DOCUMENT RESUME

ED 288 292 EC 200 763

AUTHOR	VanBiervliet, Alan
TITLE	Instructional Uses of Bar Code Technology.
SPONS AGENCY	Office of Special Education and Rehabilitative Services (ED), Washington, DC.
PUB DATE	Apr 87
GRANT	G008430075
NOTE	16p.; Paper presented at the Annual Convention of the Council for Exceptional Chilren (65th, Chicago, IL, April 20-24, 1987).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Artificial Speech; *Assistive Devices (for Disabled); Audiotape Cassettes; Braille; Electronic Equipment; Elementary Secondary Education; *Mental Retardation; *Physical Disabilities; Pictorial Stimuli; Sensory Aids; *User Needs (Information); *Visual Impairments
IDENTIFIERS	*Barcodes; Magic Wand Speaking Reader; Speech Synthesizers; Talking Tracks; Texas Instruments

ABSTRACT

The paper examines applications and research on the use of bar code technology to aid mentally retarded, physically handicapped, visually impaired, and other handicapped persons in independently gaining information from a variety of sources. Bar code reader technology is compared to alternative information systems such as Braille, pictorial instruction, and cassette tapes. The "Magic Wand Speaking Reader," intended to be used with Texas Instruments, Inc.'s "Talking Tracks" bar codes and a computer-aided bar code printing system, is described and diagrammed. Research on bar code technology is reviewed, including a needs survey, engineering performance evaluation of the "Magic Wand," evaluation of the intelligibility of the synthesized speech, and successful use with bar coded recipes. Also described is ongoing research in such areas as teaching first aid skills to retarded persons and use of bar coded dictionaries. Limitations of the technology, such as the precision needed for properly tracking the bar codes, are cited. (JDD)

Instructional Uses Of Bar Code Technology

Presented by
Alan VanBiervliet,Ph.D.
Department of Teacher Education
University of Arkansas at Little Rock

Presented at
CEC's 65th Annual Convention
Chicago, April 20-24, 1987

This research and preparation of this report was supported by U.S.D.E./O.S.E.R.S. GRANT # GOO8430075.

INTRODUCTION

Written language and other standard symbol systems are available to most individuals for obtaining information. A large number of individuals with handicaps, however, are functionally illiterate with respect to their ability to gain information from the available symbol systems. This includes many mentally retarded, physically handicapped, visually impaired, and other handicapped persons. Sartain (1976) has estimated that 13 to 15 percent of the population of the United States is illiterate. Without the use of a functional symbol system, many persons with handicaps will forever remain unduly dependent upon others for their information needs. Most available self-instructional aids in schools (e.g., instructional materials), daily living (e.g., cookbooks), work (e.g., automotive manuals), and leisure (e.g., board game rules and theatre schedules) are designed to be read, thus perpetuating the handicapped nonreader's dependency. The problem is further compounded by the fact that many persons with handicaps have memory and learning difficulties (Ellis, 1970).

The development of an effective system for independently gaining information from a variety of sources is a critical need for many persons with handicaps who cannot read. These individuals need to gain new information and retrieve seldom-used or forgotten information.

Alternative Information Systems

Braille has been developed as an alternative symbol system to circumvent some of the debilitating effects of visual deficits. However, Braille requires very fine tactile discrimination skills. It has been estimated that only about 4 percent of the legally blind individuals in the U.S.A. learn to effectively use Braille (American Foundation for the Blind, 1981). One of the reasons for the low usage of Braille among blind persons is that the literary code contains 189 items with numerous rules for their usage. These rules seem very complex to an adult reader and pose various problems for the blind child as he/she tries to recognize all 189 usages of the code.

One alternative symbol system that has been successfully used to teach moderately and severely handicapped individuals is called picture reading or pictorial instruction. Pictorial instruction involves teaching individuals to obtain information and instructions from simple pictures which could be accompanied by printed words (Spellman, DeBriere, Jarboe, Campbell, & Harris, 1978). When cued by pictures, learners are taught to select items and perform actions in the order depicted. Learners who have acquired the skills to follow pictorial instruction may be able to use picture books to solve problems and to learn new tasks. Picture books can also be used as reminders of how a task is performed. Pictorial instruction has been used successfully to teach a wide range of skills including: meal preparation (Johnson & Cuvo, 1981; Martin, Rusch, James, Decker, & Trtol, 1982; Robinson-Wilson, 1977), housekeeping skills (Spellman et al., 1978), schedule and calendar skills (Spellman et al., 1978), public transportation skills (Vogelsberg & Rusch, 1980), and vocational skills (Wacker & Berg, 1983). Many moderately and severely handicapped individuals, however, never learn to utilize the picture cue system (Spellman et al., 1978). As an alternative symbol system, pictorial instruction has several disadvantages. These are: 1) many actions and objects are very difficult to depict by a picture or photograph; 2) some individuals do not learn to translate pictorial symbols into actions; 3) the system is of little benefit for severely visually impaired persons; and 4) currently there are neither standard rules governing what symbols to use nor rules concerning the syntactic arrangement of the symbols.

Another procedure for obtaining information is to store the information on cassette tapes which can be played back at anytime. Perera and Cobb (1978) described the Learning Through Listening Project which used tape-recorded materials for teaching visually impaired students. The "Talking Book" system also used this procedures. Many visually impaired persons use cassette players to store and retrieve information on a daily basis (e.g., university students use this procedures for taking class notes). Alberto, Sharton, Briggs, and Stright(1986) described the use of a cassette recorder to auditorily prompt adolescents with severe handicaps to successfully perform meal preparation, domestic, and vocational tasks. This procedure enables handicapped individuals to access information in a wide variety of settings with reliable, inexpensive equipment.

The primary disadvantage of this alternative is that the searching and scanning skills that are necessary to find a particular piece of information on a tape are too complex for many handicapped persons.

Several devices have been developed to convert text into either auditory or tactile stimuli for visually impaired persons. Examples of these devices are the Kurzweil Reading Machine which produced synthetic speech from printed materials (Goodrich, Bennett, De L'Aune, Lauer, & Mowinsi, 1979; Selvin, 1981) and the Optacon which produces a tactile stimulus to the reader's fingertip (Moore & Hunt, 1981; Thurman & Weiss-Kapp, 1977). These devices, however, are fairly fragile, require considerable skill and training to use (particularly the Optacon), and they are beyond the financial range of most handicapped persons (costing from $3,000 to $35,000).

Bar Code Readers

Another strategy for effectively obtaining information from a variety of sources is the use of bar code reader technology. For many years this technology has been used to obtain reliable information for merchandise inventory and sales. Basically this system involves passing a light sensitive pen or laser over a printed code containing bars of varying thickness which correspond to coded numbers. Bar codes can be printed anywhere on an item. Information regarding the product that is stored in the machine's memory can then be accessed and presented via a visual display, printed on paper, or spoken aloud with the aid of a voice synthesizer.

An information system for handicapped persons would consist of a portable device which could "read" printed bar code from a variety of sources. The processing unit would then transcribe the code and auditorily present the information via a speech synthesizer. A bar code reader system could be effectively used by individuals with a broad range of disabilities, from mentally retarded persons to severely visually impaired persons. This system would have a wide variety of uses as a means of obtaining new information (learning) and retrieving forgotten information. Some of the possible uses for the system include:

1. Enabling severely visually impaired persons to "read" a restaurant menu equipped with bar code.
2. Providing instructions on how to place emergency calls including whom to call, how to call, and what information to give.
3. Enabling nonreaders to "read" bus and recreational activity schedules.

4. Providing instructions (bar coded recipes) on preparing nutritious meals.
5. Providing instructions on how to perform a wide variety of tasks such as completing a checkbook, doing laundry, using a kitchen tool, playing a board game, treating emergency injuries, and performing a new work task.
6. Providing instructions on how to properly take medication.
7. Providing direct instruction in spelling skills development.
8. Enabling visually impaired learners to "learn" independent of a sighted teacher.
9. Strengtening previously learned information and skills.

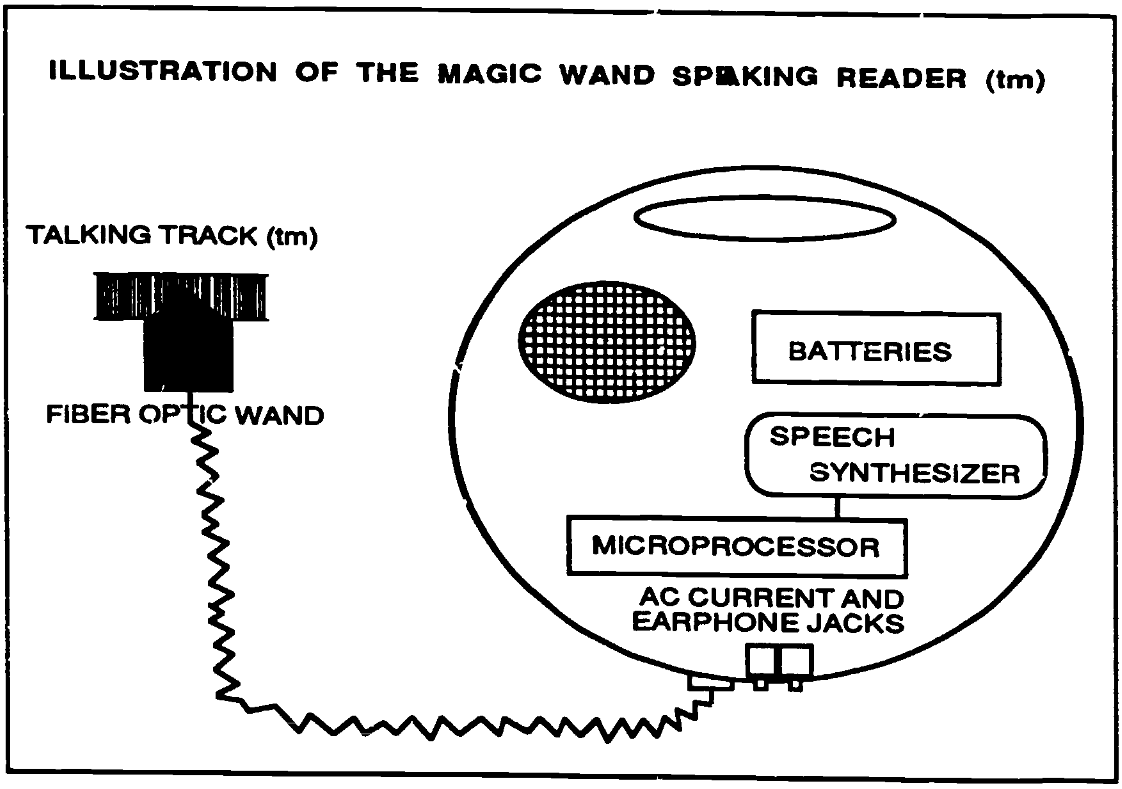
In addition, this same bar code system could be used as an effective augmentative communication aid due to its speech output, ease of use, flexibility, and programmability.

Talking Tracks™

Texas Instruments, Inc. has taken bar code technology one step beyond inventory control by developing a unique bar code called Talking Tracks which incorporate instructions for a microprocessor. Rather than simply containing identification numbers, Talking Tracks contain coded instructions for producing words, sentences, sound effects, music, and instructions for a variety of educational tasks. Bar codes that convey instructions to a microprocessor can be viewed as "printware" (i.e., printed software). The lengths of Talking Tracks vary with the amount of information encoded. For example, the word "How" requires a bar code .9 inches long and the question "How ya doing?" requires a bar code 1.8 inches long. The height of printware can be varied to meet an individual's eye-hand coordination ability. For example, Talking Tracks measuring 1.5 inches high might be needed by three year olds, whereas, a six year old could accurately scan Talking Tracks measuring only .5 inches high. When printed on coated paper, Talking Tracks are very durable, withstanding thousands of scans before they deteriorate. In addition, printware can be easily duplicated using a photocopy machine.

Magic Wand Speaking Reader™

The Magic Wand Speaking Reader is a device that was developed by Texas Instruments as an educational toy to read, decode, and utilize Talking Tracks. This device appears to be capable of serving a wide range of educational, habilitation, and daily living needs of persons with disabilities. The Magic Wand consists of five basic components: 1) fiber optic wand, 2) microprocessor, 3) speech synthesizer, 4) speaker or earphone, and 5) power supply.



The wand is a small, hand-held, fiber optic scanner that "reads" and decodes the Talking Tracks as it is glided over the bar codes. The wand beams a light source onto the bar codes and the light is absorbed by the black bars and reflected back to the scanner by the white spaces. These patterns are converted into electrical impulses which are sent via a coiled cable from the wand to the built-in microprocessor. The microprocessor interprets this information and activates one of its many educational and game modes as well as activating the speech synthesizer. The microprocessor is programmed as an educational tool for use in reading activities, multiple choice tasks, auditory memory tasks, spelling tasks, sequencing tasks, and musical activities. It can rapidly and reliably provide feedback as to the accuracy of a student's response through the speech synthesizer. The built-in speech synthesizer is capable of producing virtually any word in the English language in a variety of voices, as well as producing sound effects, musical notes, and songs. The speech synthesizer is based on the linear predictive coding (LPC) procedure. Signals from the speech synthesizer are sent to either a built-in speaker or an earphone jack for public or private listening. The Magic Wand operates on four D-cell batteries (for up to 27 hrs. of continuous operation using alkaline batteries) or on AC current through a built-in jack and an optional AC adapter.

BAR CODE TECHNOLOGY RESEARCH

Needs Survey

A survey was conducted during the Spring of 1983 concerning the need and possible uses for this technology. Questionnaires were sent to 244 agencies providing educational services to persons with visual impairments and to 277 residential facilities providing services tc persons with mental retardation. Approximately 70 percent of the respondents reported they would acquire a bar code reader if appropriate bar coded materials were available. They also reported that from 15 to 17 percent of their clients could benefit from the use of a bar code reader. The respondents recommended that bar coded materials and applied evaluation of this technology be conducted in the following areas: reading, braille instruction, domestic living activities (cooking and cleaning), academic tasks, labelling, self-instruction, medication instructions, communication, directories, language instruction, and vocational activities.

In conjunction with LINC Resources, a follow-up survey of several hundred special educators who have acquired the Magic Wand is currently being conducted. This survey is designed to obtain information concerning the uses of the Magic Wand, recommendations concerning needed bar coded curriculum materials, and recommendations concerning hardware modifications.

Performance Evaluation

Engineering performance tests conducted at U.A.L.R. have proven the Magic Wand to be a portable, durable, and reliable device. These tests were conducted in accordance to Underwriters Laboratories Standard (UL 696). It is light weight (3.1 lbs), and it operates on batteries for up to

27 hours of continuous operation using four D-cell alkaline batteries. The device is robust and durable ("Takes a wackin' and keeps on yackin'"); it successfully passsed repeated drop tests from three feet high. The Magic Wand is also able to operate under a variety of extreme environmental conditions; units operated correctly under test conditions varying from 20 degrees farenheit to 140 degrees and under high and low humidity conditions. The system is currently packaged in an 11 x 2 inch easily carried plastic disk. Technicians at the University of Arkansas at Little Rock have repackaged the system into a more conveniently carried 1 1/2 x 3 x 4 inch unit resembling a pocket cassette player.

SPECIFICATIONS

PRICE	$35 - 75
SIZE (Inches)	11.0 Diameter 2.0 Thick
WEIGHT (With Batteries)	3.1 Lbs.
BATTERIES	4-D Cell Alkaline
BATTERY LIFE	Approx 27 Hours Optional AC Adapter
VOICE OUTPUT	Speaker/Earphone
SYNTHETIC SPEECH	Linear Predictive Coding
CAPACITY	Unlimited Words, Sentences, Voices, Sound Effects, Songs
SPEED	Est. 60-70 WPM
BUILT IN TURN-OFF	Approx 1.5 Minutes
BAR CODE DURABILITY	15,000-20,000 Scans
DROP TEST (3 Ft.)	Passed
TEMPERATURE/HUMIDITY TESTS	20° to 140° Passed +90% Humidity Passed

Evaluation has demonstrated that the Magic Wand unit is capable of reading 96 sets of bar code ranging from 2.5 to 6 inches long within 5 minutes. This indicates that a user can "read" over 66 words per minute using the Magic Wand. An evaluation of the scanning speed of the unit demonstrated that the Magic Wand can be correctly operated at a speed from 8 inches per second (ips) to 1 ips. However, the optimum speed for accurate scanning is from 5 ips to 2 ips. In addition, our data indicate that the printed bars (Talking Tracks found in books produced by Texas Instruments) are capable of withstanding from 15,000 to 20,000 scans before they deteriorate to the degree where they cannot be "read".

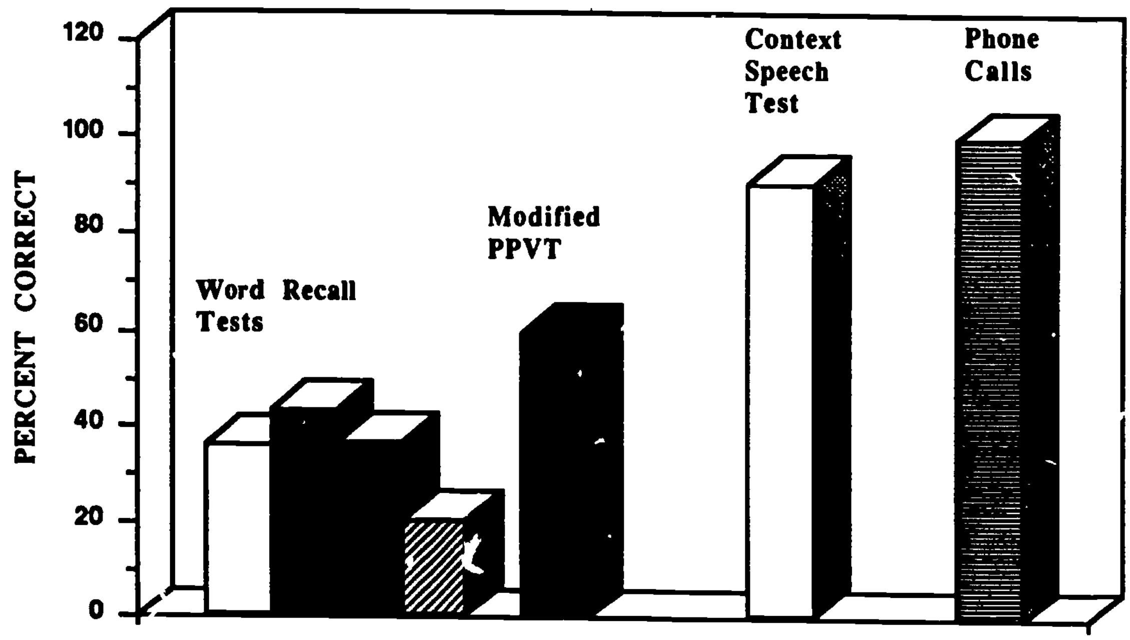
Synthetic Speech Evaluation

One crucial factor as to the effectiveness of any device that produces synthetic speech is the clarity or understandability of the speech. Grady, Judge, McCarthy, and Mills (1985) reported on the evaluation of the intelligibility of the Magic Wand's speech. Nine adults with mild to severe levels of retardation participated in their study involving selecting a picture given its name. They concluded that the Magic Wand produced satisfactory quality synthesized speech.

A series of investigations into the quality of the Magic Wand's synthesized speech were conducted at UALR. One study involved monosyllabic word recall tests with 25 synthesized and 25 natural speech words presented in a random order. Sixty disabled and non-disabled persons participated in the study. All groups of participants made a high number of errors(from 20% to 96%) on recorded synthesized speech words. The most common error pattern was substituting an "s" sound for the initial consonant (eg., "son" for "done").

A second study involved twenty adults with moderate to severe retardation participating in a modified Peabody Picture Vocabulary Test. One half of the words were presented in natural speech and one half of the words were presented in synthetic speech. The participants responded incorrectly on from from 20 to 80 percent (mean=40%) of the synthetic speech trials.

A third study evaluated the comprehension of the magic Wand's speech within a funtional context. This "functional" speech discrimination test was conducted at 13 different fast food restaurants, 20 different grocery stores, and 4 different department stores. A research assistant entered the establishment and made a request using the Magic Wand (e.g., "I want a small coke", "Where is the milk", and "Where is the elevator"). The clerks and counter attendants were "naive" listeners in so far as they did not receive any instruction or information prior to the request. The clerks and counter attendants responded correctly (i.e., understood the request) on 90 out of 100 trials. The main reason given for failure to understand the speech was that they could not hear the words. In addition, 17 requests were made over the phone, and all were responded to correctly by the listeners.



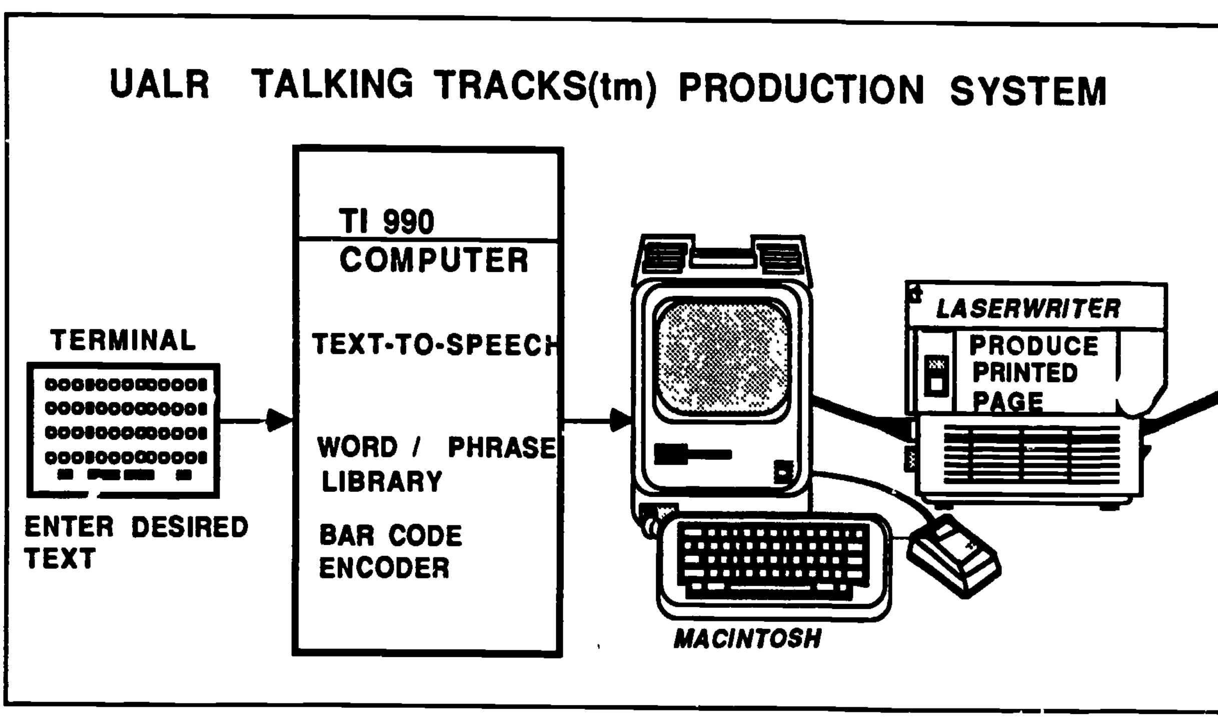
A variety of factors are currently being explored to improve the discrimination of the synthesized speech including reducing speaker vibration, filtering high pitched noise, and evaluating the speech under conditions which include contextual cues.

Evaluation of Bar Coded Recipes

The steps for ten simple recipes have been bar coded and line drawn graphics have been created for each step. The bar coded instructions and pictures have been combined to create pictorial recipes for persons with mental retardation. These specially prepared recipe booklets are currently being used to evaluate the effectiveness of bar coded instructions for persons with moderate to severe mental retardation. All three participants were able to master the recipes following bar coded instructions.

Bar Code Printing System

In order to support and promote research and development activities, a licensing agreement was secured between Texas Instruments, Inc. and the University of Arkansas for the noncommercial production of Talking Tracks (tm) for educational and research purposes. The resulting bar code production system consists of four basic components. The first two components were developed by Texas Instruments, these are: 1) text-to-speech software which enable words entered at the keyboard to be synthesized and edited; and 2) bar code encoder which translates the synthesized speech into digitized data. The second two components were developed at UALR and it enables bar codes, graphics and text to be produced using a desktop publishing system. The first part of this desktop publishing system consists of specially designed software which converts digitized bar codes into graphic files on the Apple MacIntosh. The second component of the system consists of the adaptation of commercial software packages for creating text and graphics and for printing using the Apple Laserwriter. This system has enabled the project to support the use and evaluation of bar code technology by dozens of educators, therapists, and researchers across the U.S.A. and abroad.



Ongoing Research Concerning the Instructional Uses of Bar Code Technology

Four studies are currently ongoing concerning the evaluation of bar code technology in special education settings. One study involves evaluating the effectiveness of combining bar codes with pictorial first aid manuals for instructing students with moderate to severe retardation. One step bar coded instructions have been prepared for eight of the first aid produres that were developed by Project MORE (Stevens, Keilitz, and Lent, 1978). A combined multiple baseline and alternating treatments design is being used in this study. Baseline performances were determined for six students. The students are currently in the maintenance phase of the study. Following the training and maintenance phases, the students will be tested to determine whether they can follow untrained first aid procedures using bar coded materials.

The second study concerns the use of bar coded reading materials for students with learning disabilities. This study will evaluate the effects that bar coded "dictionaries" and bar coded introductions have on oral reading and comprehension performances. Six students have been selected to participate in this study, bar coded materials have been prepared, and baseline measures are currently being collected.

The third study concerns the evaluation of bar coded instructional materials for children with severe visual impairments. Pilot work established effective modifications to the bar coded materials (i.e., embossing guidelines) and modifications to the scanning procedures which enable visually impaired persons to easily scan the codes. Baseline measures will be taken during the upcoming weeks.

The fourth study concerns the evaluation of this technology as an augmentative communication aid. This project will involve teaching four nonvocal children to scan bar codes, teaching the children to use the devices for communication, and comparing the communication effectiveness of bar code readers versus non-automated communication boards in community settings. Baseline measures of communication skills are currently being collected and scanning training is being conducted.

Current Limitations

Although the Magic Wand appears to have a variety of valuable uses, several concerns have been identified in regards to its design and performance. One problem is the precision needed for properly tracking bar codes. The precision requirements cause difficulties for young users and for users with physical impairments or severe intellectual impairments. Modification of the Magic Wand to facilitate grasping, tracking guides, and careful positioning of the bar codes might ameliorate some of the tracking problems.

Although the Magic Wand's speech is generally acceptable (Grady, et al., 1985), many words are still unintelligible (VanBiervliet, 1987). From the time the device was designed to the present, there have been considerable improvements in synthetic speech production. Modifications to the Magic Wand to facilitate speech discrimination could include replacing the built-in speaker with a higher quality speaker, reducing housing vibrations that occur when the device "speaks", and upgrading the speech hardware/firmware with current technology. Incorporation of these modifications should improve the intelligibility of the Magic Wand's speech.

A third limitation is the restricted vocabulary that is currently available. Although unique words and phrases can be produced at the University of Arkansas at Little Rock, the development of software to produce Talking Tracks using common microcomputers is sorely needed. This software would enable parents, teachers, and other professionals to produce Talking tracks using a microcomputer, a laser quality printer, and a text-to-speech-to-bar code program.

A final limitation is its child-like packaging. Although the Magic Wand is currently packaged in an 11 x 2 inch blue plastic disk, the cicuitry is held on a 3x3 inch cicuit board. This cicuit board along with a smaller battery source and speaker could be packaged in a unit resembling a personal cassette player.

CONCLUSIONS

Bar codes can be used to supplement virtually any instruction or information that can be provided in a printed format. The possibilities for increasing the independence of many handicapped individuals as a result of this technology are considerable. The use of bar code readers as efficient, self operated education/communication aids deserves careful development and evaluation.

REFERENCES

Alberto, P.A., Sharpton, W.R., Briggs, A., & Stright, M. (1986). Facilitating task acquisition through the use of a self-operated auditory prompting system. TASH, 11, 85-91.

Ellis, N.R. (1970). Memory processes in retardates and normals. In N.R. Ellis (Ed.), International review of research in mental retardation, Vol. 4. New York: Academic Press.

Goodrich, G. L., Bennett, R.R., De L'Aune, W.R., Lauer, H., & Nowinski, L. (1979). Kurzweil Reading Machine: A partial evaluation of its optical character recognition error rate. Journal of Visual Impairment & Blindness, 73, 389-399.

Grady, J., Judge, J., McCarthy, B., & Mills, N. (1985). Developing a communication prosthesis for mentally retarded adults. In M. Gergen & D. Hagen (Eds.), Computer Technology for the Handicapped (pp. 48-55). Henderson, MN: Closing The Gap.

Johnson, B., & Cuvo, A. (1981). Teaching mentally retarded adults to cook. Behavior Modificaiton, 5, 187-202.

Martin, J., Rusch, F., James, V., Decker, P.J., & Trtol, K. (1982). The use of picture cues to establish self-control in the preparation of complex meals by mentally retarded adults. Applied Research in Mental Retardation, 3, 105-119.

Moore, B., & Hunt, H. (1981). Optacon: A versatile communication tool. Journal of Visual Impairment & Blindness, 75, 343-345.

Perera, T.B., & Cobb, E.S. (1978). A minicomputer-based learning analysis system for optimizing PSI instructional materials for the visually handicapped. Behavior Research Methods and Instrumentation, 10, 231-237.

Robinson-Wilson, M.A. (1976). Picture recipe cards as an approach to teaching severely retarded adults to cook. In G.T. Bellamy (Ed.), Habilitation of the severely and profoundly retarded. Reports from the Specialized Training Program, Monograph, 99-108.

Sartain, H.W. (1976). Instruction of disabled learners: A reading perspective. Journal of Learning Disabilities, 9, 489-497.

Selvin, H.C. (1981). The Kurzweil Reading Machine: False hopes and realistic expectations. Journal of Visual Impairment & Blindness, 75, 76-77.

Spellman, C., DeBriere, T., Jarboe, D., Campbell, S., and Harris, C. (1978). Pictorial instruction: Training daily living skills, In M.E. Snell (Ed.) Systematic instruciton of the moderately and severely handicapped. Columbus, OH: Charles E. Merrill.

Stevens, C.J., Keilitz, I., and Lent, J.R.(1978). Daily living skills: Taking Care of Simple Injuries. Northbrook, IL: Hubbard.

Thurman, D., & Weiss-Kapp, S. (1977). Optacon instruction for the deaf-blind. Education of the Visually Handicapped, 9, 47-50.

VanBiervliet, A. (1987). Enabling handicapped nonreaders to independently obtain information: Initial development and evaluation of a bar code reader system (Final Report). Submitted to U.S.D.E./O.S.E.R.S., Grant # G008430075, Washington, D.C.

Vogelsberg, T., & Rusch, F. (1980). Community mobility training. In F. R. Rusch & D.E. Mithaug (Eds.). Vocational training for mentally retarded persons. Champaign, IL: Research Press.

Wacker, D.P., & Berg, W.K. (1983). Effects of picture prompts on the acquisition of complex vocational tasks by mentally retarded adolescents. Journal of Applied Behavior Analysis, 16, 417-433.