Chapter 7

Applying Mastery Learning Theory

I have recently investigated several different approaches to teaching based on my understanding of the research results mentioned in earlier chapters. One comparison featured two versions of an illustrated presentation on the structure and function of the human heart (Spencer, 1990). The first used simple line illustrations, similar to those in Dwyer's experiment. The second was the same but also had animation sequences to explain particular aspects of the functioning of the heart. These animation sequences were under the student's control and could be viewed at will.

The results confirmed my suspicions: the human information processing system is able to fill in the gaps between the various stages of such a presentation and animated graphics do not appear to be very beneficial in terms of increasing student achievement. Research from several earlier studies with film, television and transparencies have also reached the same conclusion (Spencer, 1981).

These results are not going to please many hardware and software producers who are committed to giving us systems which offer increasingly elaborate displays in colour with full motion pictures. Such displays may be very attractive, but are they going to be more effective in educational terms?

Please do not misunderstand me: I am not against technology as a means of improving student performance; I merely wish to see the technology used for what it can do best and my second line of research has shown what this may be!

Much of the research on media and methods in education has been disappointing, but one area has shown more promise than others: the provision of corrective feedback and a demand for mastery performance.

These methods are certainly producing significant educational effects and this has led Walberg (1984) to comment that:

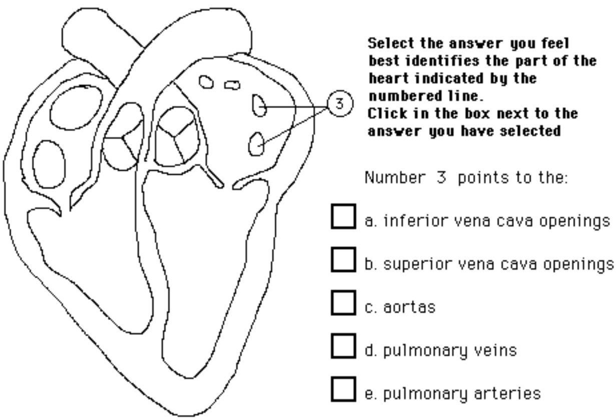
> .... the psychological components of mastery learning rank first and fourth in their effects on educational outcomes:... instructional cues, engagement, and corrective feedback have effects equal to approximately one standard deviation. Separate syntheses of mastery programs in science show an average effect of .8.

The HyperHeart programme is an attempt to provide instruction in the structure and functioning of the heart for 14-16 year olds based on the programme which has been used by Frank Dwyer (1978) for many years. There are several versions: text only; text plus simple line drawings; text plus simple line drawings, with animation sequences. The text only version has been shown by Dwyer to be inferior to the simple line illustrations, particularly when the test incorporates illustrations. The version with animation sequences was produced to assess the value of moving pictures to explain complex, dynamic situations. The previous research in this area has tended to show that only small gains are likely to accrue from the addition of motion sequences. This has considerable implications for the new inter-active technologies.

Each of these versions can be of two types: mastery and non-mastery. With the non-mastery type of programme subjects pass through the structure of the heart material at their own pace, taking an illustrated test before continuing with the functioning of the heart and ending with two verbal tests and, finally, a drawing test. The mastery programmes test the subject after the structure of the heart section and have a 95% criterion level. Each test item diagnoses the probable reason for an incorrect answer and provides correctives (Figure 7.1). For example, left-right, vein-artery and auricle-ventricle confusions are identified and corrected; several confusions may be identified and each corrected within one response eg left-right/auricle-ventricle. Test results and completion times are conveniently stored in a log file for each student.

Research has shown that lowering of the criterion level for mastery to 80% (from 95-100%) results in a halving of the observed ES. Initial trials with the high criterion level in this programme (95%) have been very encouraging. When the programme was introduced in schools the teachers felt that such a criterion would deter most students and that they would simply abandon the

Figure 7.1: Test and remedial frames of HyperHeart programme



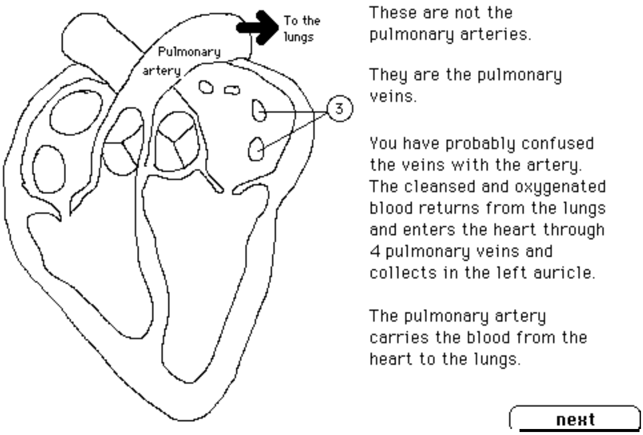
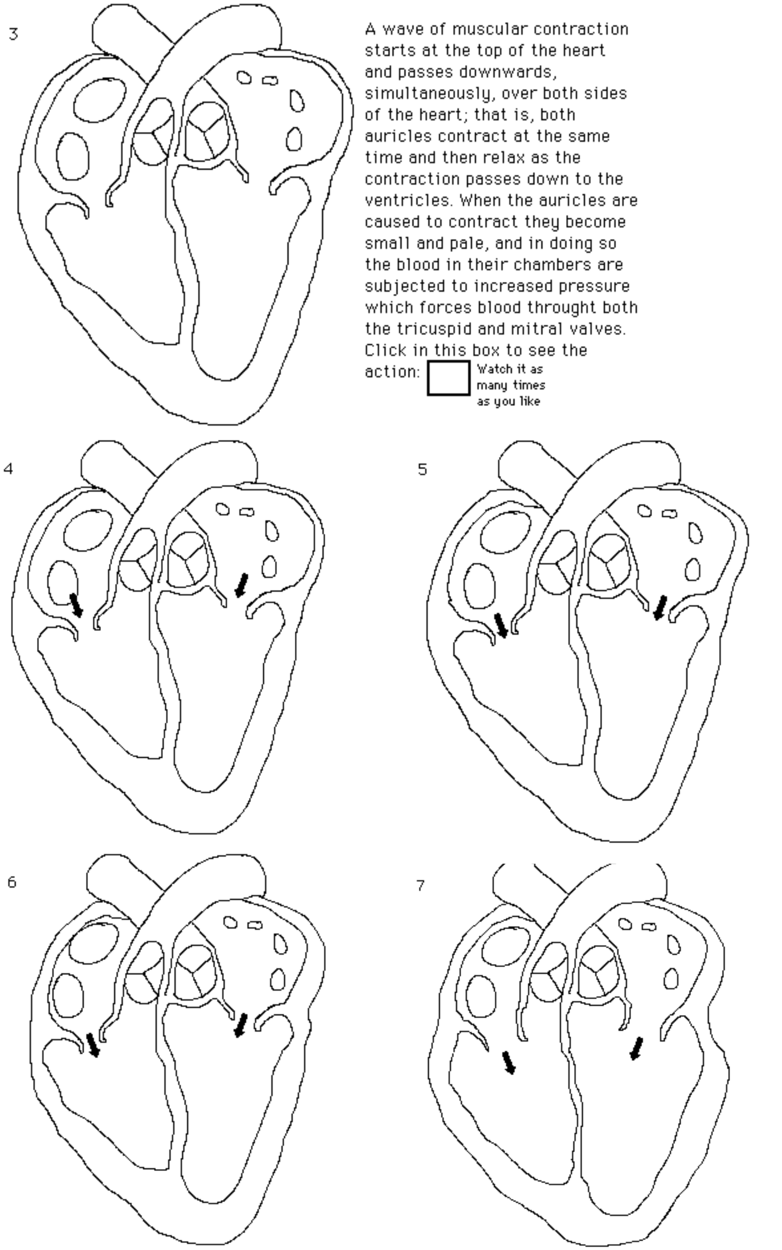


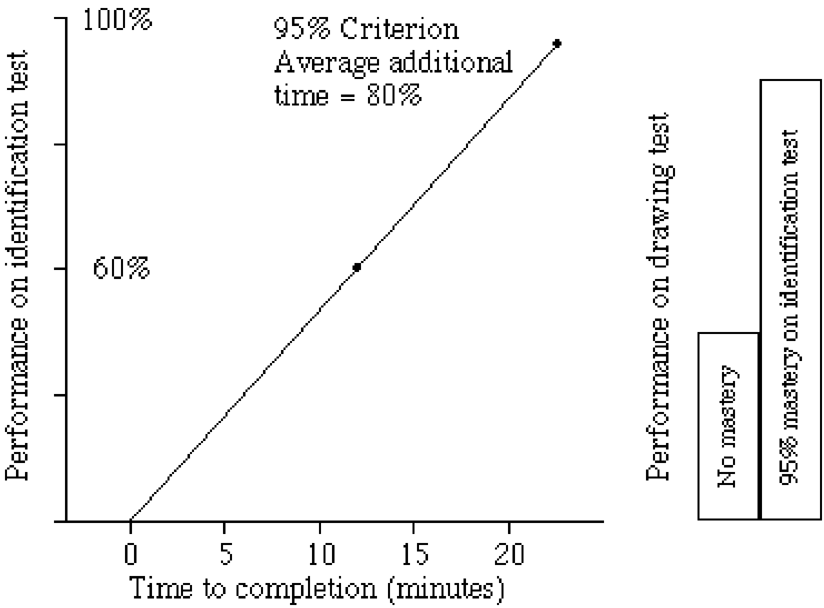
Figure 7.2: Animation frames from HyperHeart programme



programme. This has not been the case. Even students of low ability have persevered and mastered the material, gaining a positive self-image in the process, much to the surprise of their teachers. The only mastery condition students who have abandoned their work were a minority of those assigned to the text-only condition. These students found too great a discrepancy between the teaching programme and the demands of the illustrated test items. Certainly, the power of illustrations to aid in understanding and their importance in maintaining perseverance has been amply demonstrated in the preliminary experimental studies. The additional time taken to achieve mastery has ranged from 25% to 100%, but in all cases students have felt that the extra effort has been worthwhile.

The addition of animation sequences (Figure 7.2), which can be repeated as required by the student, obviously increases the time taken to complete the programme but does not appear to influence the performance as measured by the tests. This confirms the prediction based on previous research in this area, and once again raises the question of the value of motion sequences for teaching

Figure 7.3: Test results of HyperHeart programme



such topics. Indeed, it may be said to challenge the very concept of inter-active multi-media: why use expensive multi-media systems when simpler, less expensive systems are just as efficient?

The results of this study strongly support the view that the latest generation of computers, combining text and graphic displays at an affordable price, can provide instruction that leads to excellence, provided that educational technologists designing the educational software apply the knowledge gained through the years from research and avoid the seduction of superfluous, but superficially more attractive methods of display.

Students with learning difficulties took on average 82% longer to achieve mastery, but reached levels of performance which were well above those predicted by teaching staff. The high level of performance on the initial test, which required students to identify parts of the heart, also transferred to a test requiring students to draw diagrammatic representations of the heart (Figure 7.3).

The inter-active mode of the new information technologies, which includes machine simulations of human interactions, provides the key to the success of those approaches which are more effective. The essence of this mode is that it provides opportunities for feedback. The nature of that feedback is crucial. It can vary from the simplest indication, without explanation, that an answer is incorrect, to the full diagnostic interactions which artificial intelligence systems can offer. The primary purpose of the diagnosis in mastery learning is to ensure complete understanding of the taught material. The most effective methods of instruction seem to include these diagnostic interactions combined with mastery conditions .

On this basis, it is not surprising that earlier approaches such as programmed learning methods, which simply report success or failure with minimal interactive features and no diagnosis or mastery conditions, are not very effective. Similarly, computer-based methods which show all the hallmarks of early programmed learning methods, are likely to be no more effective.

It is interesting to note that research confirms that the computer is most successful when interactively simulating real world events or tutoring, both of which capitalise on the provision of feedback (Kulik et al, 1980).

RECOVERING READING USING COMPUTER MASTERY PROGRAMMES

When reviewing the literature on educational technologies and methodologies (Spencer, 1991) I suggested that the poor performance associated with a variety of basic skills, such as reading, could be raised by amounts considered to be educationally significant using a number of different media employing mastery methods, such as Learning for Mastery and the Personalised System of Instruction.

Unlike many programmes designed to teach or encourage reading skills, the reading programmes developed for this project (Spencer, 1996) provide instantaneous feedback, and identify and reward correct responses, with high criterion levels set for progression from one task to the next. For example, in figure 7.4 the pupil has correctly entered the first letter of the word. This is retained on the screen, as are further correct responses. This is crucial in developing pupil self-confidence. Instead of waiting until the pupil has incorrectly spelled the full word, at which point s/he is told that s/he is wrong (as many modern programmes continue to do), each response is monitored and corrected as necessary.

SUMMARY OF THE UNDERLYING THEORY

The HyperReading programmes are designed to teach reading skills indirectly through programmes which develop spelling skills. A more direct route would be to utilise computer speech recognition features, but as van Daal and van der Leij (1992) suggest, adequate speech recognition facilities to evaluate reading-aloud responses are only available at prohibitively high prices. However, developments have made it possible to provide high quality speech via relatively low cost computers, making them more suited to assist in spelling type programmes rather then in reading exercises. Reading skills benefit from this approach because a critical step in reading acquisition is made when children shift from a visual strategy for reading words to an alphabetic strategy, which is first learned in spelling and later carried over to reading. This is a crucial phase because in the course of spelling development, children learn more about how sounds relate to letters (Frith , 1985).

The concept of mastery can be traced back from Bloom's formulation in Learning for Mastery (1968/81) to Carroll's seminal paper A Model of School Learning (1963). Central to this is the concept that by using appropriate strategies most children (and by this Carroll means 95%) can attain levels of performance similar to the top 20% in an average classroom. Carroll's model, which forms the basis of Bloom's LFM, places emphasis on the amount of time available for study and the time needed to completely master a given task. Clearly the amount of time needed is related to the ability of the pupil, but also to the ability of the teacher to provide appropriate instruction.

Mastery methods are often considered to be close to the behaviouristic approaches suggested by Skinner (1954) and the computer programme described below may look uncomfortably like a Crowder branching strategy from the 1960s (or even a Skinner linear programme). It is, however, rather more sophisticated and responsive. Skinner suggested that a country which could produce quantities of washing machines as labour-saving devices surely could produce teaching machines on the same scale. My latest washing machine purchase is generations ahead of anything available in the 1950s: it is microprocessor controlled, and I simply select one of a large variety of options and the machine carries out its complex task of adjusting water volume and temperature, spin speeds and drying temperature. The modern computer with appropriate teaching programmes offers similar advances over earlier designs. However, such computer programmes are only one medium out of many that can be employed in the classroom for the teaching of reading eg. paired reading, or any method which places the learner in direct contact, on a regular basis, with an expert reader who encourages mastery.

The value of a systematic method of teaching reading may be called into question and it is true that the majority of pupils acquire their reading skills through a variety of less highly structured approaches. However, for children who are failing to get started a highly structured approach may prove to be more effective. The mastery methodology employed may also be considered to place too much emphasis on rote learning, rather than general (problem-solving) strategies. However, the problems of illiteracy must be attributed not only to learner, or even teacher, deficiencies, but also to the written form of the language: written English is profoundly illogical, especially the most common 200 words, and the rules, such as they are, cannot always be applied in a regular manner. The Chinese have a similar problem with their written language and adopt a simple rote learning strategy as the most effective method, as do the Japanese. This approach, I believe, can be adopted as one strategy for pupils who are failing to develop their English reading skills.

EARLY MODELS OF THE HYPERREAD COMPUTER PROGRAMME

The Macintosh computer has built-in sound recording and playback facilities, making it suitable for language work, and runs the HyperCard application which presents information on the computer screen as a series of cards, rather like pages in a book.

The first approach was to convert the individual child's reading book into an electronic version. Such a version could read the page to the child, hilighting each word as it was read. The basic idea behind this was that many of the children who were failing in their reading simply did not get sufficient support outside school hours: the computer "reading" could compensate for this. Davidson and Noyes (1995) confirm this in their study, which was based on a similar premise: "Children who read at home regularly simply get more practice than those who don't" (Topping, 1985). Their programme "read" the child's school book, providing an additional hour of reading each week over a 4 week period. The results showed no significant difference between reading the book to a teacher and reading it with the computer providing help when necessary.

The initial HyperRead programme also included a mastery element. The pupil was required to take part in a short test after each page had been read. This consisted of presenting to the pupil a list of the words that had just been read. The pupil was required to select a word which the computer "spoke" (eg. "Now choose the word car.") Those words which were incorrectly selected were placed in a "mastery loop". The mastery loop was a method which gradually eliminated those words which were correctly identified but kept the incorrect words, which were recycled until all words were correctly identified. Thus, after each page was read by the computer, the pupil was active and could not move on to the next page until all the words had been mastered.

This phase was only partially successful. I have noticed that with many talking books, which run from CD-ROM on modern computers, children are easily distracted from the screen and do not follow the laboriously hilighted words, often only turning to the screen when a dramatic sound effect is heard. Our pupils also became bored with the constant demand of responding to words that they knew, before being allowed on to a new page.

A refinement was to set up a database with a record for each pupil. The record stored the performance of a reading test (with mastery loop) which included all the words to be used in the electronic version of their reading book. When they had mastered the words in the list, the programme took them to the appropriated electronic book and read it to them (no test being applied), providing a reward for their effort and reinforcing their learning. This was moderately successful, but again it was noticed that the pupils tended to be easily distracted when the electronic book was being read—in fact, the part which did fully occupy their attention was the testing phase: they really enjoyed this, especially when appropriate computer game noises were added.

In consultation with a group of primary school teachers it was decided that if a programme could be devised that effectively taught specific words, the children would then be able to read their books without assistance, making the talking computer book feature redundant. The challenge was to devise such a teaching programme.

The teachers consulted felt that many features, which they employed when teaching reading and spelling, should be built into the computer programme:

1. The teachers entered lists of words directly into the computer, so that individual schemes of work were developed.
2. Two types of test were developed: a recognition (look-and-say type) test and a spelling test.
3. The recognition test was designed so that the number of alternative words presented varied from 2 to 6. The pupil saw a group of words in boxes on the screen and was asked by the computer to choose a particular word (Choose "boy"). When the correct word was clicked a small animated jack-in-the-box appeared. Incorrect boxes were marked, gradually eliminating the incorrect responses.
4. The spelling test offered control over the way each word was displayed. The word could be shown for several seconds before the pupil responded. This could be varied in 0.5 seconds steps from 0 to 10 seconds.
5. The number of letters of the word to be spelled could also be varied, ranging from one letter to the complete word. This feature also allowed for forward or backward chaining (ie. starting from the first or last letter) and for particular groups of letters within words to be targeted.
6. A "virtual" keyboard was created on the screen and pupils responded by pointing to a letter and clicking it as appropriate. The letters available on the virtual keyboard could take many different forms (eg. all the letters of the alphabet could be shown either in QWERTY form or ABC form; alternatively, only those letters required to complete the task could be shown).
7. Errors in spelling were identified immediately a response was made, and the pupil offered a number of additional attempts, until mastery of the word was achieved. The number of additional attempts could range from 2 to 10, but usually was set at 3. This is shown in Figure 7.4.
8. A mastery loop was applied to each group of words under test. Groups of words which failed the mastery criterion level on the first attempt were repeated until the criterion was reached for the whole group. This is shown in Figure 7.5.

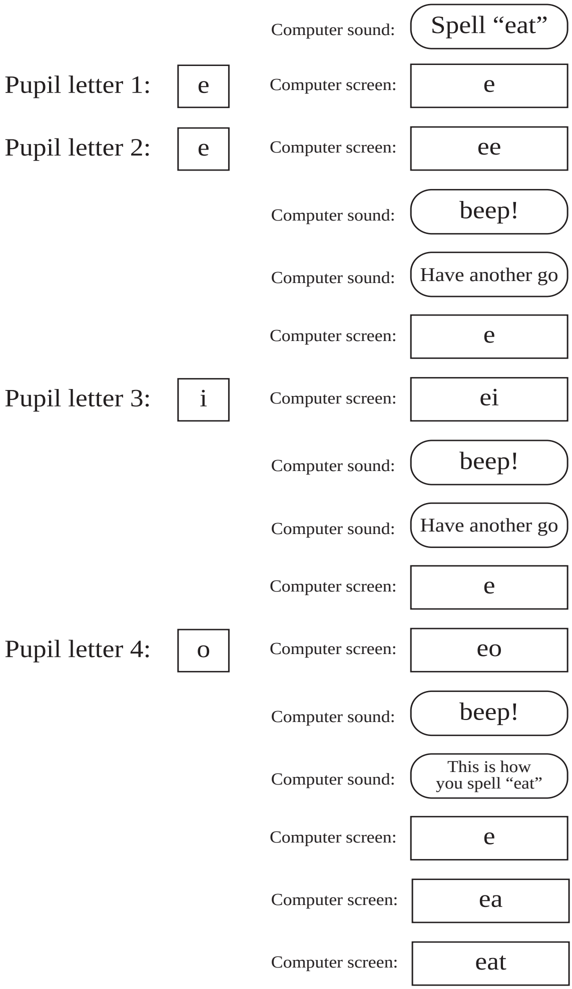


Figure 7.4: HyperRead programme sequence

9. A limit could be imposed on the number of attempts permitted in the mastery loop, both for individual words and groups of words. It had been noticed that a mastery loop without such a cut-out response could produce despair in children who were required to work endlessly at the same words.

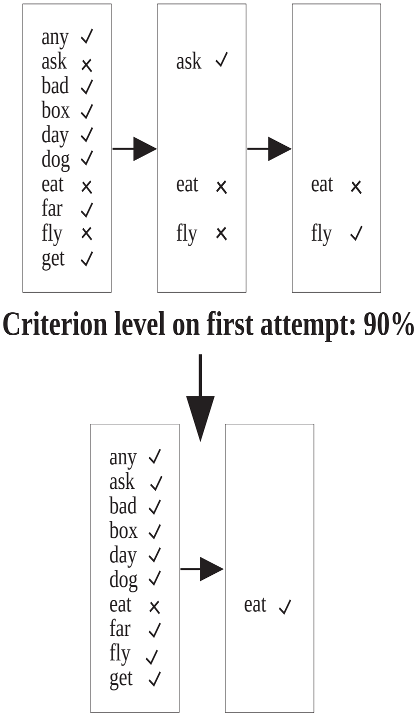


Figure 7.5: Remedial mastery sequence of HyperRead programme

10. A complete record of each pupil's responses was logged on their student record card, to enable the teacher to decide upon further appropriate action.
11. A short audio-visual reward, consisting of one of several animated characters dancing to a tune, appeared after each successful session.
12. The pupil card could be set into one of two modes: the pupil mode showed minimal information (pupil name and start button) and could not be altered; the teacher mode allowed various setting to be changed.

The computer programme, which included all the above features, was used within the first phase of the Portable Reading Laboratory project supported by the National Council for Educational Technology “Portable Computers in Schools” project (Bowell, France & Redfern, 1994).

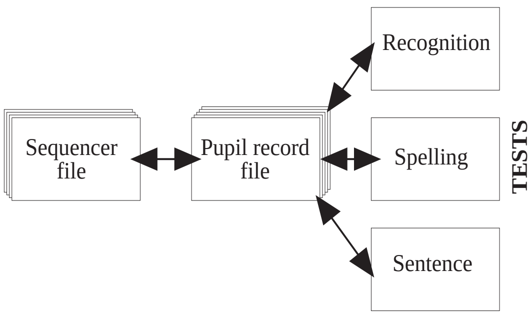
During this time the programme was in general use in two schools, running on 8 portable computers, and a small group of children was studied intensively. A major problem emerged early in this phase: teachers had demanded a large array of controls to apply to each individual child’s interaction with the computer, but with increasing demands being made on their time they could not always make the necessary adjustments to the individual pupil record cards.

For example, a group of words may be required to be spelled with a brief glimpse of the word before each was spelled (called the “hints” condition). Following this, the words would be required to be spelled without any hint. The teacher had to continually reset the hints control for each pupil, meaning that the pupil was constantly demanding the teacher’s attention.

However, the results from this initial phase were very promising. For example, one 9 year-old child who could not read the most common word in the English language rapidly learned to read and spell the most common 10 English words, using the programme for 12 minutes a day for 1 week.

These results were so encouraging that a new approach to the setting up of the control features for each pupil, designed to save teacher time, was adopted. This consisted of separate files (called sequencer files) which have the details of a particular sequence of control settings which can then be applied to a particular pupil record file (Figure 7.6). The pupil record file loads up the relevant information from the sequencer file (instead of having the teacher reset it), goes to the relevant test file, which records the pupil performance and calculates a performance score. In most of the early research the pupils started

Figure 7.6: Sequence control of HyperRead programme



at the first card of each new sequence and gradually moved from simple to more complex tasks. This is the general pattern for the following data.

The introduction of the sequencing feature led to the need for control of the time a pupil spent working on the automated sequence. The time for study was set on the pupil card, and used the computer clock to determine how long the pupil had worked with the materials. After a preset time, usually 10-15 minutes, the session was ended, and another student took over.

The pupil record card logged the performance of the pupil, noting the sequence and card level at the end of a session. The pupil's next session, usually the following day, started from this point.

RESEARCH RESULTS

The following case study shows the effectiveness and limitations of the computer mastery approach to the teaching of reading.

Pupil S was mentioned earlier in this report. He was 9.5 years old when he started using the computer programme. At school he had failed to establish any reading skills. He had experienced a very difficult home life and received no help with his work from his family. He was the youngest child of six, the parents had separated and his natural father had died the year before. He was sharing a bedroom with his elder brothers, at least one of whom takes drugs. In school he was frequently tired and was hard to keep on task, his level of interest being difficult to raise or maintain. He was at Stage 3 on the Special Needs Register and was to be considered for Stage 4 (referral for Statement) when he was next seen by the educational psychologist. On the WISC (R) test he was found to have a verbal IQ of 82, placing him in the below average range of ability.

He was first tested on his alphabet and had no problems, and no identifiable letter confusions. When tested on the most common 120 words (Reid, 1989) his score was very low (2 words). He demonstrated his ability to learn several words during an intensive investigation with the early version of the programme and would work for 10-15 minutes before becoming distracted.

In the programme that was devised for him the most common 120 English words were broken down into groups of 10 words, starting with the most common 10. Within these groups word lengths were mixed, varying from 1 to 6 letters, with an average of 3 letters for the first 50 words. The auto time facility was set at 12 minutes, giving 12-15 minutes daily work with the computer programme. Twenty cards made up a sequence for each group of 10 words, each card containing a separate set of control features. The class teacher arranged for the pupil to work on a daily basis with the programme and the pupil was given responsibility for setting the equipment up, switching the computer

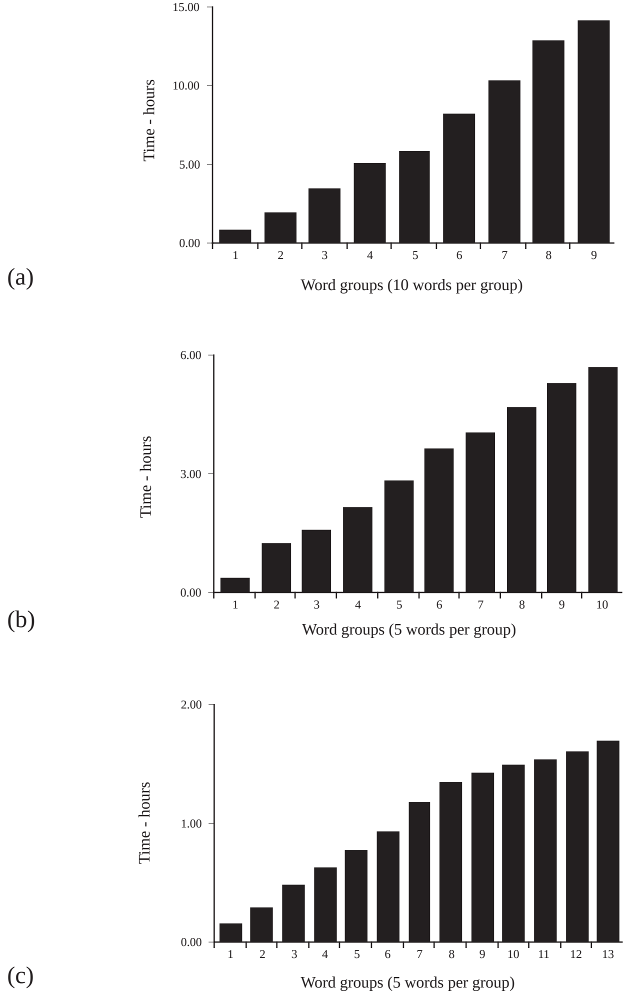


Figure 7.7: Cumulative time spent on HyperRead programme

on, choosing the appropriate pupil record card, and working through the day's sequences. Full details of the pupil's responses were automatically logged, together with times and scores for each sequence.

Figure 7.7(a) shows the results for the first 9 groups of words. It represents the cumulative time spent working with the programme. Each bar represents the total amount of time taken to learn the particular group of words and the preceding groups. The difference between one bar and the next is the amount of time spent learning that particular group of 10 words.

The cumulative time curve shows a steady work rate, the time being a little longer towards the end of the sequence. The average rate of completion was 6.4 minutes per word for the first fifty words, and 9.5 minutes per word for the first 90 words.

This an impressive acquisition rate for a child who at the start of the teaching programme could read only 2 of the most common 120 words ("I" and "a"). A month later, having worked on the programme for an average of 16 minutes each day, he could read 50 of the words.

Pupil S spent a total of 14.08 hours, during a 12 week period, working with the computer programme and mastered the reading of 90 words. When tested on the whole 90 words his reading score was 89%; and when retested 8 weeks later, after the summer vacation, his score was 67%.

However, after the summer holiday pupil S was placed in a new class. The computer programme was available on a computer exclusively used by the class, and available particularly to pupil S. Although in the previous class the pupil had been responsible for setting up the computer and working on the programme, this did not happen in the new class. Instead of an intensive daily session with the programme, the pupil used it very occasionally (1-2 times per month). After 7 months of normal classroom activities, with sporadic use of the computer programme, his performance had only reached 69%. There is some consolation here in the knowledge that mastery programmes do produce learning that is resilient to forgetting (possibly because of the over-learning of some of the content), as demonstrated by Kulik et al's (1990) meta-analysis.

Pupil C was 6.25 years old when he started working with the computer programme. He was the second of three children in the family and there was no apparent encouragement or stimulus for learning at home. He seemed to spend most of his time watching "endless videos" according to teaching staff. Pupil C and his younger brother have major problems with speech, although their elder sister does not have such problems. The father attended special school in his youth. Educational psychologists noted the discrepancy between pupil C's ability, which was average with an cognitive index of 94, and his poor understanding of language, which was coupled with a severe phonological problem. This had not responded to speech therapy, and the pupil was finding it increasingly difficult to access the National Curriculum at a level appropriate to his ability. His attention span was limited, especially for activities that involve long periods of listening, which was consistent with his limited understanding of language. A programme of daily speech therapy implemented by a teaching assistant was stopped following financial cut-backs, since which time his progress had been classed as minimal. The pupil was statemented prior to the start of the computer project and it was agreed that he should have a structured language programme on a frequent and regular basis, with the school providing for this by the use of the laptop computer for basic sight vocabulary and spelling.

The results from earlier use of the computer programme scheme led to a new strategy which involved learning groups of 5 words rather than 10. A word recognition task with 100% criterion level was followed by spelling tasks in which the pupil was required to spell the first letter of each word, followed by the second, third and fourth letters. For each of the four letters, two conditions were used: the pupil was first shown the letter (hints condition) before responding; the pupil was then asked to spell the letters without any hints. For pupils with low sight vocabulary this method brought about a gradual learning of the first 4 letters of the words. Pupil C's sight vocabulary test score with the 120 most common words was 62%. Figure 7.7(b) shows the rate of acquisition of those 50 words with which he was not familiar. Working an average of 13 minutes per day on the programme he made rapid progress, acquiring 50 words in 5.67 hours (a rate of 7 minutes per word). When finally retested on the 120 words his score was 114 (95%).

Pupil J was identified as having learning difficulties with reading, writing and spelling when he was a pupil in Key Stage 1. His class teacher worked with the school's SEN coordinator to provide support strategies. He scored poorly in KS SATs obtaining level 1 in reading, writing and spelling. In 1992 a teacher's aide was appointed for 5 hours per week to assist the pupil with learning programmes established by schools staff in liaison with the learning support service. The pupil's parent was very concerned about the lack of progress, given the close liaison between home and school. The educational psychologist had been involved in providing professional advice concerning the pupil's uncooperative behaviour at home. An initial statement of the pupil's special educational needs was made in 1993 and the teacher's aide continued to support the pupil for 5 hours per week (1 hour daily).

The pupil has a history of being moody and uncooperative, making individual targets difficult to implement. He responds well to things he enjoys, and he enjoys working with computers, but otherwise can be extremely difficult to motivate. He is articulate and is capable of expressing himself orally. He has an exceptionally good vocabulary. The most recent psychological tests indicate the discrepancy between his receptive language and literacy. Using the British Picture Vocabulary Scale (short form) his performance is rated as 14.9 years, but his basic reading (word recognition) is 7.3 years and reading comprehension is 7.0 years.

The computer programme was running in the school with all children in the class using the programme, in order to identify the general benefits of such an approach to teaching reading and spelling to the full range of abilities. Pupil J responded very positively to the programme, in fact, at times more positively than to his teacher's aide. This responsiveness to the computer programme led to him receiving a regular session of 15 minutes per day with the computer, under the supervision of the assistant.

Figure 7.7(c) shows his performance with the most common 65 words. The initial strategy was the same as for pupil C and resulted in 45 words being covered in 1.33 hours (1.8 minutes per word). This was considered by the teachers to be excellent, given his temperamental nature: he worked consistently and enthusiastically on task for each 15 minute session. However, he did indicate that he was getting bored with the procedure of slowly building up each word and an "express" version was prepared for words 41 to 65, in which he was required to spell the first 4 letters of the word, without working through letters 1 to 3, initially with a 2 second hint and then without a hint. The rate of working through the words increased dramatically, as can be seen in the graph: 25 words in 21.6 minutes (0.9 minutes per word).

Pupil J had a particular difficulty with reading and spelling non-phonetic words such as "people" and "because". When he was given the opportunity to work out a method (sometimes complicated) for memorising these particular words, with the gentle correction from a non-human agency, his approach to his work changed dramatically. Prior to the introduction of the computer programme he was not cooperative when tested for his reading of the 120 most common words and a baseline could not be established. However, on completion of the programme his confidence and cooperation had improved: he could read all 120 words and could spell 93% of them.

Upon completion of the basic sight vocabulary words, a new programme was designed which required the pupil to write out whole sentences, based on the most common 200 words, using a similar strategy to that employed in the spelling of individual words. He has worked on a regular basis with this programme for two terms and now has little difficulty in completing sentences 6-8 words in length.

MASTERY AND ACHIEVING STUDENT POTENTIAL

Pupil S's case demonstrates the validity of the mastery approach. For many years appropriate instruction was not provided, and the result was that he failed to master any reading skills and consequently made little progress. By providing an appropriate strategy, and sufficient time on task, rapid progress was made. When this strategy was discontinued progress ceased, although the attained level of performance was substantially maintained, supporting the data provided by Kulik et al's meta-analysis (1979), which clearly demonstrates the strength of the learning under mastery conditions.

Pupil C also had very specific needs and these were also met by the same programmed characteristics as those of Pupil S. Pupil C's problems were identified at an earlier stage than Pupil S, and his needs will continue to be met by a combination of the computer programme support, now featuring 400 basic words (and sentences made from the basic words), and daily support from a teacher's aide. Under these conditions he has already mastered a basic sight vocabulary and is expected to continue to make good progress.

Pupil J's needs were rather different and required an alternative mastery approach, which was more specifically directed at his need for support at a higher level. Having gained confidence with the mastery of reading and spelling of the basic 120 words he continues to make progress with the most common 200 words by building up complete sentences within a new computer module.

In all the above cases, as predicted by Carroll and Bloom, teachers indicate that pupil self-esteem appears to have been raised, which in turn has had an effect on pupil perseverance, which Carroll identifies as a key factor in the amount of time a pupil will actually spend on task. This sets up a self-sustaining cycle of improvement: appropriate tasks, with corrective feedback, lead to mastery performance, which raises self-esteem and makes the pupil more prepared to invest more effort in learning.

The computer programme is not currently sufficiently intelligent to select the type of structure most suitable for a pupil, but this feature will be built into the system in the near future. With such an algorithmic artificial intelligence in place the programme could contain 12-24 months of work for pupils, with full details of performance available to the teacher, even to the extent of suggesting appropriate reading books for the pupils!

REFERENCES

Bloom, B.S. (1968/81) All Our Children Learning. (Chapter 8: Learning for mastery) 153-177. McGraw-Hill: London.

Bowell, B., France, S. and Redfern, S. (1994) Portable Computers in Action. National Council for Educational Technology: Coventry.

Carroll, J. (1963) 'A model of school learning', Teachers College Record, 64, 723-733.

Davidson, J. and Noyes, P. (1995) 'Computer-generated speech-feedback as support for reading instruction', Support for Learning, 10(1), 35-39.

Dwyer, F.M. (1978) Strategies for Improving Visual Learning. Pennsylvania: Pennsylvania State University.

Kulik, C.L.C., Kulik, J.A. and Bangert-Drowns, R.L. (1990) 'Effectiveness of mastery learning programmes - a meta-analysis', Review of Educational Research, 60(2), 265-299.

Kulik, J.A., Kulik, C.C. and Cohen, P.A. (1979) 'A meta-analysis of outcome studies of Keller's personalised system of instruction', American Psychologist , 34(4), 307-318.

Kulik, J.A., Kulik, C.C. and Cohen, P.A. (1980) 'Effectiveness of Computer-based college teaching: a meta-analysis of findings', Review of Educational Research, 50(4), 525-545.

Reid, D. (1989) Word for Word. LDA: London

Skinner, B.F. (1954) 'The science of learning and the art of teaching', Harvard Educational Review, 24(2), 86-97.

Spencer, K.A. (1981) 'Alternative media: a review of the instructional effectiveness', Educational Broadcasting International, 14(2), 90-94.

Spencer, K.A. (1990) 'HyperCard: teaching technology for successful learning', Journal of Audiovisual Media in Medicine, 13, 25-30.

Spencer, K.A. (1991) 'Modes, media and methods: the search for educational effectiveness', British Journal of Educational Technology, 22(1), 12-22.

Spencer, K.A. (1996) 'Recovering Reading Using Computer Mastery Programmes', British Journal of Educational Technology, in press.

Topping, K. (1985) Parental involvement in reading: Theoretical and empirical background. In K. Topping and S. Wolfendale (Eds.) Parental Involvement in Children's Reading. Croom-Helm: Beckenhem.

Treiman, R. 1984 'Individual differences among children in reading and spelling styles', Journal of Experimental Child Psychology, 37, 463-477.

Van Daal, V.H.P. and van der Leij, A. (1992) 'Computer-based reading and spelling for children with learning disabilities', Journal of Learning Disabilities, 25(3), 186-195.

Walberg, H.J. (1984) 'Improving the productivity of America's schools', Educational Leadership, May, 19-27.