6 Computer technology and support of older dyslexic pupils

6.1 Dyslexic difficulties in secondary school

Older students with dyslexia continue to face difficulties in learning even if they have received appropriate intervention and have been able to improve their literacy skills significantly as a result (Hunter-Carsch & Herrington, 2001; Riddick, Farmer & Sterling, 1997). Difficulties with tasks involving phonological processing and/or verbal memory tend to persist not only into the teenage years (Goulandris & Snowling, 2001) but also into adulthood (see Beaton, McDougall & Singleton, 1997). The typical adolescent dyslexic will have poor phonic skills, below average word reading skills, average or slightly below average reading comprehension, and very slow reading speed. Spelling is liable to be very weak, and the student will be likely to experience major problems in constructing written work. There may also be problems in mathematics and foreign language learning. Memory will be weak, with consequent problems in rote learning for assessment, and recall in exams is liable to be poor. Organisational and study skills will also be rather limited.

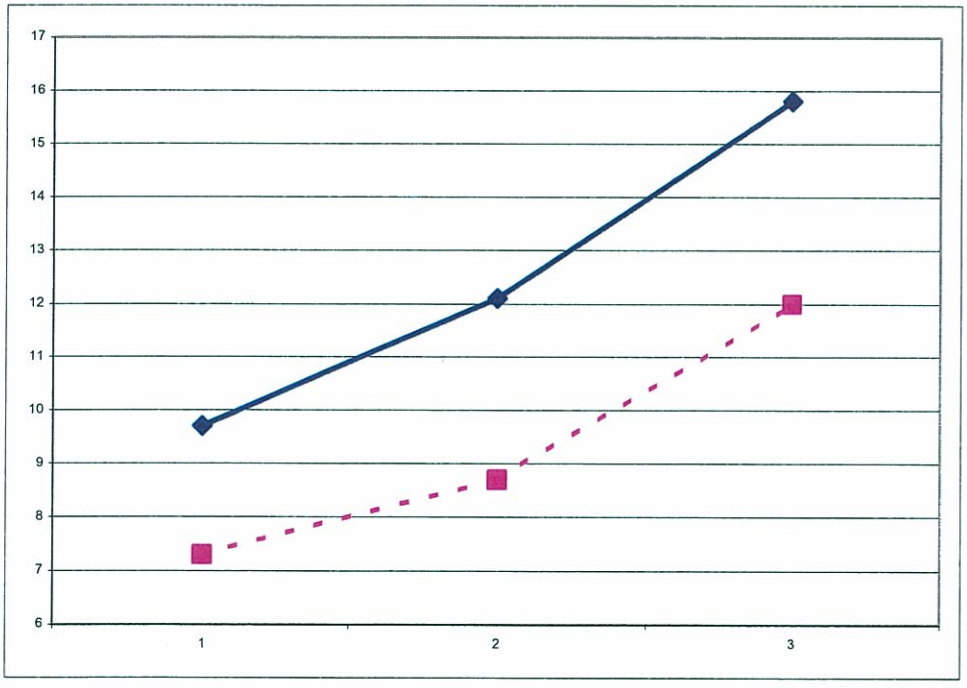

Figure 10. Progress in reading age (dotted line) compared with chronological age (solid line) of a group of 18 dyslexic students studied from chronological age 9 (time 1) to age 12 (time 2) to age 15 (time 3) (data from Goulandris & Snowling, 2001)

Goulandris & Snowling (2001) followed up a group of 18 dyslexic children from age 9 to age 15 and found that none of them had fully overcome their problems and been able to catch up with their peers, despite apparent positive motivation and self-image. The results for reading are shown in Figure 10, and indicate that the gap between them and their peers (who would be expected mostly to have reading ages within a year of their

chronological age) did not narrow: in fact, it increased slightly. The results for spelling were worse: at the end of the five-year study the average spelling age of these students was 10 years 5 months, some 5 years and 5 months behind the mean of their age group.

Hunter-Carsch (2001) has reviewed ways in which dyslexic students can be effectively supported in secondary schools. She outlines several main areas of activity that will need careful attention if students' learning and achievements are to be maximised, including:

- *Differentiation* in writing activities with emphasis on systematic drafting and redrafting
- *Peer tutoring* in which dyslexic students are paired with peers who have good literacy skills and the pairs work together on reading, spelling and writing activities
- Use of *computer technology*, especially for spell checking, organisation of written work, drafting and redrafting
- *Specialised spelling support*: Hughes and Hunter-Carsch (2001) have detailed several ways in which secondary-age students can be taught to improve their spelling skills; Ferrier (2008) has shown how synthetic phonics can be used to teach spelling to dyslexic teenagers, and Brooks (2007) lists six phonics-based schemes which have been used at secondary level
- *Raising awareness* of subject teaching staff and training in practical ways of differentiating work for dyslexic students
- *Parental support* and home-school liaison.

It is clear that conventional instruction still plays a significant part in assisting the older dyslexic student to address their literacy difficulties and general problems with learning. However, these, and many other, professionals in this field also advocate the use of computer technology to enhance and support learning in the secondary school.

6.2 Use of computers in instruction

Computers can be used as part of the instructional process in order to help children learn basic skills and curriculum-related material (commonly known as 'computer assisted learning' or CAL, for short), and also to facilitate reading, writing and the organisation of information by means of technologies such as text-to-speech, voice input and planning tools. The former is often called 'computer assisted learning' (CAL) and most CAL programs in this field are designed for primary-aged pupils. Indeed, several of the successful phonologically-based intervention studies already covered in this review have made good use of CAL (see Sections 3.3.1, 3.3.2, 3.3.3, 3.3.10). The latter is often referred to more generically as 'assistive technology', although that label also may include digital technology other than personal computers (e.g. digital voice recorders, hand-held spelling checkers, dictionary pens).

6.2.1 The advantages of computer assisted learning (CAL) for dyslexics

Developing effective literacy skills requires large amounts of practice for all children, regardless of whether they struggle with literacy. Without practice, component skills do not become well established so that they can be applied automatically and without conscious effort – a key feature of fluency in reading, spelling and writing (see Section 2.6.6). Children who lag behind in literacy development, as dyslexics do, gain far less practice than other children (Torgesen, Rashotte & Alexander, 2001) and consequently it is increasingly difficult for them to catch up with their peers. Computers have the particular advantage of being able to deliver large amounts of practice in a stimulating and enjoyable way, and thus offer improved prospects of catching up.

Singleton (1991) identified five principal advantages of CAL for dyslexic learners:

- Enhanced motivation
- Individualised instruction
- Delivery of immediate informative feedback
- Provision of an active learning environment
- Capacity to monitor the pupil's performance in real time.

It is outside the scope of this review to list all the many CAL programs designed to provide practice in the component skills of reading and spelling. Interested readers are referred to reviews by Crivelli (2008), and Crivelli, Thomson and Andersson (2004). However, the positive features of CAL may be illustrated by examining a single investigation in this field. Singleton and Simmons (2001) reported a study of the use of the program 'Wordshark' in 403 primary and secondary schools. Wordshark is a popular CAL program, currently used in around 20% of UK schools. It provides training in word recognition and developing phonic skills for reading and spelling, using a wide range of different games that are entertaining as well as challenging. The program includes different wordlists, including those drawn from the intervention programme 'Alpha to Omega' (Hornsby & Shear, 1974), from the original National Literacy Strategy materials, and from the 'Letters and Sounds' framework for teaching synthetic phonics. Thus the program is sufficiently flexible to be used with any of these teaching schemes. Type of speech feedback (whole-word or segmented) varies according to the particular task. Wordshark is not designed to be used in isolation or as a stand-alone intervention; rather, the aim is that it should be used to provide regular practice for the child in order to reinforce and consolidate phonic principles that are newly acquired from teacher delivered instruction. To use Wordshark the teacher first identifies the phonic components that the child needs to learn, and the child then selects games that provide practice on those components. Thus instruction is individualised according to the child's needs. The child's progress is also continuously monitored by the program so that the teacher can decide when to move the child on to new components.

The motivational aspects of Wordshark are immediately apparent. An example is the game called 'Sharks', in which the child uses the mouse pointer first to 'catch' a shark (whilst avoiding being 'eaten'): this requires some manual dexterity. When a shark is 'caught' the computer says a word from the current word list and the child has to type in the word. Various supports are provided. When the child gets the word correct the shark is rendered harmless (it loses its teeth). Another example of a game in Wordshark is

'Dictionary Fish', in which various dictionary skills are practised. The aim is to select the correct part of the dictionary for a given word, whereupon the child can steer a parent fish through a barrier, with the baby fish shoaling after. The aim is to be swift enough to save the babies from the marauding sharks. Singleton and Simmons (2001) found that children's motivation was improved by engaging in these activities, with 68% of children showing significantly increased motivation and a further 26% showing slightly increased motivation. Van Daal and Reitsma (2000) have reported comparable motivational benefits in a study of a similar type of CAL program used with dyslexic children in the Netherlands. Many other researchers and practitioners have observed the same motivational effects with dyslexic children (e.g. Crivelli, Thomson & Andersson, 2004; Rooms, 2000; Thomson & Watkins, 1990). Hedley (2004) also reported that use of ILS significantly enhances self-esteem of secondary school pupils with literacy difficulties.

The above examples of games in Wordshark also illustrate how the program provides an active learning environment with immediate informative feedback, which may be contrasted with the passive learning environment encountered when carrying out learning activities using conventional book-based or pen-and-paper materials. Of course, in conventional learning tasks the teacher can provide feedback but, except in group work or 1:1 tuition, this is often delayed, reducing its effectiveness in consolidating learning. Singleton and Simmons (2001) also found that 91% of children using Wordshark made improvements in reading skills, including 27% who made substantial improvement. 93% made improvements in spelling, including 36% who made substantial improvement.

6.2.2 Speech feedback

Roth and Beck (1987) were among the first to show that computer programs designed to provide training in word recognition and decoding could result not only in improvements in those skills but also in better comprehension. These authors pioneered the use of digitised speech for both corrective feedback and for assistance when the child is unsure how to proceed. Children (age 9–10 years) with average or below average reading ability showed significant gains, even though they each spent a modest amount of time using the software (about 20–24 hours in total over eight months). It was concluded that such programs can be very cost-effective and could also help older failing readers. Reitsma (1988) found that optional speech feedback – where the spoken form of any word is given by the computer on request – improved the reading ability of 7-year-old beginning readers as much as traditional classroom 'guided reading' (i.e. where children read aloud and errors are corrected by a teacher). Subsequent studies confirmed the general importance of speech feedback in computer-assisted literacy learning (e.g. Miles, 1994; Moseley, 1990; Olofsson, 1992; Olson and Wise, 1992; Wise et al., 1989). However, the issue of what type of speech feedback is most effective has proved to be tricky. In a long-term training study with poor readers (mean age 10 years), Wise et al. (1989) found that *segmented* feedback (i.e. where words are broken down into syllables, onsets and rimes, etc.) was superior to *whole-word* feedback. However, later studies did not find such an advantage for syllable-segmented feedback (Olson and Wise, 1992; Spaai, Ellermann and Reitsma, 1991; Elbro, Rasmussen and Spelling, 1996).

Subsequent research has shown that there is clearly a role within software designed to improve reading skills for both types of feedback. Some programs, such as Wordshark and Leescircus (Van Daal & Reitsma, 2000) have incorporated both types of feedback, while phonics training programs have mainly used segmented feedback (e.g. Wise, Ring

and Olson, 2000). Software designed for beginning readers, especially 'talking books' (see Lewin, 1997, 1998, 2000; Underwood, 2000; Underwood & Underwood, 1998) and also programs designed to develop word recognition and text reading skills in older students (e.g. Davidson & Noyes, 1994; Davidson, Coles, Noyes & Terrell, 1991) have mainly relied on whole-word feedback.

6.2.3 Integrated Learning Systems

CAL is often seen at its most advanced in Integrated Learning Systems (ILSs). An ILS incorporates assessment and diagnosis of student skills, delivery of carefully structured learning materials via a computer network, continuous monitoring of performance and automatic adjustment of instruction where required, and generation of individual and group performance data for use by teachers and administrators (Willis, Stephens and Matthews, 1996; Brown, 1997). ILSs have been widely adopted in the USA, but the take-up in the UK has been more cautious, partly because they are very expensive, and partly because there have been reservations about their effectiveness. However, Van Dusen and Worthen (1994) argued that the dearth of positive results from evaluations is not necessarily because ILSs are inherently ineffective, but rather because implementation of the systems has been too weak. UK studies of ILSs have been evaluated by Wood and colleagues, who concluded that, while investigations have failed to produce overall convincing evidence for educational gains of ILSs, some studies have shown positive benefits (Wood, 1998; Wood, Underwood and Avis, 1999). Underwood (2000), in comparing an ILS and a talking book for developing reading skills of primary school children, found that both methods were highly motivating for children and resulted in gains in reading.

Lewis (1999) has reviewed the evidence from eight different research studies on the use of ILS with students with learning difficulties in the UK. The results were mixed, but overall this analysis also failed to produce clear evidence that ILS, as used in these particular studies, has significant benefits for children with special needs. On the other hand, Williams (2001) reported a study of using ILS to develop skills of 200 secondary school pupils with poor literacy; improvement was noted in self-esteem as well as learning. However, perhaps most importantly, all these authors agree that there are good reasons to expect that the effects of an ILS will be mediated and strongly influenced by classroom practice. Miller, DeJean and Miller (2000) highlight how the embedded curricula in an ILS may sometimes be congruent with those of the school or the teacher, but often may be at variance with them, with potentially negative consequences.

On the basis of current evidence there is little to support the use of ILS with dyslexic pupils. It would appear that, as a learning activity, ILS is too generic and insufficiently focused on the needs of pupils with SEN, although if properly integrated within the curriculum so that it complements conventional teaching, it might be a useful (if expensive) way of enabling non-SEN children to practise and apply their literacy skills. Clearly further research is required on this topic.

6.3 Research on computer-based interventions with dyslexic children

The most comprehensive review of the use of computer technology on literacy was conducted by Torgerson and Zhu (2003). Meta-analysis was limited to those with RCT

designs and employing children aged 5–16; 12 such studies were identified but, overall, effect sizes were not significantly different from zero. Dynarski et al. (2007) also drew similar conclusions from a large-scale national review in the USA. However, against the rather dismal picture regarding the efficacy of computer technology as a means of educational instruction painted by Torgerson and Zhu (2003) and Dynarski et al. (2007) must be set the results of studies that have focused specifically on children with learning disabilities or dyslexia.

Lewis, Graves, Ashton & Kieley (1998) carried out a study of children's writing and spelling using training in word processing. 108 children from grades 4 to 8 with learning disabilities received one hour of training per week over 20 weeks. Compared with a control group the trained group showed significant improvements in writing skills, most notably in the amount of spelling errors they made when writing, but with a rather small effect size (ES 0.28).

There have been several notable reviews on the use of computer technology to improve the spelling skills of children with learning disabilities. Fulk and Stormont-Spurgin (1995) reviewed published research on spelling interventions for pupils with learning disabilities, and noted that eight of a total of nine separate studies that used CAL reported positive effects of CAL. In a more recent systematic review and meta-analysis of the field, Torgerson and Elbourne (2002) concluded that at best there was only a modest effect of CAL on spelling development. McArthur et al. (2001) reviewed published data on the use of computers to teach or support literacy in samples of students with learning difficulties. The authors concluded that 'cautious optimism' was justified regarding the potential of technology to improve the literacy skills of such students. Wanzek et al. (2006) carried out a review of seven spelling interventions for children with learning disabilities that involved use of computers. Overall, interventions involving spelling with assistive technology using speech feedback, word prediction and spell checking yielded positive effects on students' spelling.

Van Daal and Reitsma (2000) report on two studies using Leescircus, an interactive CAL program for Dutch children which is similar to Wordshark (although a Dutch version of Wordshark has now been developed). Leescircus comprises a variety of different games designed to draw children's attention to the phonological structure of words, to learn the correspondences between letters and sounds, and to develop automaticity in word reading and spelling. In the first study, a group of kindergarten children (about 6.5 years) were given regular opportunities to use the program and their reading progress was compared with a control group. At post-test, the experimental group was found to significantly out-perform the control group on both word reading and decoding (non-word reading). During the project, the children spent a total of 1.5–6 hours using the program, and yet the level of reading competence that was achieved was equivalent to that which was normally attained after three months of formal reading instruction. In the second study, a group of learning disabled children (mean age 10.7 years) who had serious spelling difficulties and were experiencing motivational problems used the Leescircus program. The children made significant improvements in spelling and were also found to display more positive behaviours when working with the computer compared with normal classroom activities.

Tijms, Hoeks, Paulussen-Hoogeboom & Smolenaars (2003) reported on a study using LEXY, a highly structured CAL program designed to help dyslexic people learn to recognize and use the phonological and morphological structure of Dutch words. Of the total of 100 dyslexic participants in the study, 83 were of school age. The intervention involved weekly 45-minute computer-based teaching sessions during each of which a

new phonic principle was introduced; the participants were also expected to engage in three 15-minute sessions of additional practice at home each week. Results showed that, after 26 weeks of intervention, word reading and text reading were both significantly improved, with moderately large effect sizes (word reading ES 0.54; text reading ES 0.66). Spelling was also significantly improved with a very large effect size (2.15), although there was subsequent washout that reduced the magnitude of this gain somewhat. Tijms (2004) reported on a further study that replicated the earlier findings. Participants showed stable improvements in reading over a period of one to four years after intervention. However, although the gains were substantial, the average reading level of the participants remained below normal levels at the end of the study and thereafter.

A further study of LEXY with 267 Dutch children with dyslexia aged 10–14 years (Tijms & Hoeks, 2005) employed the same design as used by Tijms et al. (2003). The results revealed large, generalized beneficial effects of the intervention, with effects being largest for accuracy, somewhat smaller for fluency. Text reading errors were reduced by 50%, with mean standard scores of reading accuracy increasing from 84 at pre-test to 106 at post-test. Spelling errors were reduced by 80%, with mean standard scores of spelling accuracy increasing from 54 at pre-test to 102 at post-test. Text reading fluency increased more than 25% (SS increase from 61 to 85) and word reading rate by 30% (SS increase from 77 to 88).

Wise, Ring and Olson (2000) studied 200 children in 2nd to 5th grades (age range 7–11 years) who spent 29 hours using a CAL reading intervention program over approximately 6 months. The children were assigned to one of two conditions: a phonologically-based training condition, and a contextual reading condition that emphasized comprehension strategies. The results showed that children who had received the phonologically-based computerized instruction gained significantly more in phonological skills (ES 0.7), phonic decoding (ES 1.0) and untimed word reading ability (ES 0.52), although children who had received the contextual reading intervention were better at timed word reading (ES 0.32).

Lundberg (1995) studied the impact of speech feedback in a CAL program used with a total of 83 poor readers in grades 2 to 8 in Sweden, who regularly used the program 2-3 times per week over the school year. The total amount of computer-based practice averaged about 30 hours. When compared with a group of 59 control children who had received conventional special education without computer training, the group that had received computer-based practice showed gains in reading and spelling, but this was significant only for the students in grade 8.

Nicolson, Fawcett & Nicolson (1999) evaluated a computer-based literacy intervention program called RITA (Reader's Intelligent Teaching Assistant) with 74 pupils in primary schools (see Section 3.3.2). The computer program RITA does not replace the teacher; rather the teacher uses RITA to specify activities for the child to work through, and RITA stores and analyses the results of the student's work. Over a 10-week intervention period, and in comparison with control groups matched on age and reading ability, the RITA study produced effect sizes for reading of 0.30–1.34 and for spelling of 0.77–0.98. The authors concluded that this was a successful highly cost-effective intervention. Lynch, Fawcett & Nicolson (2000) also reported significant improvements in reading and spelling for a small group of 8 severely dyslexic secondary school pupils who were taught using RITA.

6.4 Studies of assistive technology with older dyslexic students

Miles, Martin and Owen (1998) reported on a study of the effects of using voice dictation software with dyslexic pupils. 12 dyslexic pupils in secondary schools in Devon were studied over a 10-week period. The findings showed that these pupils made an average gain of 13.4 months in reading age (ratio gain 5.4), and 6.1 months in spelling (ratio gain 2.4), and produced 45% more written output in handwriting work than they had before the outset of the project.

Sutherland and Smith (1997) carried out a survey of the use of portable word processors by dyslexic students in secondary schools. They found that 88% of the subject teachers who were teaching these students noted significant improvements in presentation and readability of their work, and 78% observed improvements in their spelling.

Lange, McPhillips, Mulhern and Wylie (2006) studied 93 secondary school pupils with reading difficulties in Northern Ireland. All were below average in reading and 43% were in the lowest 10% of readers (standard score <80). Students were assigned to one of three conditions, with matching across conditions for reading, spelling, verbal and non-verbal IQ, gender and socio-economic status. The intervention group received 45-minute training sessions in using the computer program Texthelp Read&Write GOLD once each week for six weeks. Texthelp Read&Write GOLD is a talking word processor that includes scan-and-read capability, spellchecker, dictionary, and other study tools and visual features. The two other conditions served as controls, and the students in these groups engaged in training activities using Microsoft Word. The results, on tests of text reading comprehension, word meanings and spelling accuracy, showed significant benefits of the Texthelp Read&Write GOLD intervention when compared with the other two groups, indicating that assistive technology can be beneficial for students with dyslexia.

Lewis (2007) compiled a report on the Technology for Learning Disabilities project being carried out in schools under the auspices of Central Washington University over the school years 2005–06 and 2006–07. The technology being used to support writing was 'Texthelp Read&Write GOLD'. The participants were learning disabled students in grades 6 to 12. Over the course of the first year of the project the students (N=53) were found to have significantly improved on every writing assessment component except keeping sentences on topic. There was a 39% increase in number of words written in the test, and a 10% increase in spelling accuracy. At the end the second year of the study the students who had been using Texthelp Read&Write GOLD were found to have significantly improved their scores from pre-test to post-test on every component of the writing assessment, and also to score significantly higher than a comparison group on every aspect of the writing assessment. In the post-test the Texthelp Read&Write GOLD group produced 60% more words in their writing than the comparison group, and their spelling accuracy was also 8% better.

6.5 Conclusions

The impact of computer assisted learning on the development of literacy in children with dyslexia or learning disabilities has been found to vary from study to study. There is little evidence that large-scale Integrated Learning Systems are helpful for pupils with dyslexia, but smaller-scale, more carefully targeted CAL programs can have significant

impact on reading and spelling, particularly when programs incorporate speech feedback. In addition, CAL can have motivational benefits for children with dyslexia.

The difficulties that most, if not all, dyslexic students encounter in secondary school may be addressed using a variety of support techniques. Conventional instruction and training can still have a significant role in this work, but, increasingly, assistive technology is used to support the learning of older dyslexics. Research studies on this are rather thin on the ground, but those that have been published indicate that word processing activities, especially those in which there are enhanced supportive features,[15] significantly improve writing and spelling skills.

[15] Enhanced supportive features for word processing include voice dictation, text-to-speech, and sophisticated spell checking that identifies 'dyslexic-type' errors; conventional spelling checkers are really designed to identify typing errors rather than spelling errors and rarely provide appropriate corrections for phonological errors (e.g. 'sitee' will not be identified by a conventional spell checker as a misspelling of 'city').