Summary

Children need to control their own writing. But they can't do it alone. Teachers need to help them maintain control because when they are successful, children see themselves as important learners with things to say. Furthermore, when children control the writing process, they write far beyond traditional expectations, spell better, and take pride in the craft of handwriting.

It isn't easy to help children control their own writing. Teachers need information to know when and how to help. Preliminary research from this study of children's composing shows that handwriting is a critical index for showing where to begin to help children.

When children first write, they treat writing as speech. They draw to supply context for the subject, run words together, spell words as they sound, let words run around the page, speak out loud when they write, blacken in letters, use capitals and exclamation points liberally.

Redrafting demands a new view of space and aesthetics. Just when the child has solved early problems of space, new information demands different help from the teacher. But this new step is a boon to good handwriting. When the craft of handwriting follows the crafting of the child's *own information*, a greater level of excellence in final copy is achieved.

Today Toni isn't bothered when her words run together or down the side of the page. Tomorrow she will be. She will need to see another way to handle the problem. Her teacher will need to know how to help Toni. Good teachers see these disturbances, and ask timely questions to show children how to solve problems for themselves. They ask good questions because they know how children learn to write.

A Dynamic Approach to Teaching Handwriting Skills

Iain Macleod
and Peter Procter

Abstract

A computer-based system for teaching handwriting skills has been developed, using a graphic display screen and a hand-held "pen." The system is such that exercises can be completed only by executing the required sequence of strokes in the specified order and direction and within a preset accuracy. In the simplest presentation, a thin guideline is displayed for each stroke in turn. The computer responds to correct pen movements by leaving a thicker track behind. Incorrect pen movements are ignored and a blinking spot calls attention to the point where the pen should be. The resultant visual pattern is the teacher's well-formed example rather than the student's actual strokes, thus reinforcing the appearance of the desired result rather than the student's possibly ill-formed attempts. The system emphasizes the process used in creating cursive writing as well as the appearance of the product and, in one application, has been used to teach fluent signatures to intellectually handicapped students.

The process used to create cursive script has subtle yet profound effects on the appearance of the product. A computer-based system which gently but insistently fosters conformity to a dynamic specification for the creation of cursive script has been developed at The Woden School in Canberra as part of a collaborative project with The Australian National University Department of Engineering Physics. An overview of earlier work in this project which concerns the application of computer techniques to assessment and development of basic skills in intellectually handicapped children is given by Macleod and Overheu (1977).

Many aspects of presentability need to be considered for handicapped students seeking open employment. As they enter the adult workforce it becomes necessary for them to fill out job applications and to sign various documents (such as pay receipts). It is especially desirable to be able to sign in cursive writing rather than printing. There are, unfortunately, many students who cannot sign their names in an acceptable manner and who thus reduce their chances of obtaining open employment (even when ability to write is not a prerequisite skill).

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Iain Macleod's address: Dept. of Engineering Physics, Australian National University, Canberra, A.C.T. 2600, Australia.

The main problems observed when students were trying to sign their names were:
Poor fine motor control resulted in shaky and angular letterforms instead of smooth curves and well-defined cusps.
Failure to perceive and/or correctly reproduce spatial relationships between different parts of letters led to distorted shapes.
Incorrect stroke sequences and/or directions led to a progressive deterioration from the model.
Difficulty with connection of letters to each other adversely affected both the appearance and flow of writing.

A small computer installed at The Woden School has a DIGIVUE graphic display screen on which lines, text, and other material can be displayed. Associated with this screen is a hand-held "pen," the position of which can be determined by the computer. An exploratory study was made to see if appropriate use of these devices might enable students to learn a fluent signature where other approaches were proving unsatisfactory.

A specific objective of the study was that, following instruction using computing techniques, students would be able to write their names in cursive handwriting with a ballpoint pen on ordinary paper. The style and sequence of strokes in each signature were to follow that presented in a model. To be examined were: the type of computer and educational programs to bring about this change, the success of transfer from the display screen to pen and paper, and student reaction to the program and the computer devices (which in turn might lead to further modification). Because of the exploratory nature of the study, the limited number of suitable students available, and the highly individual nature of their problems, only a limited evaluation of effectiveness was made. A more rigorous evaluation drawing on students from a larger population is planned, using the techniques described below (Geffen, 1978).

Students in the Exploratory Study

Three students who could not sign their names satisfactorily were used as subjects. They all had a history of difficulty with school work and their handwriting was only one aspect of this. Only one or two fifteen-minute sessions per week were given, which allowed the subjects to manage their school and work programs without undue interruption. Instruction was to continue until satisfactory signatures could be produced or it was clear that no significant progress was being made.

Mark (fourteen years) was able to read and was relatively prolific, if disjointed, in his written output. He could print his whole name in manuscript, but the letterforms and interconnections were in what appeared to be a variety of teacher-taught and self-developed styles. His handwriting had been particularly resistant to teacher-initiated change over the preceding two years. Individual lessons using accepted techniques—such as direct copying from samples, tracing faint and dotted examples, manual guidance as the strokes were being made, large arm movements, writing in the air, following sandpaper letters and grooves made in wood, and tracing on his forehead—had not produced any significant differences other than an increase in frustration.

Mark also had physical problems with his shoulder and arm movement and with fine motor control tasks. These problems showed up in his writing; strokes were rarely smooth or fluently executed. Tension was quite obvious in his posture (not only during writing tasks) and could be seen in the slash of his pencil. He did not keep a consistently even alignment across a page with ruled lines. The conventional proportion between upper- and lower-case letters was not maintained, with different types of letters (upper- and lower-case, printing and cursive) being intermingled. Spacing between words was often no wider than spacing between letters. More importantly, the sequence in which he formed the strokes of each individual letter made transfer to cursive writing difficult because the general progression from left to right was continually interrupted—even within an individual letter—and each letter did not flow towards the next.

Harold (fourteen years) was able to print his first name slowly but could not reliably spell his five-letter surname. He was an extremely hesitant reader and writer. His writing was all done in manuscript printing. He had decided against learning a cursive style under classroom conditions and had made no attempt to modify his own style in that direction. He claimed it was too complicated. Again, he was by now resistant to teacher-initiated change and as he did not seem to need the speed that might be achieved with a cursive style, perhaps his choice was satisfactory for his own school use. The formation of his letters was tentative and he depended on teacher confirmation and help with some letters. His writing was usually faint, with poor alignment across the page and small letters. On the other hand, his printing style was regular in stroke sequence for the known letters except that closures in the *a-o-d* group of letters were not completed.

Clarence (thirteen years) was a reluctant reader and had a poor record of school attendance. His usual handwriting style was printing but if pressed he could copy a limited quantity of cursive script. He could write his first name in cursive but not his surname, which had a double *r* in it. While he could manage a single *r*, he

Figure 1. Mark's initial signature (copied from records).

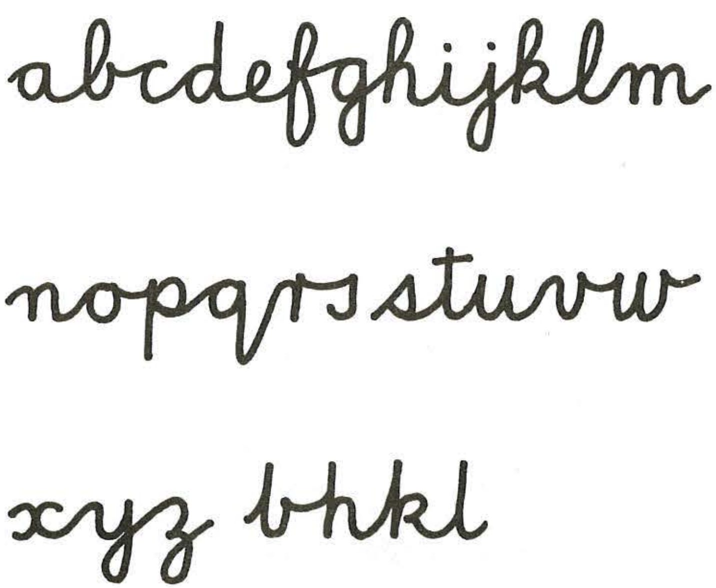


Figure 2. The model alphabet selected for use in the study—a variation of commercial cursive.

confused the two different styles of the letter that he had learned—one from school and one from his mother. This presented a problem of relearning or extinguishing what is acknowledged to be a difficult letter. His handwriting suffered from untidiness, erasures, and over-written letters, but his style showed physical competence at the task of producing letterforms.

The writing instruction in the present study differed little in aim from the normal school program. Pen on paper signatures were collected from the three subjects before they began to use the computer and all other teaching of cursive handwriting was discontinued for the duration of the experiment. Mark's initial signature is depicted in Figure 1. Further examples were taken at intervals during the program.

The subjects were not learning a completely new skill as all could hold a pencil and print at least. What was being attempted was the relearning and remediation of a known skill together with the introduction of an unfamiliar style in cursive handwriting. The style chosen was similar to that developed by Spalding and Spalding (1957)(Figure 2). Allowance for some individual differences was made with optional choice of a loop for letters such as *k* and *l*. The usual slant of cursive was omitted as a compromise with printing. Further individualization of handwriting style could be made subsequent to the program if thought desirable.

Equipment Details

The DIGIVUE display screen and associated pen are shown in Figure 3. The display is 21.7 cm square and consists of a 512 by 512 line matrix of small (pinhead sized) neon-orange light points. Each point can be lit or extinguished individually. The "quantized" representation of graphic detail by small light points is quite satisfactory except for fine detail. This precludes writing with letters less than a few millimeters in height, but has not proved to be a significant limitation. In practice, using large letters (a few centimeters high) on the display screen for tracking exercises seems to have advantages in reducing problems of fine motor control and aiding perception of stroke orientation, curvature, and connectivity. Students tend to reduce the size of their signature automatically when transferring to paper.

The pen used with the display is the size and shape of a thick pencil. The computer calculates the pen position using the lengths

Figure 3. A student using the display screen and pen.

of two fine strings attached to the pen just above the tip. The strings are lightly tensioned and pass through eyelets at the left and right above the display. The nylon tip of the pen is spring loaded and operates a switch inside the pen body which indicates whether or not the pen is pressing down on the surface. Only a light pressure is required to operate the switch, and the nylon tip lets the pen slide easily over the surface. It is thus possible to give the impression of writing by getting the computer to leave a lighted track under the tip of the pen as it is pressed down and moved around the display screen. This impression is aided by the DIGIVUE's steady flicker-free display and high contrast.

The face of the screen is angled at 20° from the vertical, providing subjects with a presentation which is readily observable. Being near to vertical also helps with letter strokes being "up" or "down" on the writing surface. The slight upward force on the pen resulting from the tension in the strings does not interfere with gripping the pen or with writing.

Parallax errors arise because the actual display is about 7 mm behind the front surface and because the pen position is measured at a point slightly above the tip. The effect of these errors is circumvented by arranging for a small square box or cursor to appear on the display centered on the calculated pen position. To ensure that the cursor box is always visible, each point around its perimeter is made the complement of the background detail (i.e., dark goes to light and vice-versa). Rather than watching the pen tip, subjects watch the cursor (which also defines the active area under the tip during tracking exercises). Because all three subjects were right-handed, the cursor was deliberately offset several millimeters to the left of the pen tip as an aid to visibility.

Around the edge of the display screen are "function boxes," as can be seen in Figure 3. When the pen is pressed down momen-

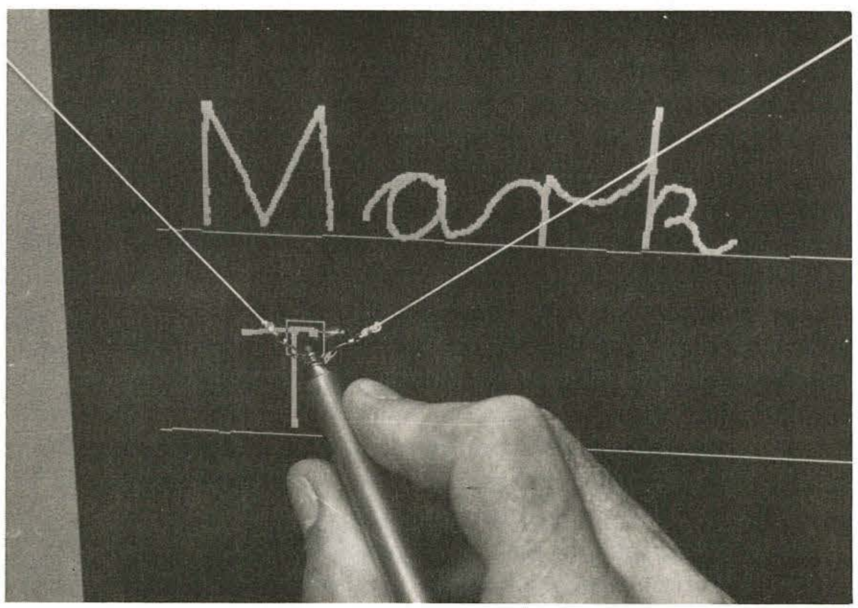


Figure 4. The DIGIVUE display seen by the student.

tarily inside one of these boxes, the computer program carries out the requested function (e.g., starts a new tracking exercise or changes the value of a parameter such as the thickness of track left by the pen during free drawing, or the size of the cursor box). Some boxes were marked with colored dots as an aid to the subjects, who controlled the equipment themselves as far as practicable. Other boxes were used by teachers when creating exercise files (i.e., "pages" of writing tasks) and had no effect during exercise sessions.

Instructional Strategy

At the beginning of the study subjects were given a period of free drawing to familiarize themselves with the display, pen and cursor box. By pressing the pen inside the various function boxes they could draw, erase parts of drawings or clear the screen completely, change the width of track left by the pen (in the range 1 through 30 points), or store drawings for later recall.

As an introduction to tracking exercises, some horizontal wavy lines stored as a computer file were recalled as thin (1 point wide) guidelines which the subject attempted to track, aided by a small blinking spot (5 points square) which indicated where the pen should be. The thin guideline changed into a thicker track (3 points wide) as the subject moved along it, tracking successfully. If he started at the wrong end, moved in the wrong direction, moved off the guideline, or lifted the pen, track filling stopped and the blinking spot called his attention back to the point where the pen should have been. Successful tracking required the blinking spot to be inside the cursor box with the pen pressed down and moving in the correct direction. The difficulty of the task was adjusted by varying the cursor box size in the range of 10 through 30 points square.

The subject then moved on to begin tracking lines with sudden direction changes and other basic elements of both printing and cursive writing. Each exercise consisted of a series of strokes, each of which had to be successfully tracked before the next was presented. The teacher defined these strokes when creating the exercise file simply by lifting the pen momentarily at the end of each stroke. Introductory exercises occupied no more than the first fifteen-minute session.

A signature file was constructed for each subject and used as follows. The subject's name was analyzed for its stroke sequence in the style selected and then entered by the teacher (via the DIGIVUE screen and pen) together with a reinforcing message including similar letter sequences, and stored as a file on the computer's disk. On playback each stroke appeared as a thin guideline with the signal spot blinking to indicate the beginning of the stroke. Each point on the guideline was made the complement of the background detail so that the guideline was visible even where it lay along a previous stroke (e.g., the upstroke in the letter *r*). The subject tracked along the stroke keeping the cursor box around the blinking spot and leaving a thicker line behind. As tracking of each stroke was successfully completed, the next guideline appeared without delay like a pathway unfolding or moving along. Thus each stroke indicated its own dynamic pattern as it was about to be drawn by the subject. An example of the display seen by the subjects is shown in Figure 4. The signal spot can be seen inside the cursor box leading the filled-in track along the guideline. At the end of each "page" (i.e., display screen full) a smiling face pattern appeared, to indicate the end of that task. An important point was that subjects were informed of any errors quickly yet gently because track filling proceeded only when they were tracking correctly.

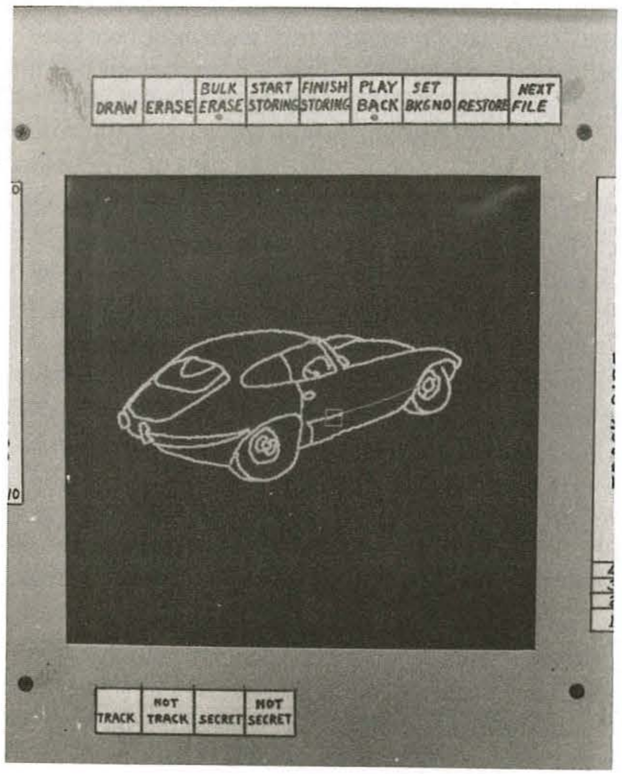
Two files were created for each signature. One involved tracking as described above, while in the other an example which did not have to be tracked was presented at the top of the screen, and the subject had to track "secret" strokes beneath the example which were presented without any guidelines. The blinking spot and track filling operated as before so that the task appeared to the subject as a copying exercise. Each session included the signature file, but as only one of the tasks involved. Reward files included tracking pictures of cars and cartoon characters (see Figure 5) and a file for free drawing recall. A special file was created to practice the letter *r*.

Features of the Program

There are several features of this style of presentation which are not available with ordinary handwriting instruction. The visual feedback is tightly controlled in relation to both stroke sequence and direction and letter shape. The student does not see his own poor initial attempts at approximating the model—he sees only the model itself. This is because the size of the cursor box allows for lack of manual precision while the predefined track continues to be illuminated by the student. Success in tracking can be arranged for the most shaky hand and the correct visual information always results no matter what actual path the student follows. This is a greater degree of control than that placed on a student either by tracing a letter or using a chemically treated pen to reveal an invisible pattern, because neither of these methods enforces the stroke sequence or direction, and tracing does not control the resultant visual pattern. The actual pen movements used by the student are recorded by the computer and can be reproduced at the end of each exercise if desired.

A second feature is that the program always positively reinforces correct responses and ignores incorrect responses. It is able to

Figure 5. An example of a tracking picture.



shape the student's response with increasing accuracy by reduction of the cursor box size. It reduces the alternatives available to the student (Moxley, 1975) to easily manageable proportions, since in ordinary handwriting instruction the path the pen must follow is open to a great variety of direction over which the learner has little control. Choice is not eliminated though, and the extent of choice faced by the student can be varied to suit his abilities.

The main advantage of the program is that it reveals handwriting skills to the student as a dynamic process. Even the acknowledged major study in visually guided motion (handwriting) by Birch and Lefford (1967) looks at handwriting or pattern making more as a product than as a process. While the skill is being learned, handwriting is a process where the emphasis must be on motion. The product of marks on the page with their conventional meaning follows from this learning process. The program described comes closer to recognizing the dynamics of handwriting skills than any other system available.

Results

All subjects learned their new signatures and were able to write them with a pen on paper in increasing conformity with the computer presentation. Attributes used in judging progress towards criterion were: letter shapes; smoothness of strokes; and interletter proportions, alignment, spacing, and connections. The first feature to appear on paper was the stroke sequence of the model, followed by increasing smoothness of line, better letter proportions, and then a reduction in size of the letters by making them smaller than they appeared on the display. Mark took twenty-six attempts (i.e., fifteen-minute sessions) at doing his signature with the computer, Harold sixteen attempts, and Clarence eight attempts to reach criterion. At this stage, both names in their signatures had the appropriate capitals, letterforms, and joins. Mark's signature included ten letters and six joins. His progress during instruction is shown in Figure 6. Towards the end of instruction emphasis was placed on overall fluency—Mark's final signature is shown in Figure 7. An encouraging aspect of the subjects' reaction to the program was the close attention they paid to the task and the patient presentation possible through computer mediation.

The skills acquired with the computer pen and display transferred fairly readily to pen and paper, apart from the initial ten-

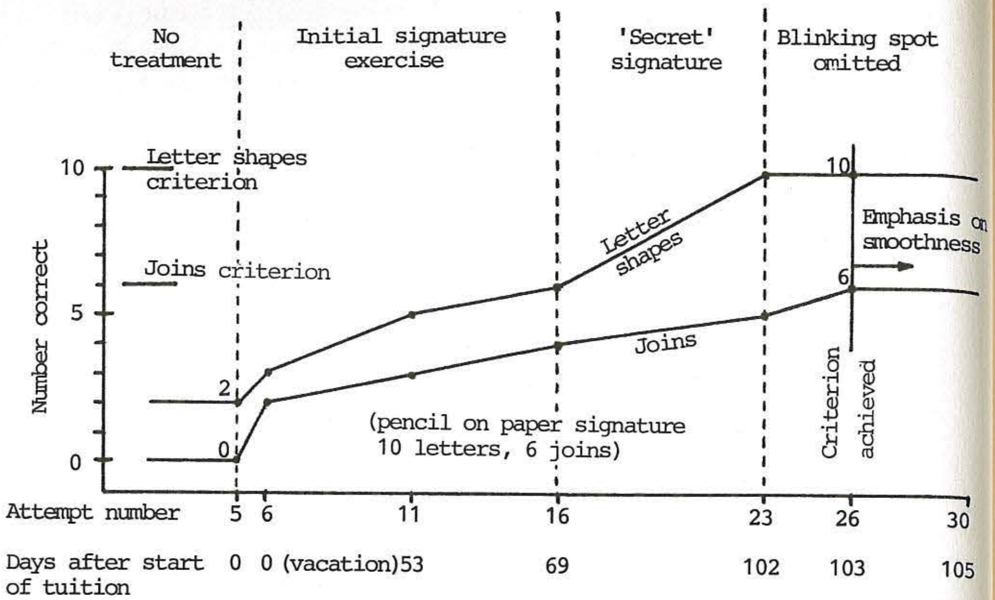


Figure 6. Mark's progress towards criterion.

dency to use large letters. Transfer to the area of handwriting in general was not assessed because of the limited aim of the program, namely, to teach fluent signatures. Harold and Clarence left The Woden School shortly after completion of instruction and no evaluation of long-term retention of the skills they acquired has been made. Six months after the end of instruction, Mark could still execute his signature with reasonable fluency and accuracy, but he had reverted to the original form of *r* in his Christian name (see Figure 1). Long-term retention would clearly be improved by tapering off instruction over a period of several months rather than terminating suddenly.

Discussion

For students who have not progressed satisfactorily despite extensive tuition with a range of methods, and who have become conditioned to failure in the handwriting area, the radical difference of the computer presentation (together with the natural fascination of computer devices) allows a fresh start to be made. The program

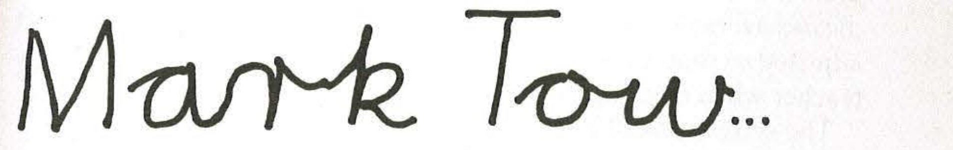


Figure 7. Mark's final signature (copied from records).

structure makes success likely no matter how uncertain the student's efforts, by breaking a complex operation into a series of simple steps. Students can therefore move quickly onto writing which is meaningful to them (e.g., their signatures) rather than having to spend a lot of time on preliminary exercises.

The degree of assistance to the subjects was progressively reduced so that the task they were performing approximated normal writing more closely. First the cursor box size was reduced. Next the blinking spot was disabled so that subjects had to remember (or find out by trial and error) which direction each stroke had to be drawn in. The degree of segmentation was then reduced so that guidelines for whole letters or sequences of letters instead of individual strokes were presented as units, thus reducing assistance with the order of stroke completion. Finally, an example of the required signature was presented at the top of the screen and the subject had to track a "secret" signature on the lower part of the screen which was presented with the blinking spot but without guidelines. The subject had to track an invisible path, remembering stroke sequences and anticipating changes of direction. The good results obtained were partly attributable to the ease with which exercises could be tailored to fit individual student needs.

To develop further fluency and exercise handwriting dynamics, an alternative presentation is possible. In this case the exercise material is segmented only at points where the pen would normally be lifted (such as in crossing a *t*). The computer presents the guideline for each segment and waits for the student to press the pen down on the blinking spot. The spot then moves along the guideline at a speed which varies dynamically in the same fashion as that used by the teacher in creating the exercise, leaving a thicker track behind. The student tries to track the moving spot (which does not wait for him except at the beginning of each segment) and an audible tone sounds when he is tracking successfully. On completion of each exercise, a bar graph at the right of the display indicates average tracking accuracy. The speed of movement can be adjusted so that it is slower or even faster than that used by the teacher when creating the exercise.

The system described is clearly applicable to teaching of handwriting skills in general as well as to teaching signatures. In this regard, tasks have been devised which exercise perception of stroke orientation and curvature. It has been suggested that the techniques developed could also be very useful in the rehabilitation of patients who have suffered brain and/or limb damage and who have to relearn perceptual and fine motor skills. The use of an impersonal machine to teach such skills could save mature and intelligent people some of the embarrassment they feel with a human teacher when they are unable to perform apparently simple tasks.

The costs of handwriting tuition using computer techniques are somewhat greater than with conventional media. A display and pen similar to that used currently costs several thousand dollars, and could easily be interfaced to an existing minicomputer. They could also be connected to a remote computer via telephone lines, but an inexpensive microcomputer would be required locally to look after the details of cursor generation, track filling, etc. The costs of computing devices continue to decrease while their capabilities and reliability increase, but at present the most obvious application of a computer-based approach is in cases where conventional techniques are not proving satisfactory.

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Considerations for the Design of a New Pen Range

Chris Rhodes

Abstract

Basic questions that confront a pen designer begin with the style of the nib. Apart from specialists' pens used for commercial marking or technical graphics, the designer is restricted to the fountain pen, the ballpoint, the fibre-tip, the plastic-tip, and the roller-tip. Unique, specialized inks and reservoir systems serve each of these kinds of pens. Each pen's usability is directly affected by its barrel design, which can vary in size for children and adults.

The most important single component of the pen is the nib—the business end. Despite an apparent revolution in the technology of nib design, the actual range of available nib configurations is relatively limited. If one excludes felt-tips (restricted now to marking and colouring) and the new capillary tube pens (found almost exclusively in technical and graphic studios), we are left with only these alternatives: the fountain pen nib, the ballpoint, the fibre-tip, and most recently the plastic-tip and the roller-tip. Of these the fountain pen nib, the plastic- and fibre-tips all employ the principle of capillary action but rely predominantly on another principle: the mutual affinity of ink and metal or plastic.

Ballpoint Pens

The first commercially successful fountain pen was marketed by E. L. Waterman in the 1880's. That same decade also saw the first ballpoint patent. In technological terms, however, they were generations apart, and it took some fifty years before the potential of the ballpoint could be realised. The first truly viable ballpoint was patented in 1938. In this and all subsequent designs a viscous ink is drawn from the reservoir by its affinity for the revolving ball. The ball itself, in modern versions, is made of tungsten carbide or stainless steel. It is fitted into a finely engineered housing, the bottom section of which contains a series of feed channels (Figure 1). As the ball rotates it draws ink through these feed channels and carries it round onto the writing surface where it transfers cleanly

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Author's address: Berol Limited, Oldmedow Road, King's Lynn, Norfolk PE30 4JR, England.