (receiving the speech synthesized lesson) and vice versa. The instructional content is changed to a second unit, so that the treatments were relatively independent of each other.

Risk and Benefits:

No risk noted beyond those found from using a standard computer. Benefit is from more science instruction.
Confidentiality/Anonymity:

The researcher assured the students that only group data would be used in the determination of the results. Only school administrators and researcher will have access to data.

Consent/Assent

See Attached
The effectiveness of text-to-speech synthesis in a multimedia learning environment on students with specific learning disabilities in reading.

Principal Investigator: Joseph T. Scholz, Doctoral Candidate

I. The Purpose of the Research Project
You child is invited to participate in a study to examine the effectiveness of text-to-speech synthesis in a multimedia learning environment on students with specific learning disabilities in reading. This study involves approximately 30 subjects in addition to your child.

II. Procedures
The specific procedures used in this research will be outlined by your child's science teacher. Your child will be assisting in testing the educational effectiveness of two types of multimedia instructional tools. The time and conditions required for your child to participate in the project are approximately one hour for 14 days. There is no possible risk and discomfort to your child as a participant beyond using a computer.

III. Benefits of This Project.
Your participation in this project will provide information that may be helpful to other students with learning disabilities such as your child. No guarantee of benefits has been made to encourage your child to participate. You may receive a summary of this research when completed. Please provide a self-addressed envelope to your child's teacher for the researcher.

IV. Extent of Anonymity and Confidentiality
The results of this study will be kept strictly confidential. At no time will the researchers release the results of the study to anyone other than individuals working on the project without your written consent. The information you provide will be pooled into group data. No individual data will be used in any of the analyses or written reports of the research.

The experiment may be video taped. These tapes will only be reviewed by your child's teacher and JT Scholz, researcher, and will be erased after June 1st, 1995.

V. Compensation:
Your child will receive extra credit as part of regular class requirements. Your child may receive credit for the class in which he/she are enrolled.

VI. Freedom to Withdraw
Your child is free to withdraw form this study at any time without penalty to your grade. If your child chooses to withdraw, he/she will not be penalized by reduction in grade for his/her science course. An alternative extra credit assignment will be available.

VII. Approval of Research
This research project has been approved, as required by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University, by the department of Vocational and Technical Education and the Headmaster of your school.

VII. Subjects Responsibilities
I know of no reason my/our child cannot participate in this study which will require completion of two multimedia science units using the Life Story computer-based instructional program.

Parent/Guardian Signature  Date

IX. Subject Permission
I/we have read the information about the condition of this educational evaluation project and give my/our voluntary consent for participation of my/our child in this project. Should I have any questions about this research or it's conduct, I should contact:

Jane Doe, Site Teacher (XXX) XXX-XXXX
JT Scholz, Investigator (703) 381-2454
Ernest R. Stout (703) 231-9359
Chair, IRB Research Division
Virginia Polytechnic Institute and State University

Informed assent for participants of investigative projects.

The effectiveness of text-to-speech synthesis in a multimedia learning environment on students with specific learning disabilities in reading.

Principal Investigator: Joseph T. Scholz, Doctoral Candidate

I. The Purpose of the Research Project
You are being asked to help in a test of the ability of text-to-speech synthesis (a computer voice reading the words on the computer screen to you) in a science lesson taught on a computer. This project uses about 30 students.

II. Procedures
The exact steps to be used in this research will be outlined by your science teacher. You will be asked to use two different versions (one lesson for each version) of a computer (multimedia) learning program, you will be tested at the end of each lesson. The time and conditions required for you to participate in the project are approximately one hour for 14 days. There is no possible risk or pain to you beyond that of using a computer.

III. Benefits of This Project.
Your joining in this project will provide information that may be helpful to other students with learning disabilities, students such as yourself.
No guarantee of benefits has been made to encourage you to participate.
You may receive a summary of this research project when it is completed. Please provide a self-addressed envelope to your teacher.

IV. Extent of Anonymity and Confidentiality
The results of this study will be kept very private. At no time, will I (the researcher) give the results of the study to anyone other than those individuals working on the project without your permission.
The information you provide will be combined into group data. No individual data will be used in writing reports of the project.
The classroom where the experiment is located may be video taped. These tapes will only be reviewed by your teacher and JT Scholz, researcher, and will be erased after June 1st, 1995.

V. Compensation:
You will receive extra credit as part of regular class grading.
You may receive credit for the science class in which you take part.

VI. Freedom to Withdraw
You are free to quit this project at anytime without damage to your grade. If you choose to quit, you will not be penalized in your science course. You will be given another extra credit project to make-up the points.

VII. Approval of Research
This study has been approved, by the Institutional Review Board at Virginia Polytechnic Institute and State University, by the department of Vocational and Technical Education at Virginia Polytechnic Institute and State University and the headmaster of your school.

VII. Subjects' Responsibilities
I will join in this study which will require me to take and finish two multimedia science lessons using the Life Story computer-based teaching program.

Student Signature ___________________________ Date ________________

IX. Subject Permission
I have read the information about this educational project and give my permission to join this project. Should I have any questions about this project, I will contact:

Jane Doe, Site Teacher ___________________________ (XXX) XXX-XXXX
JT Scholz, Investigator ___________________________ (703) 381-2454
Ernest R. Stout ___________________________ (703) 231-9359
Chair, IRB Research Division
MEMORANDUM

TO: Joseph T. Scholz
Vocational and Technical Education

FROM: Ernest R. Stout
Associate Provost for Research

DATE: February 20, 1995

SUBJECT: IRB EXPEDITED APPROVAL/"The Effectiveness of Text-to-Speech Synthesis in a Multimedia Learning Environment on Students with Specific Learning Disabilities in Reading"
Ref. 95-055

I have reviewed your request to the IRB for the above referenced project. I concur with Dr. Stewart that the experiments are of minimal risk to the human subjects who will participate and that appropriate safeguards have been taken.

This approval is valid for 12 months. If the involvement with human subjects is not complete within 12 months or there is a significant change in the protocol of the project, the project may be resubmitted for extension or approval.

On behalf of the Institutional Review Board for Research Involving Human Subjects, I have given your request expedited approval.

Best wishes.

ERS/php

c: Dr. Stewart
INVESTIGATION INVOLVING HUMAN SUBJECTS

Principal Investigator(s): Joseph T. Scholtz
Department: Voc & Tech Educ

Project Title: The effectiveness of text-to-speech synthesis in a multimedia learning environment on students with specific learning disabilities in reading.

Source of Support: Departmental Research [ ] Sponsored Research [ ] Proposal No. [ ] Dissertation [ ]

1. The criteria for "expedited review" by the Institutional Review Board for a project involving the use of human subjects and with minimal risk is one or more of the following. Please initial an applicable condition and provide a substantiating statement if present.

☐ a. Collection of:

1) hair or nail clipping in a non-disfiguring manner;
2) deidentified terror:
3) permanent teeth if patient care indicates need of extraction.

☐ b. Collection of secretions and external secretions: sweat, uncalibrated saliva, placenta removed at delivery, amniotic fluid obtained at time of rupture of the membrane.

☐ c. Recording of data from subjects 18 years of age, using non-invasive procedures routinely employed in clinical practice.

☐ d. Collection of blood samples by venipuncture (not exceeding 150 ml/week per patient, and no more than twice a week) from subjects 18 years of age, in good health and not pregnant.

☐ e. Collection of supragingival and subgingival dental plaque and calculus, provided the procedure is no more invasive than routine scaling of the teeth.

☐ f. Voice recordings.

☐ g. Moderate exercise by healthy volunteers.

☐ h. Study of existing data, documents, records, pathological specimens or diagnostic specimens.

☐ i. Research on drug or devices for which an investigational exemption is not required.

☐ 2. If the project involves human subjects who are exposed to "more than minimal risk" and are not covered by the criteria above (1 to 9), the IRB review must involve the full IRB panel. Please check if the research involves more than minimal risk and provide a substantiating statement of protocol.

☐ 3. Human subjects would be involved in the proposed activity as either: Adults (and/or Children) [ ] Feasible [ ] Abortuses [ ] Pregnant Women [ ] Persons [ ] Mentally Retarded [ ] Mentally Diseased [ ]

Note that if children are involved in the research as human subjects, they may have to provide consent as well as their parents.

Whether or not the project may undergo "expedited review" or must be reviewed by the full Institutional Review Board, it is necessary that the proposed informed consent forms be reviewed. These should be submitted with the proposal. However, if it is not sufficient time to meet the sponsor's deadline, submission can be delayed up to thirty days after submission of the proposal without jeopardizing the IRB certification in the prospective reporting.

Minimal risk means that the risks of harm are not greater, considering the probability and magnitude, than those encountered in daily life or during performance of routine physical or psychological examinations or tests.

"Subject at risk is an individual who may be exposed to the possibility of injury as a consequence or participation as a subject in any research, development, or related activity which deviates from the application of those established and accepted methods necessary to meet the needs, or which increases the ordinary risks of daily life, including the recognized risks inherent in a chosen occupation or field of service.

This is to certify that the project identified above will be carried out as approved by the Human Subject Review Board, and will neither be modified nor carried out beyond the period approved beyond without express review and approval by the Board.

Signature: [ ] Date: [ ]

The Human Subject Review Board has reviewed the protocol identified above, as it involves human subjects, and hereby approves the conduct of the project for [ ] months, at which time the protocol must be re-submitted for approval to continue.

Signature: [ ] Date: [ ]
Appendix C

Classroom Requirements
The Forman School Classroom  Equipment List

**Learning Stations**

The Forman School Computer Lab Set-up  
LC -III Bay

<table>
<thead>
<tr>
<th>Station #</th>
<th>Equipment Description</th>
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</table>
| #1        | LC III with 8 Megs RAM  
High speed CD (VT/LRC)- HP-LAS, Soft., (_____  |
| #2        | LC III with 8 Megs RAM  
SS CD (VT/TE)-HP(VT/ETL)  
Soft., (_____  |
| #3        | LC III with 8 Megs RAM  
SS CD (VT/ETL), HP (ETL)  
Soft., (_____  |
| #4        | LC III with 8 Megs RAM  
SS CD (VT/AC), HP  
Soft., (_____  |
| #5        | LC III with 8 Megs RAM  
S CD (VT/AC), HP  
Soft., (_____  |
| #6        | No use.                |
#7  LC III with 8 Megs RAM
     S CD (VT/AC), HP
     Soft., (______)

#8  LC III with 8 Megs RAM
     S CD (VT/AC), HP
     Soft., (______)

#9  LC III with 8 Megs RAM
     S CD (VT/AC), HP
     Soft., (______)

#10 LC III with 8 Megs RAM
     S CD (VT/AC), HP,
     Soft., (______)

Legend:
- LC III = Apple Macintosh using a Motorola CPU "chip" # 68030 @ 25 MHz.
- 8 Megs RAM = Amount of RAM
- S CD = Compact Disc model Number
- (VT/AC), Etc., = Ownership of the product
- HP = Head Phone Type
- Soft. = Life Story CD ROM and software.
- (______) = Equipment return check box.
Appendix D

Tentative Time Line
## Planned Timeline...

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<th>Description</th>
<th>Dec.</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
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<td>Program Dev. Making &quot;it&quot; speak</td>
<td>13 Dec</td>
<td>30 Dec</td>
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<td>Unit #1 Curr. Materials dev.</td>
<td>13 Dec</td>
<td>16 Jan</td>
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<td>Unit #2 Curr. Materials dev.</td>
<td>13 Dec</td>
<td>16 Jan</td>
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<td>Validation of unit 1 &amp; 2 Curr. Materials</td>
<td>2 Jan</td>
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<td>Pilot Test: Site</td>
<td>23 Jan</td>
<td>29 Jan</td>
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<td>Run Study: Site</td>
<td>Training Start 20 Feb - end 3 Mar.</td>
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<td>Collect Data</td>
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<td>Write-up Results...</td>
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Appendix E

Panel of Experts
Jerian Abel, Ph.D.

Doctor of Philosophy, Curriculum and Instruction, Virginia Polytechnic Institute and State University, 1995.  
Master of Science in Science Education from Radford University, 1991.  
Bachelors of science in Physical science Radford University, 1985.

Woodrow, McKenzie, Ph.D. candidate.

Doctor of Philosophy, Curriculum and Instruction, Virginia Polytechnic Institute and State University, 1996.  
Master of Arts in Teaching Biology, Northern Arizona University, 1985.  
Bachelors of Science, Honors in Biology, Concord College, 1974.

Mark England, Masters candidate.

Master of Science in Science Education from Radford University, 1996.  
Bachelors of Science in Biology, Clinch Valley College, 1993.
Appendix F

General Instructions to Review Panel and Survey Forms
Instructions to Reviewers of Life Story Science Lessons:

This form will be used to record your comments about the science knowledge—Life Story unit test. Carefully read the question in the test booklet and fill out the attached form as you review each question. Each question must be evaluated in terms of three factors:

I. Content.
II. Readability for 7-10th grader.
III. Type of knowledge tested.

Use the information provided below to guide how you evaluate and rate each item. Feel free to make lengthy comments by writing in the comment section on this sheet or anywhere on the test booklet.

I. Rating Content:
   All test items were drawn from the three lessons presented in the multimedia learning package Life Story, Units on Evolution, Heredity, and Genetic Code. A copy of the Outline is included for your review. Rate content as either Acceptable (A) or Not Acceptable (N). If not acceptable, please provide a comment to explain your reasoning.

II. Rating Readability:
   All test items should be readable and understandable to typical 7-10th grade students. Mark your suggestions for changes with regard to readability directly on the test form. It will be assumed these things were acceptable (in your opinion) wherever you do not note changes.

III. Rating Type of Knowledge:
   Each test item must be rated according to whether it tests Knowledge, Comprehension, or Application. These are defined as:

   • Knowledge (K): This category includes memorization behaviors; recall or recognition.

   • Comprehension (C): Behaviors in this category show understanding, not just memorization. Being able to explain or interpret is an indication of comprehension.

   • Application (A): Application involves being able to use, or apply, an abstract concept to a specific situation.

Rate type of knowledge on attached form by marking a K (Knowledge), a C (Comprehension), or an A (Application) in the column.

Thank you,

JT Scholz
Researcher, Va. Tech
(703) 381-2454

Life Story--
Reviewers' Guide
<table>
<thead>
<tr>
<th>Item #</th>
<th>Content A or N</th>
<th>Type of Knowledge R-C-A</th>
<th>Your Comments:</th>
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Life Story--
Reviewers' Guide
IV Consistency.
Please rate the Themes or major lessons; Theme #1-(Units on Evolution, Heredity, and Genetic Code); Theme #2 (Units on Process of Science, Microscopes, and X-ray Diffraction); Theme #3 (Units on Cells, Chromosomes and DNA), for consistency in length, Rigor, amount of effort to finish. The rating scale is (circle one):

Yes/No Theme (#1) is consistent with theme (#2). Comments:

Yes/No Theme (#2) is consistent with theme (#3). Comments:

Yes/No Theme (#2) is consistent with theme (#3). Comments:

Other comments:
Appendix G

*Unit Tests*
The Scientific Process

1) Define the scientific process.

2) What is a Hypothesis?

3) What procedure is used to test hypotheses?

4) What are the two types of variables?

5) What is the crucial distinction between technique and methodology?

6) What is the Human Genome Project?

7) How many chromosomes are there in the human genome?

8) Are they paired or singular?
9) Determining the order of the three billion base pairs that make up the chromosomes—the equivalent of reading the genetic message—is called what?

10) Anne Sayer said that Rosalind Franklin was probably an experimentalist or a theoretical scientist?

11) And Watson and Crick? (experimentalist or a theoretical scientist?)

12) How are hypotheses determined to be correct or accepted?

13) What is the difference between a hypothesis, a theory, and scientific law?

14) In your own words, did Watson and Crick follow (or break) these rules, and what was the effect?

Define the following terms:

15) Genome:

16 DNA:
The Microscope

1) What is a microscope?

2) What are the three types of microscopes discussed?

3) When did the first modern optical microscope come into use?

4) Who was the first person credited in using the optical microscope, and what did he look at?

5) Who discovered that you could bend light rays to enlarge images?

6) What word did he coin, or use first?

7) Who is credited with perfecting the microscope?

8) Two hundred years later, two scientists, Theodor Schwann and Matthias Schleiden, made what conclusion?
9) Electron microscopes are not focused with lenses. With what are they focused?

10) Who invented the first electron microscope?

11) Current electron microscopes are capable of magnification power in excess of 
    ________? (choose the best answer)
    500 times, 10,000 times, 1,000,000 times, 2,000,000 times, or 50,000,000 times.

12) Generally, what shape are lenses in optical microscopes?

13) What was the earliest biological discovery using a microscope?

Define the following terms:

14) Optical microscopes:

15) Electron microscope:

16) X-ray microscope:
X-ray Diffraction Unit

1) Who was Rosalind Franklin?

2) What happened when X-rays passed through the sample? (in your own words).

3) What is an atom?

4) How are atoms identified?

5) What important thing did the X-ray show of DNA that assisted in its discovery?

6) What device used by Gosling and Franklin, allowed for a very fine, very intense beam of X-rays to look at a single molecule of DNA? It created photographs of a quality that had been previously unattainable.

7) Who took the first X-ray diffraction photo?
8) Please identify the diagram below, and label as many of the parts as possible.

9) Why are X-rays good for making photos of small things?

10) Are there applications of X-ray diffraction in industry?

Define the following terms:

11) X-ray Diffraction:

12) Molecule:

13) X-Ray:
Appendix H

Unit Plans
Unit Plan: Evolution

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Appendix I

Diagram of Buttons for Life Story (including TTSS)
Appendix J

*Students Self-Instructions for Each Lesson (Unit)*
**Student Instructions**

**Life Story:**

*Follow instructions as best possible.*

1) At title page press your mouse button, while arrow is visible on the title page.
2) Main Menu--Place the arrow over the science title and press the mouse button.
3) Science Main Menu--Work though the three lesson starting with Evolution then Heredity and finally Genetic code. 1st Evolution 2nd Heredity 3rd Genetic Code
4) Start the Evolution lesson by clicking on the Black Evolution Icon.
5) Read the main passage.
6) When finished with the main passage, play or watch the movie/animation.

*Note: Please read and listen to the audio when appropriate. You are requested to press the audio button ("Speak Words") when it is present. You are also asked to read along with the audio (Synthesized Speech) rather than just listening.*

7) Explore the "Related Exhibits" section by clicking on the buttons.
8) Work through the questions in each section. Record you answers on the worksheets provided.
9) When finished with the lesson on "Evolution" move to the lesson on "Heredity".
10) When finished with the lesson on "Heredity" move to the lesson on "Genetic Code".
Evolution Lesson

Student Study Questions:

How does natural selection "drive" evolution?

Does Darwin deserve sole credit for this theory?

What are the implications of this theory at the cellular level?

What is meant by "descended with modification"? Please give examples that were not presented in computer program.

Vocabulary
Please define the following terms:

Evolution:

Darwin:

Mendel:

Natural Selection:

---

Life Story—Students' Guide
The Forman School
Heredity Lesson

Student Study Questions:

What is the role of genetic counseling?

What are some examples of heritable diseases?

How does a knowledge of heredity help farmers?

Vocabulary
Please define The following terms:
Genetic Code:

Mutation:

Gene:

Mendel's First Law:

Mendel's Second Law:

Inherited Variation:

Genome:

Life Story—Students' Guide
The Forman School
Genetic Code Lesson

Student Study Questions:

What does "genetic" mean?

How is the code both simple and complex?

What makes the genetic code a code?

How is the genetic code different in human and animals?

Vocabulary
Please define the following terms:

DNA:

Heredity:

Amino Acids:

Codon:

RNA

rRNA:
tRNA:
mRNA:

Transcription:

Translation:
Appendix K

Daily Log of Student Instruction
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Appendix L

List of Comments
**To: Joe Scholz**  
*Total pages: 3*

**From: J. Abel**

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*Life Story*  
*Reviewers' Guide*
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**Extra Comments:**

- Combined reviews from Abel & England.
- Unit Test Evolution, question 8: change "infer" to "inference"
- On final revision, proof for correct punctuation

Call 703/626-3191 if pages are missing.
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IV Consistency.
Please rate the Themes or major lessons; Theme #1 (Units on Evolution, Heredity, and Genetic Code), Theme #2 (Units on Process of Science, Microscopes, and X-ray Diffraction); Theme #3 (Units on Cells, Chromosomes, and DNA), for consistency in length, rigor, amount of effort to finish. The rating scale is (circle one):

Yes Theme (#1) is consistent with theme (#2). Comments: Theme #1 material appears to be more difficult and requires higher level thought processes.

Yes Theme (#1) is consistent with theme (#3). Comments:
SAME AS ABOVE

Yes No Theme (#2) is consistent with theme (#3) Comments:

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*Life Story--*

*Reviewers' Guide*
IV Consistency.
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[ ] Yes/No Theme (#1) is consistent with theme (#3). Comments:

[ ] Yes/No Theme (#2) is consistent with theme (#3). Comments:

Other comments:
Appendix M

Unit Test Used for Pilot Test
Unit Test: Evolution (with answers)

1) Describe the theory of evolution:
   A) Evolution is the theory of how species change over many generations.

2) What evidence provides the main support of this theory?
   A) Fossil evidence in support of the theory of evolution.

3) What two types of changes take place? Describe what they mean for future generations.
   A) Adaptive, increase survival
   B) Non-adaptive, does not increase survival.

4) What overall effect can adaptive changes have on the organism?
   A) Increase the chances to survive, passed on to offspring.

5) Who is considered the father of evolution?
   A) Charles Darwin.

6) What book did he write that set the theories down?
   A) On the origin of species (1859).

7) What was Darwin's limitation of his understanding of the genetic process?
   A) Was not able to understand the relationship or the existence of the gene or chromosome... (too small for equipment of the day).

8) Who piggybacked his work on that of Johann Gregor Mendel with his work in peas and heredity with the inference that “elements” later to be called genes controlled inherited variation.
   A) Francis Watson.

9) Francis Watson was inspired by the 1846 classic What is life, written by the noted physicist Edwin Schoridger that stated what?
   A) Genes were key components of all living cells and life.

10) Francis Watson was convinced of what?
    A) That the genetic information in genes was contained in DNA and that DNA would be the building blocks of life.

11) What traits in humans can you name that are controlled by inherited genes or are contained in the DNA?
    A) Hair color, eye color, height, skin complexion, etc.

12) The Rosetta stone is to hieroglyphics as DNA is to ...?
    A) Unraveling the true secrets of life.

Vocabulary: Please define the following terms:

13) Evolution:
14) Darwin:
15) Mendel:
16) Natural Selection:
Unit Test: Heredity (with answers)

17) What is heredity?
   A) Heredity is the passing of certain characteristics or traits from parent to
      offspring?

18) Please describe an example of a trait passed on to you by your parents.
   A) hair color, eye color, height, etc.

19) Genetic code of the DNA is described as?
   A) The language for passing on traits.

20) What are variations in the offspring called?
   A) Mutation

21) Are they good or bad? Explain?
   A) Good because may allow species to survive, adaptation. Bad, the mutation
      could harm the individual offspring, disease.

22) Who proposed the concept of the gene, who observed the specific properties of
    garden peas, such as color and shape?
    A) It was proposed by Gregor Mendel (1865).

23) The first law of inheritance states?
    A) The cell carries two genes for each characteristics, but only one is carried by
       the sex-cells gametes.

24) The second law of inheritance states?
    A) During fertilization the cells combine, one gene is dominate –displaying
       the characteristic during that generation, and the other is recessive—
       appearing only in latter generations.

25) Who was Barbara McClintock and why did she win the Nobel prize?
    A) A biologist and her role in unraveling the biological enzymes codes of DNA.

26) What is genetic counseling?
    A) Simple lab test can tell if parents will produce children with certain
       congenital disorders, like hemophilia, down syndrome MS etc.

Vocabulary:
   Please define the following terms:

27) Genetic Code:
28) Mutation:
29) Gene:
30) Inherited Variation:
31) Genome:
Unit Test: Genetic Code (with answers)

32) How many letters make up the genetic code?
   A) Four letter code or language (A G T & C) describing each of the nucleic acids.

33) Draw what DNA (Deoxyribonucleic acid) looks like.
    A) Two ladder like strands of nucleotides that form a double helix.

34) What cells contain DNA?
    A) This self replicating structure form the RNA and makes up the chromosomes of every living thing.

35) What are amino acids?
    A) Amino acids are the building blocks of protein molecules.

36) How many types amino acids are there?
    A) There are 20 types of Amino Acids.

37) Nucleotides are the basic elements of DNA and tRNA. What three things are they made of?
    A) It is made up of a sugar, a phosphate, and a base.

38) A codon is a sequence of three _____ that form the "words" in the genetic code.
    A) Nucleotides

39) A Polypeptide chain is a short chain of amino acids produced in a specific sequence dictated by the codon arrangement in the mRNA. What is the main ingredient in a Polypeptide chain?
    A) Protein are composed of one or more polypeptide chains.

40) Three types of Templates:
    A) RNA, tRNA, mRNA

41) What is the purpose of Human Genome Project?
    A) To map out the meaning of each gene and chromosome.

42) Who is involved (key people) in Human Genome Project?

43) Why is the Human Genome Project important?
    A) For a better understanding of the relationship between the gene and certain traits passed on in latter generations.

44) What is "Mapping"?
    A) Defining each gene and the trait it is responsible for, also, its position in the chain.

Vocabulary: Please define the following terms:

45) DNA: 50) tRNA:
46) Heredity: 51) mRNA:
47) Amino Acids: 52) m RNA:
48) Codon: 53) Transcription:
49) RNA: 54) Translation:
Appendix N

List of Questions Asked of Students
Post-treatment Students Preference Questions.

Q.1 Did you feel that this program of instruction helped you to learn?

Q.2 Did you feel that you received a higher or lower grade on the unit tests because of the program? Please explain.

Q.3 Would you encourage any of your friends (with learning disabilities) to use this program?

Q.4 Did you like using the Text-to-speech program?

Q.4a What did you like most about the program?

Q.5 Would you use the program if you could modify it? If so, what modifications would you suggest?

Q.6 If you had to pay two times the cost of a text book to get the text-to-speech synthesis would you?
Appendix O

*Teacher Post-Experiment, Pre-visits Written Questionnaire*
General Teacher Procedural Information.

Class Session

Turn on all computers, insert CD ROM Life Story and load software from folder on the hard drive, Life story Evolution. Note: The software has been loaded on the computers in the proper arrangement. Please do not let students switch computers from day to day.

Take attendance (using student code numbers), record results in roll sheet provided below:

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Introduce today’s lesson with a question and answer time, encouraging discussion with the class. Take no more than 10 minutes total time.

Have students open the first lesson and proceed to read and listen to the audio when appropriate. They are requested to press the audio button ("Speak Words") if present. Students are allowed to take notes if desired, study questions and space for notes are provide in their learning books.

Students should be encouraged to read along with the audio (Synthesized Speech) rather than listening along.

Monitor students progress and answer questions concisely and consistently. (Please remember this is a self-paced learning activity.)

At the end of each lesson have the students mark their progress in the learning books program by dating their notes where they stopped. Note: Tell students their progress is not graded, the computer instruction is being tested (not them).

Note: Please do not allow students to work though the lessons out of sequence; they will tend to get "lost" and for statistical integrity it would be better if all students do the same sequence.
Specific Questions for Facilitator of the Study.

Please answer the following questions to the best of your ability. Any reference to the Program or Unit is referring to the Text-to-Speech software within a multimedia learning environment.

Thank you,
JT Scholz

Please answer the following questions with the responses listed below.
A— Agree (85% of the time)
MA— Mostly Agree (60% of the time)
MD— Mostly Disagree (60% of the time)
D— Disagree (85% of the time)

1) Do students respond positively when asked to use the program?

2) Are students using similar educational programs in other classes using the program?

3) Students used the" speak the words" buttons when they were supposed to during the program.

4) Do you think this program helped students learn the material presented?
Short Answer Questions:

5) Are students asking to use similar programs in other subjects or classes? If so, please list programs and subjects.

6) Do students seem (from your observation) to stay more or less focused on the objectives at hand, while using this program?

7) Do the sample students’ attention span compare with the current methods used? Please explain.

8) Do students seem (from your observation) to enjoy using this program?

9) What successes have students had with this unit/program?

10) What problems did students have with this unit/program?

11) Would you encourage the students to this program in the future?

12) If the problems, listed above were fixed, would you then encourage students to use this program in the future?

13) What are the primary things you liked about this program?

14) What are the primary things you disliked about this program?

Joseph Thomas Scholz

jscholz @ kiowa.astate.edu
W(501) 972-2072 412 West Nettleton Av
H (501) 931-1913 Jonesboro, AR 72401

Education:

Ph.D., Vocational and Technical Education, December 1995
Virginia Polytechnic Institute & State University, Blacksburg, VA
Concentration: Technology Education, Minor in Curriculum and
Instructional Design.
Dissertation: Determining effects of text-to-speech synthesis in a
multimedia environment on science achievement with students with
learning disabilities in reading.
Advisor: Mark Sanders

Masters of Industrial Education December 1988
Clemson University, Clemson, SC
Area of Interest: Graphic Communication, Technology Education and
Secondary Education Counseling.

Bachelor of Science in Industrial Arts Education (K-12) August 1986
Millersville University of Pennsylvania, Millersville, PA
Area of Interest: Graphics Arts and Psychology

Liberal Arts Transfer— (66 Credits) June 1983
Catonsville Community College, Catonsville, MD
Area of Interest: General Studies and Psychology

Professional Interest:

To obtain a challenging technology educational position allowing an
opportunity to apply my skills in the area of communication technology. With
focus on the active design and implementation of programs linking education
with industry preferably, although not limited to, graphic communications,
multimedia, telecommunication and computer courseware design.

Certification:

Pennsylvania: Instructional I -Industrial Arts K-12
Vocational I Graphic Arts and Printing
Principles of Technology - Level I
Certification: continued

Virginia:  
- Director of Supervision *  
- Director of Curriculum and Instruction *  
- Director of Vocational Education *  
- Director of Technology Education *  
- Instructional I - Technology Education, Psychology, and Vocational Education* (*= Expected in May, 1996)

Awards, Honors and Grants:

- Phi Kappa Sigma, Baltzor Scholar, 1993, 1994  
- Graduate Student Assembly Travel Award, 1994  
- International Graphic Arts Educators Association 1992 Incentive Award  
- Screen Printing Association International Scholarship Recipient (RIT) 1991  
- Apple Computer K-12 Education Equipment Grant Recipient/Truman High Communication Technology Program 1989-91  
- Truman Communication Education/Industry Cooperative Program (non-vocational) 1990-91  
- Bristol Township School District Commendation for Teaching Excellence 1990  
- Truman High Technology Student Association (Advisor) Pennsylvania State champions and runners up in planographic printing. 1990 & 1991  
- Gravure Association of America, Gravure Fellowship Recipient 1987-88

Professional Affiliations:

- Omicron Tau Theta  
- Epsilon Pi Tau  
- Phi Delta Kappa – Virginia Tech Chapter Newsletter Editor  
- International Graphic Arts Educators Association  
- International Technology Education Association – National Conference Presenter  
- Virginia Tech Technology Education Collegiate Association – Graduate Advisor  
- Screen Printers Association International  
- Technology Education Association of Pennsylvania – State Conference Presenter  
- Clemson Graphic Arts Society – Graduate Advisor  
- Technical Association of Graphic Arts  
- Clemson Technology Education Club – Founder and Graduate Advisor  
- Millersville Industrial Arts Society – Treasurer
Experience:

Instructor of Printing and Graphic Communications Aug., 1995- Present
Responsible for all aspects of printing instruction, lead staff member in a 4-year baccalaureate program.
Printing and Journalism Program,
Arkansas State University, Jonesboro, Arkansas

Graduate Teaching Assistant in Graphic Communications Aug. 1991-May, 1995
Responsible for all aspects of two sections of a junior level course.
Technology Education Program,
Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Consultant, New River Community College Oct. 1994
Responsible for all aspects of the evaluation of a Title III professional development grant.
New River Community College, Dublin, Virginia

Courseware Developer; Animation and Computer Artist May 1993- April 1994
Responsibilities included: computer artist, animator and courseware programmer,
programs used: Authorware Professional, Macromind Director, Adobe Photoshop
Interactive Design & Development, Blacksburg,, Virginia

Teacher of Speech/Communication and Computers June-Aug. 1993
Created, designed and implemented all phases of high school college preparatory courses for economically and socially challenged youth.
The Upward Bound Program
Virginia Polytechnic Institute and State University, Blacksburg, VA

Courseware Developer- Authorware Professional June-Aug. 1992
Sole designer, artist and programmer for the prototype laser disc interface program for computer based instruction of first and second year veterinary students.
MD-VA Veterinary Science School
Virginia Polytechnic Institute and State University, Blacksburg, VA

Teaching Assistant in Telecommunications July 1992
Assisted in teaching all aspects of one week intensive continuing education course for Virginia teachers and administrators on the introduction and applications of the internet in the public schools.
Educational Technologies Program, EDCI,
Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Experience: continued

Teaching Assistant in Multimedia & Presentation Graphics--MS-DOS. July 1992
Assisted in teaching all aspects of one week intensive course on the introduction and
applications of the presentation graphics on MS-DOS machines. Utilizing Toolbook
and PowerPoint computer applications.
Educational Technology Program, EDCI
Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Teaching Assistant in Computer Graphics -- MS-DOS. June 1992
Assisted in teaching all aspects of one week intensive course on the introduction and
applications of the computer Graphics on MS-DOS machines. Utilizing Paint Brush
and Photoshop computer applications.
Educational Technology Program, EDCI
Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Responsible for redesign and implementation of exemplary communication
technology courses and program within the technology education department.
Courses taught; Drafting I (w/ AutoCAD), Graphic Arts I & II, Communication
Technology, and Home Remodeling.
Harry S Truman High School, Grades 10-12
Bristol Township School District, Bristol, PA

Research Fellow Dec. 1987 - June 1988
Responsible for all aspects national survey studying the needs of schools and their
relation with the Gravure industry. Prepared surveys, correspondence and
presentations (local and national) for project.
Gravure Association of America
Clemson University, Clemson, SC

School Counselor (intern) Feb. 1988 - June 1988
Experienced many aspects of high school counseling, including course scheduling;
peer, direct, individual and group therapy; and psychological test
administration. Designed and implemented a custom drop-out prevention
program, to link special students at Wren High School with mentors -- college
students at Clemson University.
Wren High School, Piedmont, SC

Graduate Teaching Assistant Sept. 1987 - July 1988
Photography and Graphic Arts
Responsible for all aspects of two sections of Photography I, one section of
Drafting I (w/AutoCAD), and 12 hr's. of Graphic arts lab instruction. (Assignment
varied with semester).
Industrial Education Department
Clemson University, Clemson, SC
Experience: continued

Teacher of Industrial Arts, grades 7th and 9th  Sept. 1986 - Jan. 1987
Teacher of Metals I & II, Graphic Arts I & II, Four sections of 7th grade general arts.
Treddyffrin/Easttown Jr. H. S.
Treddyffrin Easttown School District, Berwyn PA

Instructor of Introduction to Graphic Arts  June 1985 - July 1985
Designed and implemented all phases of graphic arts course with high emphasis on industry involvement, and subject areas; drafting, screen printing, offset printing and typesetting.
Howard County Vocational Technical School
Ellicott City, MD

Student Teaching:

Teacher of Design Technology; Ages 11-18  Mar. 1986 - June 1986
Subjects Taught; Wood I, II, Metal I and Power I, II, III
St. Paul's Way School,
Inner London Education Authority, London, England

Teacher of Industrial Arts
Subjects Taught; Photo I, II, III and Graphics I, II
Landisville, PA

Other Related Experience and Training:

Course for school personnel on the implementations of school to work, 2+2+2,
Tech-prep federal programs.
Dr. James Hoerner,
Virginia Tech, Blacksburg, VA

Tech-Prep--Application and Implementation.  March 1992
Course for school personnel on the application and implementation of "seed money" grants for school to work, 2+2+2, Tech-prep federal programs.
Dr. James Hoerner,
Virginia Tech, Blacksburg, VA

Wrote, edited, designed and coordinated efforts in the production of newsletters for the following organizations; Phi Delta Kappa Professional Fraternity, Graduate Student Assembly, and Phi Kappa Sigma Fraternity.
Experience: continued

Construction Experience

Assistant Forman, Designer, and Carpenter (rough and finish) positions on four historic home renovation projects.
Bristol Design and Development
Bristol, PA and Baltimore, MD

Principles of Technology

Course for certification to teach Principles of Technology I, for implementation in a high school technology education program.
Dr. Joseph McCade
Millersville University, Millersville, PA

Publications and Presentations:


Publications and Presentations: continued


Extra-Curricular Activities:

• Unified Martial Artist Group of VA Tech- Club, Head Instructor & Founder
• Ski Club, VA Tech & Clemson
• Truman High School Head Indoor and Outdoor Track Coach
• Truman High School Head Cross-Country Coach
• Varsity Track and Cross-Country at Millersville University
• Phi Kappa Sigma Fraternity at Miliersville University- President, Historian, Service Chairman and Alumni Chairman. Greek Council- Historian