Teaching Keyboarding and Computer Skills to Persons with Developmental Disabilities[1]

Debbie McCuin and John O. Cooper

The Ohio State University

Running head: KEYBOARDING

---

[1]This report is based on a thesis submitted by the first author in partial fulfillment of the requirements for the Master of Arts degree at The Ohio State University. We wish to express our thanks to Nancy Archer, Diane Knupp, the Shelby County Board of Mental Retardation and Developmental Disabilities, and those people who agreed to participate in this study. Without their help, encouragement, and cooperation this work could not have been completed, and their time and efforts are appreciated. Address correspondence to John O. Cooper, Applied Behavior Analysis Program, The Ohio State University, 356 Arps Hall, 1945 N. High St., Columbus, OH 43210.

Abstract

This study investigated whether fluency of keyboarding skills of adults with developmental disabilities could be developed to a level acceptable for competitive employment and whether teaching participants correct keyboarding fingering improved their speed and accuracy. We also measured the transfer of typing skills to an electric typewriter. Results indicate that participants with developmental disabilities can learn to keyboard on a computer and on a typewriter although no conclusions can be drawn regarding the efficacy of teaching correct keyboard fingering. Participants and staff reported that the training was helpful.

Teaching Keyboarding and Computer Skills to
Persons with Developmental Disabilities

Technological change is occurring at an astounding pace. Computers are widely used in business and other sectors and this along with rapid technological change increases the need for the educational system to teach computer literacy and applications. Computer applications are more commonly taught in business education courses, in trade and technical schools, and from within the computer industry (Campbell & Kaplan, 1980). Computers, and the many new uses of them for people with disabilities, are also making their way into the rehabilitation field (Roessler, 1986). In addition, as computers have become more used and visible in society, they are more common in schools and with time have filtered down to special education.

Unfortunately, Christensen and Cosden (1986) found that placement in a special education setting has an adverse effect upon a student's prospect for acquiring computer knowledge. They noted that students with special needs are often not taught skills sufficient for computer literacy or how to use the computer as a work tool. Computers are used for instruction (e.g., computer assisted instruction), but there is little in the literature to indicate that students with special needs are taught <u>how</u> to use computers. There is some literature that addresses word processing and other applications to students with learning disabilities (Chisholm, 1987; Maddux, 1984), but overall, few studies address teaching special education students or adults with developmental disabilities computer literacy or keyboarding skills.

It is regrettable that people with disabilities are not taught computer skills because the more widespread use of computers in business and industry increases the employment opportunities of people who can use computer technology. Fortunately, some professionals believe that computer literacy is an important goal in the rehabilitation field (McCollum & Chan, 1985) and that business education--where it seems logical that computer skills be taught--needs to take positive steps to mainstream and integrate special education students (Reed, 1987). Studies show that people with disabilities can be trained to work in occupations that use computers and are successful in competitive employment situations (Crimando & Godley, 1985; Kiernan & Ciborowski, 1986; Saka, 1986).

People who can use computers also have opportunities beyond those in competitive employment. For example, persons with developmental disabilities who learn computer and keyboarding skills have expanded access to leisure activities and games, personal growth through instruction and information gathering, communication by way of modems or mailnets, and personal typing. Moreover, fluent keyboarding skills may give persons with disabilities feelings of technological equality with others who are not disabled or who are computer literate (McGee & McLaughlin, 1992).

Keyboarding is viewed by some as a very important skill in acquiring computer literacy (Craighead & Switzer, 1983; Saka, 1985; Stewart & Jones, 1983). Very few experimental or case studies were found in the literature, however, that address teaching keyboarding skills to children or adults with disabilities. Fewer studies were found which specifically deal with teaching these skills to persons with developmental disabilities. There seems to be a realistic need for these skills to be taught yet little available information or data on how to do so.

This study addressed teaching keyboarding skills as an integral component of participants' acquisition of more comprehensive computer literacy. For a performance skill like keyboarding to be functional, though, one must exhibit both a fairly high response frequency and good accuracy of response. This combination of accuracy plus speed is the basic definition of fluency (Binder, 1993; Binder & Watkins, 1990). Fluency is also more broadly defined as, "the rate of a performance that makes skills not only useful in everyday affairs, but also remembered even after a significant period of no practice" (Johnson & Layng, 1992, p. 1476). Fluency development was deemed very important in the teaching of keyboarding, and the instructional methods used in this study were developed to increase fluency and to make keyboarding a useful, functional activity.

The purpose of this study was to determine whether fluency (i.e., speed and accuracy) of keyboarding skills of participants with developmental disabilities could be developed to a level acceptable for competitive employment. The study also investigated whether teaching participants correct keyboard fingering increased the number of keystrokes per minute typed and decreased the number of errors made. Finally, the transfer of typing skills to an electric typewriter was measured. The study was not designed to demonstrate a functional relationship between the training methods used and improved keyboarding skills. The study is intended, however, to emphasize the importance of effective instructional methods and as a demonstration of fluency training.

Method

Participants

Five participants employed in an adult service vocational component of a County Board of Mental Retardation and Developmental Disabilities were selected as participants. All were Caucasian, and all lived in a small Midwestern city. Two participants lived with family, two lived in their own house or apartment, and one lived in a group home.

These people were selected because of some previous typing and/or computer experience or because they were judged by the Employment Services Division Coordinator of the County Board of Mental Retardation and Developmental Disabilities to have some potential to use skills learned in this study in a future work setting. These participants also had no motor disabilities that precluded their reaching the instructional goal of 300 keystrokes per minute. In addition, they knew about the proposed teaching program, agreed to participate, and viewed the target skills as beneficial.

Table 1 presents specific individual participant characteristics.

Table 1 about here

Setting

Keyboard training took place in the conference room of the building where participants received vocational training. The room measured approximately 4.72 m by 6.86 m. Placement of the computer and peripheral equipment on a table required the participants and manager (i.e., first author) to face a wall when working. There were two windows above the table, but they were high enough to make looking out difficult when seated in front of the computer. The typewriter sat either to the left of the computer and printer or on a table in the center of the room. A tall storage cabinet sat to the right of the table where participants worked, and two longer tables, surrounded by chairs, sat in the center of the room. A staff person's desk and book shelves faced the wall directly opposite the computer so that participants and the staff person had their backs to each other. There was also a chalkboard on the wall opposite the door.

Definition and Measurement of Dependent Variables

The number of keystrokes typed correctly and incorrectly using an Apple® Macintosh™ Plus computer with standard Qwerty keyboard and an electric typewriter from a typewritten sample page was counted during 1-min timings.

A correct keystroke was counted (a) for each letter in correct sequence within each word, (b) for each correctly capitalized letter, and (c) for each correct punctuation mark and/or space between words. An error was counted (a) for each letter in incorrect sequence within a word, (b) for each incorrectly capitalized letter, (c) for each omitted or extra punctuation mark and/or space between or within words, and (d) for each omitted, extra, or substituted letter within a word. One error was counted for two or more consecutive capitalized letters. Examples of scoring are: Once upon a time = 17 correct, 0 errors; once upno a tame = 13 correct, 4 errors; On ce uponn atim = 15 correct, 4 errors; ONCE upon a time = 17 correct, 1 error.

Dividing the number of correct keystrokes by five yielded words per minute. Consulting typing experts at local business and vocational schools to establish an average entry level speed for beginning typists in the community determined the instructional goal of 300 keystrokes per minute. The speed reported most frequently was 60 words per minute which translates to 300 keystrokes per minute.

Materials

Equipment consisted of an Apple® Macintosh™ Plus personal computer with a standard keyboard, an Apple® ImageWriter™ II printer, and a Cutting Edge 800 kilobyte external disk drive. Word processing software was Microsoft® Word (version 3.01). Participants typed on an IBM Correcting Selectric II typewriter to assess transfer of keyboarding skills. A General Electric model 3-5301 cassette tape player and audio tapes, made by the manager, were used (a) to mark the beginning and end of 1-min counting periods, (b) to help collect data during the pretest and follow up phases, and (c) to guide participants through practice sessions. The manager also used the tape player with headphones during training sessions.

One participant, because of visual impairment, used a machine that magnified text onto a view screen. He placed the practice sheets onto a moveable platform on the bottom of the machine, and it projected corresponding text onto the screen. He could adjust both the size and brightness of the text on the screen and see more text by moving the platform. Telesensory Systems, Inc. made the machine (model Vantage ERIC-W).

The manager devised the written training materials, practice sheets, and data collection sheets. Sample paragraphs used for 1-min counting periods (i.e., timings) and other paragraphs used to increase keyboarding fluency came from Typing For Accuracy (Nelson, 1985).

Experimental Design and Procedures

This study employed a pretest phase followed by keyboard training and daily practice with transfer probes to an electric typewriter. A follow up was completed several weeks after the end of training. Pretesting identified which target letters each participant could type correctly (using the proper finger) and which letters each participant typed incorrectly or not at all. Participants also typed a sample typewritten paragraph/page to determine fluency.

Keyboard training consisted of teaching participants the correct finger(s) to use to type letters of the alphabet and selected punctuation marks. Each participant was taught keys that were identified in the pretest as in need of training or correction. Each participant also had daily practice sessions to practice keyboarding keys they were learning and keys they had already mastered. In addition, each participant spent part of their daily practice time keyboarding a sample paragraph to attain fluency.

Transfer of skills to an electric typewriter was measured once during each week of training by having each participant do a 1 - min counting period on an electric typewriter using the same typewritten paragraph as was practiced during training sessions.

Pretest. The pretest phase consisted of the participants typing from a sample typewritten paragraph of approximately 120 words in length (or about 600 keystrokes). The participants' fluency of typing was assessed during 1-min periods with the computer keyboard and an electric typewriter. The manager checked each typed page and recorded the number of correct keystrokes and learning opportunities (i.e., incorrect keystrokes). The 1-min counting periods on the computer and the typewriter were repeated during three sessions for each participant.

The 1-min counting periods used pre-recorded audio taped directions. The audio taped script was: "Please get ready for your 1-min timing." (Pause) "Begin." (One min of silence) "Please stop typing."

Following a 1-min counting period, the participants typed the letters of the alphabet, the semi-colon, comma, period, and question mark and the capitalized version of each key. They also typed the return, shift, and space keys. Another pre-recorded audio tape was used during this assessment. The participants heard each letter of the alphabet and had 5 s to type the letter. For example, they heard a (5 s of silence), A (5 s of silence), b and so on until all letters were typed. A plus (+) was recorded for keyboarding the correct letter with the correct finger(s). A minus (-) was recorded if an incorrect letter was typed, if an incorrect finger(s) was used, or if the letter was not typed within 5 s.

The manager taught the participants proper handling of equipment, names of hardware components, and basic procedures necessary to use the computer (e.g., inserting diskettes properly, turning the machine on and off, identifying and opening files) during the pretesting phase.

Keyboard training. The participants had three individual 30-min training sessions per week. Training included verbal instructions, modelling, physical cues and guidance, and verbal praise. Repeated practice with an emphasis on accuracy was stressed.

Participants each had their own diskette. The manager created five blank files in each diskette labelled Monday, Tuesday, etc. The diskette files were used during each practice and training session. The manager copied all files from the participants' diskettes onto a separate diskette at the end of each week for the purpose of data collection and storage and then left five blank files on individual diskettes for use during the following week.

Each 30-min training session was arranged into 5-min segments of instruction, practice, and assessment. The first 5 min, after an initial brief conversation and the completion of basic procedures (e.g., inserting diskettes, opening correct file) consisted of reviewing letters learned the previous week. During the first week of training, the participants practiced previously known letters in this time.

The next 5-min segments were spent instructing and practicing correct fingering of five new letters. First, the manager either modelled keyboarding a letter or gave verbal/physical cues or guidance to help participants correctly keyboard the letter. The participants then keyboarded a row of this new letter. At times, the manager also modelled or gave verbal cues to ensure proper technique (e.g., keep fingers on home row, keep palms off the keyboard and feet squarely on the floor, keep eyes on page), and she sometimes said the letter(s) to aid the participants with pacing or to help identify a letter. The manager used the least amount of instruction deemed necessary, and the cues and prompts were faded out in later training sessions. These procedures were repeated until at least one row of all five new letters was typed individually. The participants then keyboarded the letters while looking at typewritten practice sheets. These practice drills first had participants type a line or two of the new letters. Then, a third letter was added for a line, and so on until the participants typed all five new letters. Again, the manager used verbal and physical cues, if needed, to ensure correct fingering. She said the letters only when necessary to help with pacing or to indicate where to begin typing. Participants were praised throughout these 10 min contingent on completing the drills accurately, using the correct finger(s), and keeping their eyes on the typewritten practice sheets. Correct typing was stressed.

During the second 5-min segment, the participants typed from typewritten practice sheets that included all previously learned letters. The manager spoke only to give cues or prompts (e.g., "Use the correct finger," "Look at the paper," "Remember accuracy) or to praise.

During the third 5-min segment, the participants practiced keyboarding the sample paragraph that was used to assess fluency (i.e., speed and accuracy). The participants keyboarded this paragraph as many times as possible during these 5 min. The manager told the participants to be as accurate as possible but also to try to go as fast as possible. The participants were reminded that this was only a practice time.

The last five minutes of each session were for assessment and closure. A 1-min counting period was completed as described in the pretest section, but the participants and manager counted correct keystrokes and learning opportunities (i.e., errors) together and displayed the results on each participant's standard celeration chart (Pennypacker, Koenig, & Lindsley, 1972). The manager then praised participants, showed each of them the keyboarding progress she or he made during the week, and gave encouragement to continue doing well in individual practice sessions.

The manager listened to an audio tape with headphones during training sessions to keep track of the 5-min segments and to allow her to be consistent with the instructions that participants heard during daily practice sessions. The manager also began leaving the room for a few minutes at a time during the later sessions and encouraged the participants to work on their own as they would in a work setting. This audio tape was the same one used during daily practice.

Target keys were taught in groups of five new keys per week during the keyboard training phase. The participants received instruction on the home row keys (a, s, d, f, g, h, j, k, l, ;) and the space and return keys first followed by instruction on the top row keys (q, w, e, r, t, y, u, i, o, p) and, lastly, the bottom row keys (z, x, c, v, b, n, m, comma, period, and question mark). Participants were taught all lower case letters first followed by instruction on how to capitalize each letter. Training on use of the two shift keys preceded instruction of capital letters.

Daily practice. Participants were instructed to practice on their own for 30-min per day, five days per week (excluding scheduled holidays and days when a participant might work at a different job site). The 30-min practice sessions followed the same procedures used during the training sessions with two exceptions. Participants practiced keyboarding only from typewritten practice sheets made by the manager, and counting and charting were not done at the end of the session. A 1-min counting period, however, was completed at the end of each practice session. The manager printed, counted, and charted the results of these sessions at a later time.

A pre-recorded cassette audio tape and a packet of typewritten practice sheets divided into numbered sets guided the participants through their individual practice sessions. The tape gave instructions at the beginning and at each 5-min interval throughout the 30-min session. Participants turned on the audio tape when they began each practice session, inserted their diskette, and opened the appropriate file (e.g., Monday, Tuesday). They began typing the practice sheets in Set 1 (i.e., letters learned last week or letters previously mastered). At the end of 5 min, the participants put aside the Set 1 practice sheets and began typing the practice sheets in Set 2 (i.e., the five new letters for the week). Participants continued typing Set 2 practice sheets. If they completed the practice sheet, they were to begin typing again from the top. The participants were told, after another 5 min passed, to put aside Set 2 practice sheets and to begin typing Set 3 practice sheets that included all previously learned letters. The participants were told to remember to look at the paper and to keep their fingers on home row. At the end of 5 min, they put aside Set 3 practice sheets and began typing from Set 4. They practiced this page repeatedly as accurately and as fast as possible. After 5 min of practice, they rested briefly then pushed the Return key four times, allowing the manager to see where practice typing ended and the 1-min counting period began. The participants then completed the 1-min counting period. Finally, participants were instructed to save their work, remove their diskette, and rewind the audio cassette tape.

Transfer. Three times during the pretest and the follow up and at the end of one training session per week participants completed an additional 1-min counting period on an electric typewriter to assess for transfer of skills. Their performances were counted and scored using the procedures described for the pretest phase.

Follow up. The follow up was completed five weeks after the end of the study. The participants typed letters of the alphabet and completed six 1-min counting periods as they did during the pretest phase. They typed on a computer keyboard and on an electric typewriter from typewritten copy. Counting and charting followed the procedures described for the pretest phase.

Procedural Integrity

An independent observer assessed the integrity of the independent variable during one of each participants' three training sessions per week, for the duration of training. The observer watched videotaped training sessions and checked, on a checklist of procedures, whether each experimental procedure was completed. The independent observer told the manager of each recorded discrepancy in applying the experimental procedures and the manager reviewed the specific procedures with the independent observer. This review and practice served to calibrate any drift from the stated procedures and to encourage consistent application of the procedures through out the experiment. The number of check marks made for application of procedures with all participants was divided by the total number of check marks possible, and the result multiplied by 100. The manager followed the training procedures 97.3 % of the time during all recorded sessions. Agreement for individual sessions ranged from 86.7 to 100 %.

Accuracy of Measurement

Accuracy checks were conducted for each of the 1-min counting periods during the pretest and the first week of training, once per week for each participant during the remaining weeks of the keyboarding and transfer training phases, and once during follow up. Accuracy of the scoring of keystrokes and keystroke learning opportunities keyboarded during 1-min counting periods was established by having the manager and a second person independently count the results of each selected timing. Both people counted each timing, reviewed the typed products together, and then independently re-counted the keystrokes and keystroke learning opportunities if 100 % accuracy was not reached. The manager and independent counter followed this procedure until 100 % agreement was established between them on each of the 1-min counting periods checked.

Results

We used graphic presentations and terms associated with Precision Teaching to present our results (e.g., Lindsley, 1972, 1990). All data appear on standard celeration charts (Pennypacker, Koening, & Lindsley, 1972) providing a standard display of frequency as count per minute and count per week (standard charts are also available in count per month and year). These charts are standard because a linear measure of behavior change across time provides a standard celeration. Celeration is a derivative of frequency (count per unit of time) and is measured as a frequency divisor per unit of time (i.e., frequency per unit of time) (Johnston & Pennypacker, 1993). A line drawn from the bottom left corner to the top right corner of any standard celeration chart has a slope of 34°. Multiples or divisors express celeration values and the 34° trend line has a celeration value of x2 (read as <u>times two</u>), a doubling in frequency every week on the day chart or every month on the weekly chart (Potts, Eshleman, & Cooper, 1993). The multiply symbol (x) and the number representing proportional changes in count across time--the multiple (e.g., x1.4)--note multiplying trend lines, and dividing trend lines use a divide symbol (÷) followed by the divisor (e.g., ÷1.4). Trend lines across a series of days that show multiplying celerations move from the lower-left portion of the chart to the upper-right, and upper-left to lower-right for dividing celerations.

The number of keystrokes and keystroke learning opportunities keyboarded on the computer during 1-min counting periods is shown in Figures 1, 2, and 3. These Figures display keystrokes and keystroke learning opportunities recorded at the end of each session during the pretest, training, and follow up phases and shows the participants' progress in fluency of keyboarding skills.

Figures 1, 2, and 3 about here

Pretest and Follow up

During the pretest and follow up phases, each participant keyboarded each letter of the alphabet, the semi-colon, comma, period, and question mark as well as the capitalized version of each of these keys. They also typed the return, shift, and space keys for a total of 63 letters or keys. This testing allowed the manager to determine the keys that each participant already knew. The pretest showed that all participants correctly typed between three and five letters, and all typed the letters "h," "j," and "n."

Follow up testing revealed that of the 63 possible letters, Participant 1 keyboarded 25 letters correctly; Participant 2 keyboarded 33 letters; Participant 3 keyboarded 37; Participant 4 keyboarded 11 letters; and Participant 5 was able to type 53 letters correctly.

Keyboard Training and Follow up

Participant 1 typed between 106 and 125 keystrokes per minute (21 to 25 words per minute) in all but three sessions over the last five weeks of training and had good accuracy with zero to two keystroke learning opportunities per minute during the last two weeks of training. Participant 2 keyboarded 89 to 111 keystrokes (18 to 22 words) per minute during the last two weeks of training. Her accuracy was also good, with zero to one keystroke learning opportunity per minute in eight of the last nine recorded sessions. The correct frequencies of the other participants did not exceed 109 keystrokes (approximately 22 words) per minute.

All participants keyboarding skills improved during the 11 weeks of the study. Their weekly learning, as shown by the celeration courses, multiplied between x1.1 to x1.25. Also, each of the participants maintained their keyboarding fluency at approximately the same number of keystrokes per minute they keyboarded at the end of the study, as shown by the follow up assessment five weeks after the end of instruction and practice.

Transfer

Transfer checks were done for each participant during each week of training and during the pretest and follow up. Participants typed from the same sample paragraph as they did during training, except they used an electric typewriter. The keystrokes and keystroke learning opportunities from these 1-min timings were counted and scored in the same manner as those generated on the computer keyboard. Figure 4 presents standard celeration charts displaying the participants' weekly progress in fluency of typing skills on an electric typewriter.

Figure 4 about here

The final typing fluencies of Participants 1 and 4 on the electric typewriter were roughly equivalent to their typing fluencies on the computer. Participant 1 typed 89 keystrokes per minute on the typewriter during the final week versus 88 to 111 keystrokes per minute on the computer. Participant 4 keyboarded 31 to 51 keystrokes per minute on the computer and 49 keystrokes per minute on the typewriter during the last week. Participants 2, 3, and 5, however, typed slightly slower on the typewriter than on the computer keyboard during training. All participants' typing skills improved during the study, and their monthly learning multiplied between x1.2 to x1.7.

Participants 1, 2, 3, and 5 typed faster on the electric typewriter than on the computer during follow up. Participant 4 typed one less keystroke per minute on the typewriter than on the computer.

DISCUSSION

The purpose of this study was to determine whether fluency (speed and accuracy) of keyboarding skills could be increased by teaching correct keyboard fingering and whether fluency could be developed to a level acceptable for competitive employment. We evaluated three research questions. (a) Will the participants' keyboarding fluency meet an instructional goal of 300 keystrokes per minute with zero to five keystroke learning opportunities (i.e., errors)?; (b) Will teaching participants correct keyboard fingering be functionally related to improved fluency?; and (c) Will keyboarding fluency transfer to an electric typewriter? This discussion presents answers to these questions and some limitations of the study. It also poses questions for future research and states implications for future vocational opportunities of participants and participants with developmental disabilities.

None of the participants keyboarded at our instructional goal of 300 keystrokes per minute; however, all improved during the 10-week training period. Participants 1 and 2 showed the most improvement. Results may have been better for Participants 3 and 5 if they had completed 10 rather than 9 weeks of training. Participant 5 began training 1 week later than the other participants, replacing a participant who began a new job and could not continue training. Participant 3 was on vacation for a week, and her fluency decelerated when she returned to training. Also, some participants were unable to practice daily because of other job demands, vacation and holiday days, and illness. We made daily practice a priority at the beginning of Week 5 for Participants 1 and 3 because their keyboarding speeds were not accelerating at a noticeable frequency.

The participants did not reach our instructional goal. Projecting from their data, it is reasonable to expect some of the participants to reach the fluency goal with on-going practice. If our projections are correct, Participants 1 and 2 could reach approximately 300 keystrokes per minute in another 10 to 12 weeks of training and practice. Speeds attained by Participants 1 and 2 compare favorably to the speeds achieved by students in Saka's (1985) study. His students keyboarded approximately 23 words per minute at the end of a 6-month study. Saka (1985) also reported that his students obtained work in computer-related fields even though they were not able to attain the entry level speed of most word processors or data entry clerks. Many other types of jobs and work situations were reported in the literature (e.g., Crimando & Godley, 1985; Kiernan & Ciborowski, 1986; Poggioli, 1983), and it is possible that our participants will have similar, and expanded, job opportunities as a result of their improved keyboarding and computer skills.

This study followed Hummel and Balcom's (1984) recommendation to use utility programs (e.g., word processing) to teach persons with disabilities about computers, and it provided the participants with new computer literacy skills. Computer literacy has been deemed an important goal in rehabilitation (McCollum & Chan, 1985), and this knowledge will potentially help these participants access computer technology or use the computer as a work tool. Improved keyboarding abilities should also serve the participants well, as a lack of keyboarding skills has been cited as interfering with the use of programs and with the computer itself (Craighead & Switzer, 1983; Hasselbring & Goin, 1988; Saka, 1985). Even though the participants did not reach the instructional goal of 300 keystrokes per minute, their acquired skills and abilities may benefit them in other job-related or personal endeavors.

All participants' keyboarding fluencies improved. It is impossible to know if the improvement is a result of learning correct fingering or is a practice effect. Another analysis is needed to determine the specific reasons for the improved fluency of our participants.

There was a marked increase in accuracy, as evidenced by a deceleration in keystroke learning opportunities per minute for all participants after they learned all letters of the alphabet and the shift keys. Unfortunately, concurrent acceleration in speed was not noticeable. Saka's (1985) results also showed an increase in accuracy after his students learned all letters and numbers, but his results indicated an acceleration of correct responses at the same time.

Correct keyboard fingering is cited as a desirable skill in itself (Craighead & Switzer, 1983; Stewart & Jones, 1983). Persons with disabilities can waste time and become frustrated searching for the right keys when they use a computer (Saka, 1986), and the ability to correctly and automatically enter information can be a valuable asset. The "hunt and peck" method of typing is not acceptable for long responses (Kisner, 1984) and may not help these participants with disabilities in either personal or work-related pursuits. Good keyboarding skills allow persons to use the computer and its programs rather than spending inordinate amounts of time attempting to input data and commands.

Improved keyboard fingering skills should also allow our participants to use computers in a wider range of leisure and instructional activities. There are a variety of games and leisure programs that these participants may now use more easily because of their improved skills. Personal typing such as letter writing and other communication may be enhanced with better keyboarding skills as well.

Four participants typed faster on the electric typewriter than on the computer during follow up. These findings most likely resulted from the participants' continued practice with the typewriter after the training program was over and the computer removed from the setting. Overall, the participants effectively transferred their keyboarding skills to the electric typewriter and had no noticeable difficulties with finding the correct keys or typing. They had to press the Return key at the end of each line, but it took them only a short time to adjust to pressing this extra key.

We found no experimental studies that assessed the transfer of keyboarding skills from a computer keyboard to an electric typewriter. This study provides data to indicate that the typing skills of adults with developmental disabilities can successfully transfer from a computer to a typewriter. If the reverse is also true, it is possible that people without immediate or lengthy access to a computer could learn keyboarding skills on a typewriter and then expand their abilities on a computer. Given the already cited need to teach keyboarding skills, the possibility of using widely available typewriters could be a useful alternative when computers are unavailable or financially unfeasible. Christensen and Cosden (1986) stated that students in special education placements are rarely taught skills sufficient for computer literacy. Temporarily using a typewriter to teach and improve keyboarding skills is one possible short-term solution to this problem in settings where computers are either unavailable or used in other ways (e.g., computer-assisted instruction).

This study had several limitations. First, training was completed within a 10-week period. It is certainly conceivable that the participants' keyboarding fluency would have improved given a longer training time. Second, participants were not always able to practice daily. Daily practice may have resulted in improved fluency over the course of training. Frequent and repeated practice is functionally related to the development of behavioral fluency (e.g., Heward, Heron, Gardner, & Prayzer, 1991; Miller, Hall, & Heward, 1994; Okyere & Heron, 1991; Samuels, 1979; Sindelar & Stoddard, 1991; Sweeney, Omness, Janusz, & Cooper, 1992). Third, this study was not analytic. We did not demonstrate that the participants' increased keyboarding fluency was functionally related to our instructional methods. Fourth, the study did not assess if keyboarding fluency would transfer to novel typewritten information. The participants were always assessed while typing the same paragraph; there were no fluency measures when they typed new material. Fifth, the participants did not type from hand-written copy or from dictated material. These could be useful skills if participants were employed in secretarial positions. Finally, this study did not specifically address word processing or data entry skills which may be useful for specific jobs. In addition, while not a limitation of the study, no computer was available to the participants after this study was completed.

A final, specific, problem concerned the "Key Repeat Rate" function of the word processing software. Some of the participants' keystroke learning opportunities during weeks 3 through 5 are probably artificially high due to a computer-related problem which caused letters to be repeated and typed very quickly when a single key was depressed. The manager eventually resolved this problem and taught some of the participants and staff persons how to change the Key Repeat Rate function in the Control Panel menu of the system software. Some participants were able to recognize the problem and make necessary corrections by themselves by the end of the fifth week.

Our current research suggests areas for future research. For instance and perhaps most importantly, an experimental analysis is needed to determine if teaching correct keyboard fingering improves keyboarding fluency. If the answer to this question is positive, then how long will it take participants with developmental disabilities to attain 300 correct keystrokes per minute or other functional keyboarding fluencies? Also, there are methods other than those used in the current study to teach keyboarding. What instructional methods are most effective and efficient in teaching functional keyboarding skills to persons with disabilities? In addition, it would be very helpful and cost-effective to know if keyboarding skills taught on an electric typewriter would easily transfer to a computer keyboard and if skills would transfer to other computer keyboards and systems.

Are keyboard adaptations necessary or beneficial in teaching persons with developmental or other disabilities keyboarding and computer skills? Cook, Leins, and Woodall (1985) described several keyboarding adaptations that can be useful for persons who have trouble with the physical configuration of the standard keyboard. Kirschenbaum, Friedman, and Melnik (1986) describe a one-handed chordic keyboard which allowed participants with varying disabilities to type from 8 to 14 words per minute after 5 hours of practice. This kind of keyboard may be beneficial for people like Participant 5 who frequently needed to remove one hand from the keyboard to move the text under his magnifying machine. Roessler (1986) argued that a Dvorak keyboard, with the most commonly struck letters on home row, would be beneficial for people who have limited physical mobility. Would the Dvorak keyboard improve the keyboarding fluency of persons without physical impairments, and is the Dvorak keyboard more efficient than the Qwerty keyboard?

With respect to improving the employment prospects of participants with developmental disabilities, at least two other questions need investigation. First, can participants be taught to keyboard from hand written and speech input as well as from typewritten text? If so, how can this be accomplished? Second, can persons with developmental disabilities learn word processing, data entry, and other skills specific to jobs available in their communities? Saka's (1985) results indicate that this is possible, but much more research is needed in this area.

Crimando and Godley (1985), Kiernan and Ciborowski (1986), and Saka (1986) reported that people with disabilities can be taught to use computers in competitive employment situations. This study, however, did not result in immediate vocational changes for the participants. At the time of the follow up, all participants remained in the same job skills training program as during keyboard training. Participants 1 and 2 were interested in pursuing office or clerical jobs and continued to independently practice typing on the typewriter at their work place. Their keyboarding fluencies were not at the level generally acceptable for entry-level word processing (e.g., 50-60 words per minute) but were sufficient for other kinds of office and clerical jobs (Saka, 1986).

All of the participants learned some keyboarding and computer skills that could be expanded in future job-specific training programs. They all learned to keyboard adequately enough to successfully use many computer applications, and all were able to master basic computer functions (e.g., turning on machine, inserting disks, finding and opening files, saving work). Their keyboarding skills and computer knowledge may serve as valuable prerequisites for future jobs or job training. The participants also learned that they could use computers, and that their future vocational possibilities were expanded as a result. Their self-reports indicated that their perceptions of their own abilities and potential was increased, and some self-imposed limitations on possible vocational opportunities were removed. Staff persons and employers in the community were also able to see the realistic potential for the participants to engage in competitive clerical jobs.

REFERENCES

Binder, C. (1993). Behavioral fluency: A new paradigm. Educational Technology, XXXIII (10), 8-14.

Binder, C., & Watkins, C. L. (1990). Precision Teaching and Direct Instruction: Measurably superior instructional technology in schools. Performance Improvement Quarterly, 3(4), 74-96.

Campbell, J. W., & Kaplan, I. (1980). The IBM project to train the handicapped. Gaithersburg, MD: International Business Machines Corporation, Federal Systems Division. (ERIC Document Reproduction Service No. ED 241 681)

Chisholm, J. (1987). The computer teaching tool--learning tool? Academic Therapy, 23, 31-36.

Christensen, C. A., & Cosden, M. A. (1986). The relationship between special education placement and instruction in computer literacy skills. Journal of Educational Computing Research, 2, 299-306.

Cook, A. M., Leins, J. D., & Woodall, H. E. (1985). Use of microcomputers by disabled persons: A rehabilitation engineering perspective. Rehabilitation Counseling Bulletin, 28, 283-292.

Craighead, D., & Switzer, M. E. (1983). Is typing the key to computer literacy? Instructor, 93(2), 178-180.

Crimando, W., & Godley, S. H. (1985). The computer's potential in enhancing employment opportunities of persons with disabilities. Rehabilitation Counseling Bulletin, 28, 275-282.

Hasselbring, T. S., & Goin, L. I. (1988). Use of computers. In G. A. Robinson, J. R. Patton, E. A. Polloway, & L. R. Sargent (Eds.), Best practices in mental disabilities (Vol. 2) (pp. 200-219). Des Moines: Iowa Department of Education.

Heward, W. L., Heron, T. E., Gardner, R., & Prayzer, R. (1991). Two strategies for improving students' writing skills. In G. Stoner, M. R. Shinn, & H. M. Walker (Eds.), Interventions for achievement and behavior problems (pp. 379-398). Silver Spring, MD: National Association of School Psychologists.

Hummel, J. W., & Balcom, F. W. (1984). Microcomputers: Not just a place for practice. Journal of Learning Disabilities, 17, 432-434.

Johnson, K. R., & Layng, T. V. J. (1992). Breaking the structuralist barrier: Literacy and numeracy with fluency. American Psychologist, 47, 1475-1490.

Johnston, J. M., & Pennypacker, H. S. (1993). Strategies and tactics of behavioral research (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Kiernan, W. E., & Ciborowski, J. (1986). Survey of employment for adults with developmental disabilities. Remedial and Special Education, 7, 25-30.

Kirschenbaum, A., Friedman, Z., & Melnik, M. (1986). Performanee of disabled persons on a chordic keyboard. Human Factors, 28, 187-194.

Kisner, E. (1984). Keyboarding--a must in tomorrow's world. The Computing Teacher, 11, 21-22.

Lindsley, O. R. (1972). From Skinner to precision teaching: The child knows best. In J. B. Jordan & L. S. Robbins (Eds.), Let's try doing something else kind of thing (pp. 1-12). Arlington, VA: Council for Exceptional Children.

Lindsley, O. R. (1990). Our aims, discoveries, failures, and problems. Journal of Precision Teaching, 7, 7 -17.

Maddux, C. D. (1984). Using microcomputers with the learning disabled. Will the potential be realized? Educational Computer, 4, 31-32.

McCollum, P. S., & Chan, F. (1985). Rehabilitation in the information age: Prologue to the future. Rehabilitation Counseling Bulletin, 28, 211-218.

McGee, W. P. T., & McLaughlin, T. F. (1992). The effects of a computer tutorial on keyboarding speed of at-risk high school students. Educational Technology, 32(1), 50-54.

Miller, A. D., Hall, S. W., & Heward, W. L. (1994). Effects of sequential 1-minute time trials, with and without inter-trial feedback, on regular and special education students' fluency with math facts. Manuscript submitted for review.

Nelson, J. (1985). Typing for accuracy (8th ed.). Baltimore: H. M. Rowe.

Okyere, B. A., & Heron, T. E. (1991). Use of self-correction to improve spelling in regular education classrooms. In G. Stoner, M. R. Shinn, & H. M. Walker (Eds.), Interventions for achievement and behavior problems (pp. 399-413). Silver Spring, MD: National Association of School Psychologists.

Pennypacker, H. S., Koenig, C., & Lindsley, O. R. (1972). Handbook of the standard behavior chart. Kansas City, KS: Precision Media.

Poggioli, F. M. (1983). The disabled can do the job . . . and do it excellently! The Ohio Business Teacher, 43, 57-61.

Potts, L., Eshleman, J. W., & Cooper, J. O. (1993). Ogden R. Lindsley and the historical development of precision teaching. The Behavior Analyst, 16(2), 177-189.

Reed, J. C. (1987). Using a team approach when mainstreaming special needs students. Business Education Forum, 41, 3-4.

Roessler, R. T. (1986). Technology utilization in rehabilitation. Rehabilitation Literature, 47, 170-173.

Saka, T. (1985). Computer work skills training for persons with developmental disabilities. Computers in Human Services, 1, 39-51.

Saka, T. (1986). The importance of keyboarding skills in computer usage with the handicapped. In H. J. Murphy (Ed.), Computer Technology/Special Education/Rehabilitation: Proceedings of the Conference (pp. 296-305). Northridge, CA: California State University.

Samuels, S. J. (1979). The method of repeated readings. Reading Teacher, 32, 403-408.

Sindelar, P. T., & Stoddard, K. (1991). Teaching reading to mildly disabled students in regular classes. In G. Stoner, M. R. Shinn, & H. M. Walker (Eds.), Interventions for achievement and behavior problems (pp. 333-355). Silver Spring, MD: National Association of School Psychologists.

Stewart, J., & Jones, B. W. (1983). Keyboarding instruction: Elementary school options. Business Education Forum, 37(7), 11-12.

Sweeney, W. J., Omness, C. K., Janusz, K. L., & Cooper, J. O. (1992). Adult literacy and precision teaching: Repeated readings and see/cover/write practice to improve reading and spelling. The Journal of Precision Teaching, 9, 6-19.

Table 1

Participant Information

Participant	Gender	Age	IQ[a]	Diagnoses
1	M	40	FS-74	Borderline Mental Retardation
				Organic Mental Disorder
2	F	45	FS-76	Borderline Mental Retardation
				Mixed Personality Disorder
3	F	47	FS-68	Mild Mental Retardation
4	M	47	SA 12.6	Mild Mental Retardation
			SQ 50	Non-verbal
5	M	25	FS-62	Mild Mental Retardation
				Schizotypal Personality Disorder
				Visual Impairment

Note. FS = full scale; SA = social age; SQ = social quotient.
[a]WAIS - R except participant 4, SA and SQ are Vineland scores.

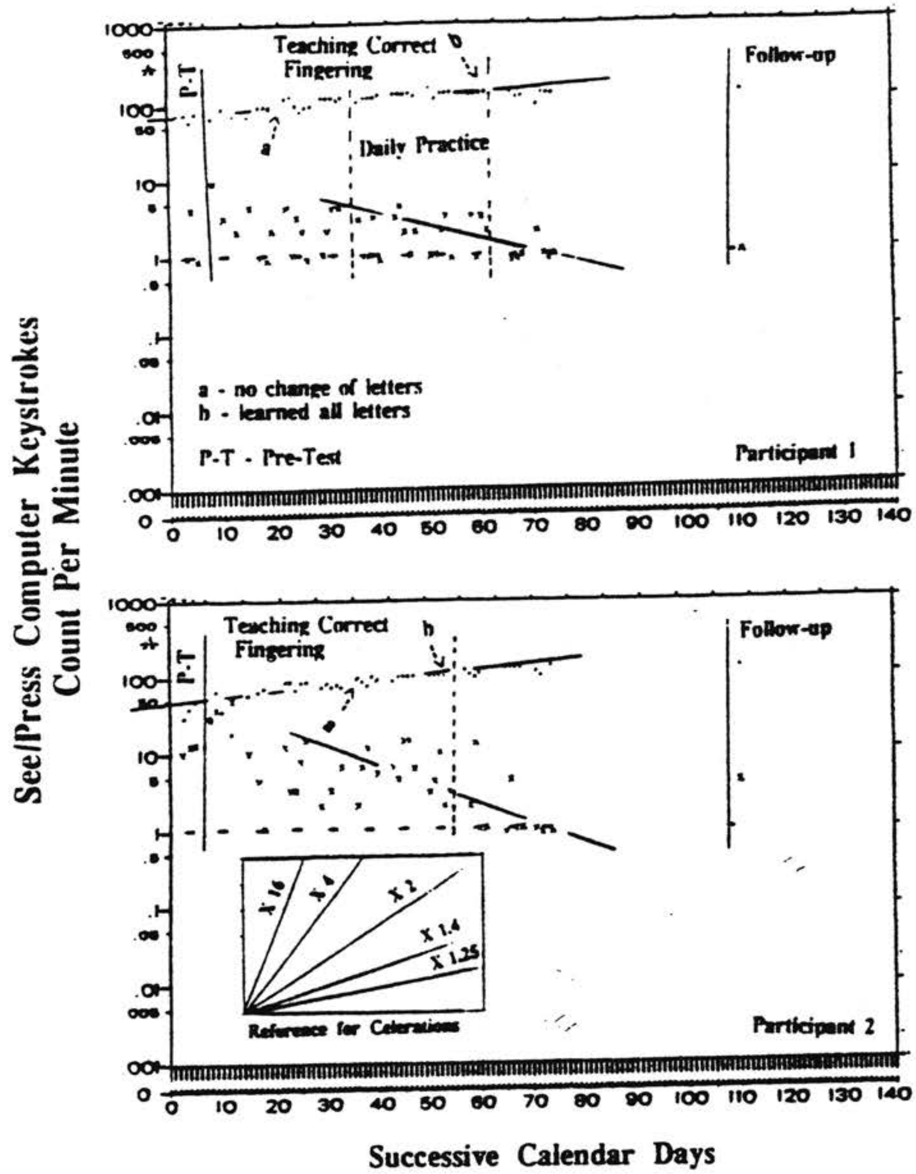
Figure Captions

Figure 1. Number of keystrokes and keystroke learning opportunities Participants 1 and 2 typed per minute on the computer. A dot (·) represents the number of correct keystrokes and an x represents learning opportunities. The dashed horizontal lines across the 1 line of the charts indicate that the keystroke counting periods were of 1-min duration.

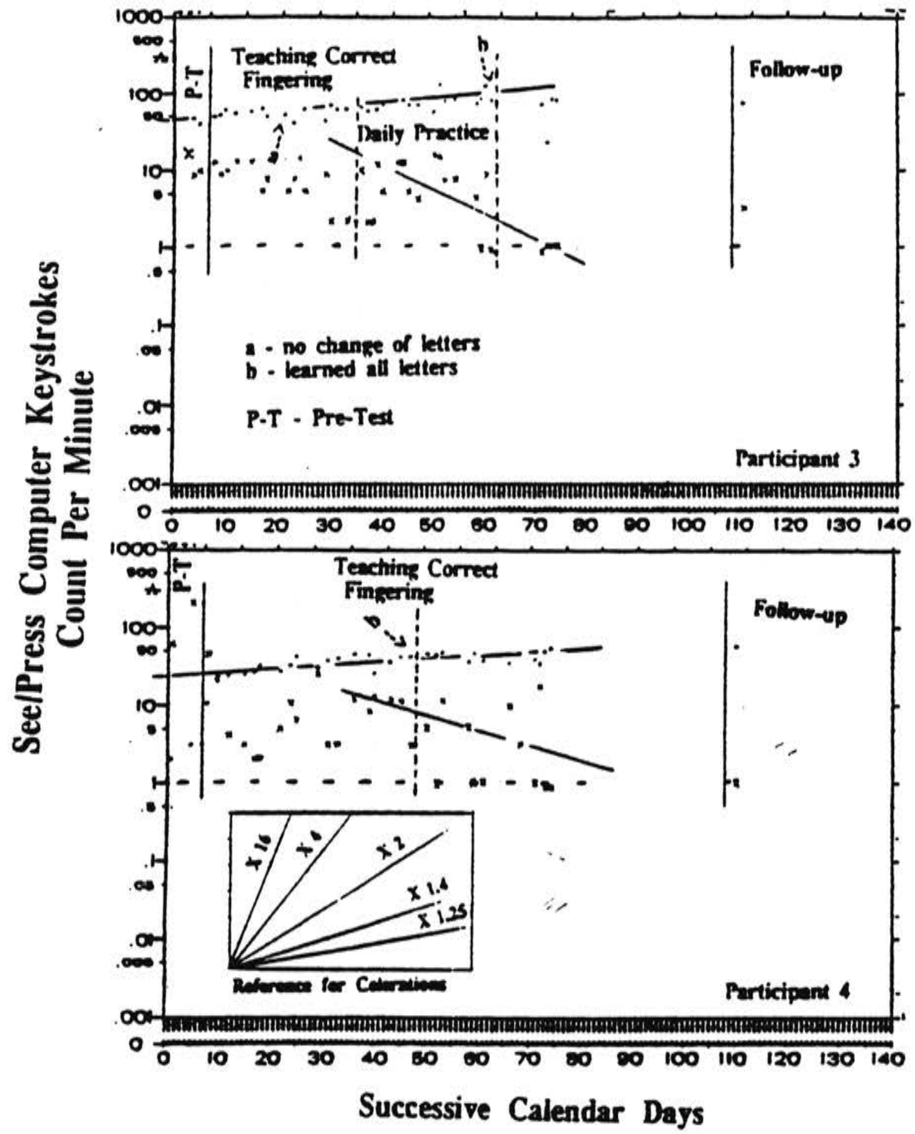
Figure 2. Number of keystrokes and keystroke learning opportunities Participants 3 and 4 typed per minute on the computer. A dot (·) represents the number of correct keystrokes and an x represents learning opportunities. The dashed horizontal lines across the 1 line of the charts indicate that the keystroke counting periods were of 1-min duration.

Figure 3. Number of keystrokes and keystroke learning opportunities Participant 5 typed per minute on the computer. A dot (·) represents the number of correct keystrokes and an x represents learning opportunities. The dashed horizontal lines across the 1 line of the charts indicate that the keystroke counting periods were of 1-min duration.

Figure 4. Number of keystrokes and keystroke learning opportunities Participants typed per minute on the typewriter. A dot (·) represents the number of correct keystrokes and an x represents learning opportunities.

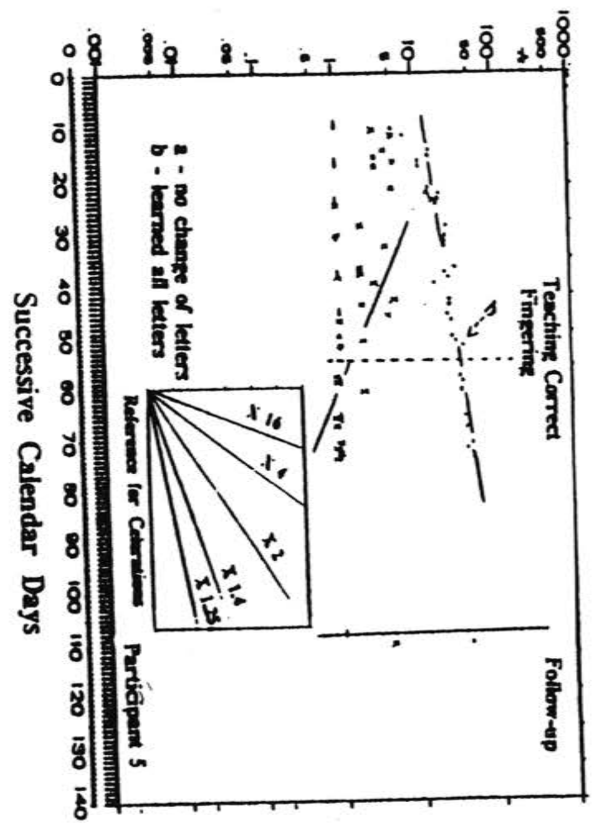


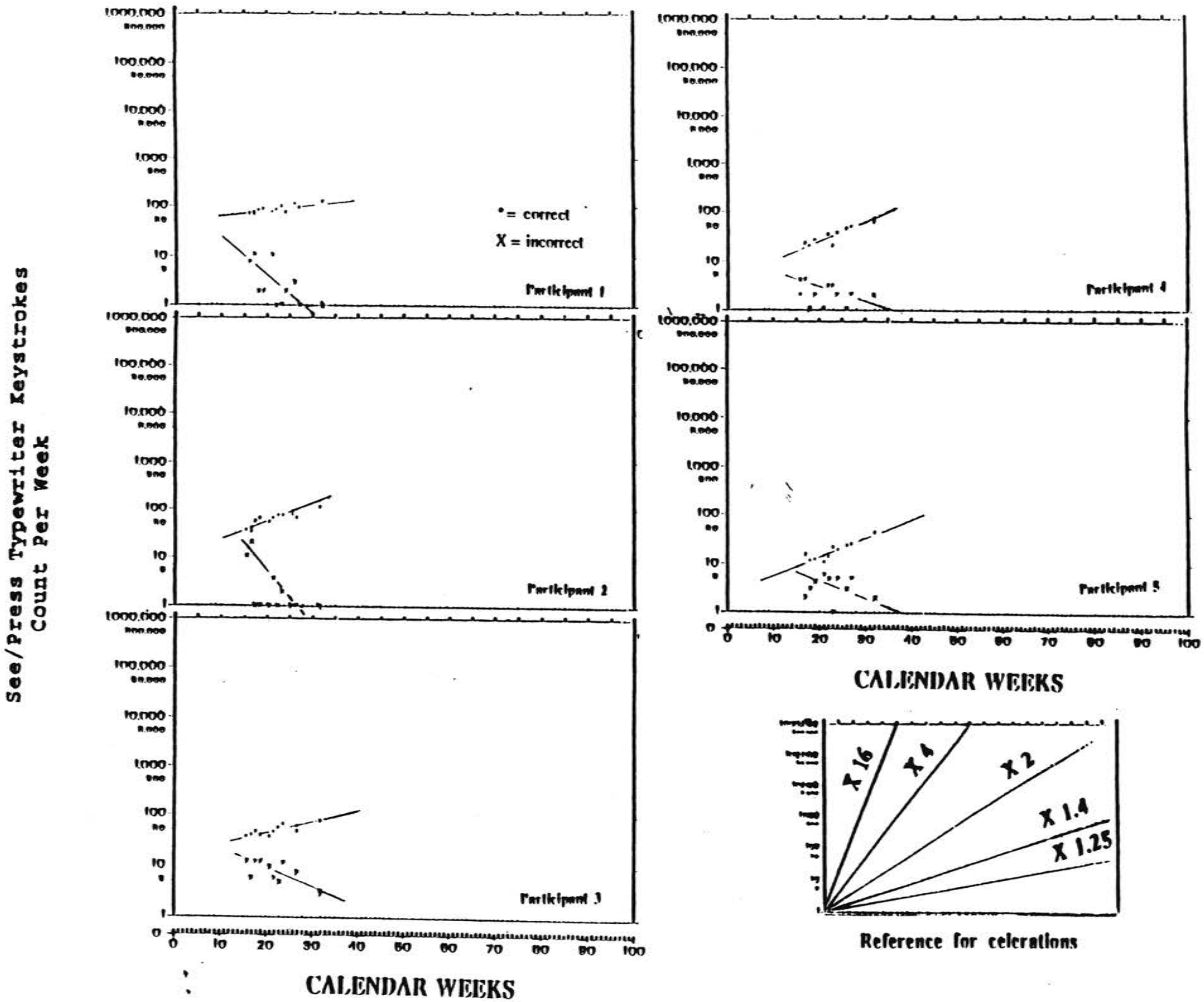
Teaching Correct Fingering
Daily Practice
Follow-up
P-T
a
b
a - no change of letters
b - learned all letters
P-T - Pre-Test
Participant 1
Participant 2
Reference for Celerations
X 16
X 4
X 2
X 1.4
X 1.25
See/Press Computer Keystrokes
Count Per Minute
Successive Calendar Days
1000
100
10
1
.1
.01
.001
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140



Teaching Correct Fingering
Daily Practice
Follow-up
P-T
a - no change of letters
b - learned all letters
P-T - Pre-Test
Participant 3
Teaching Correct Fingering
Follow-up
Reference for Celerations
Participant 4
See/Press Computer Keystrokes Count Per Minute
Successive Calendar Days

See/Press Computer Keystrokes
Count Per Minute





See/Press Typewriter Keystrokes Count Per Week
1000,000
100,000
10,000
1000
100
10
1
0
* = correct
X = incorrect
Participant 1
Participant 2
Participant 3
Participant 4
Participant 5
0 10 20 30 40 50 60 70 80 90 100
CALENDAR WEEKS
X 16
X 4
X 2
X 1.4
X 1.25
Reference for celerations