Using computer-based assessment to identify learning problems

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Assessment is an integral and essential part of all good teaching. Unless teachers have awareness of their students’ progress, decisions about appropriate strategies for developing learning cannot be made. This assessment is usually carried out on an informal basis, with the teacher noting that students who have failed to reach expected levels of attainment will require additional learning to bring them up to scratch. Such assessments, which are largely based on criteria laid down in the curriculum, may be derived from observation of the students’ work, from results of class tests and examinations, or perhaps from outcomes of statutory assessments such as Standardised Achievement Tests (SATs). These sources of information may tell the teacher about the extent of a student’s deficiencies and, possibly, in which aspects of a given subject these deficiencies lie. Rarely will such information give clues about the causes of a student’s difficulties. Whilst teachers get to know much about their students from their close and frequent contact with them, it would aid them considerably if there were effective techniques of diagnostic assessment, which teachers could use on a regular basis.

The Special Educational Needs Code of Practice (DfES 2001) places a duty on all educators, whether in mainstream or special schools, or in early education settings, to play a part in the identification and provision for pupils with special educational needs (SEN). Particular responsibilities are carried by Special Educational Needs Co-ordinators (SENCo{s}). The Code stresses the vital importance of early identification of SEN: ‘The earlier action is taken, the more responsive the child is likely to be, and the more readily can intervention be made without undue disruption to the organisation of the school.’ (p. 46, section 5:11; p. 60, section 6:10). To help identify pupils with SEN, schools are encouraged to employ a variety of strategies, including the use of screening or assessment tools (see Sections 5:13 and 6:12), but it is stressed that ‘Assessment should not be regarded as a single event but rather as a continuous process.’ (p. 46, section 5:11; p. 60, section 6:10). Early identification of problems encountered in learning — before these develop into outright failure — could enable the teacher to intervene within the mainstream classroom, rather than having to resort to withdrawal for specialist intervention. The former is educationally desirable, as the SEN Code of Practice emphasises, but it is also more cost-effective as well as being more ethical, since it does not rely on waiting for children to fail and thus tries to avoid the emotional and motivational repercussions of failure. However, all successful intervention — but especially early intervention — depends on good diagnostic information. It is not enough to know simply that a pupil has problems in learning. To shape intervention effectively it is necessary to understand the problems and their ramifications on the student’s learning behaviour. Such understanding should then be used to develop a more specifically targeted intervention.

Ideally, therefore, to teach well, all educators should not only be monitoring their students’ progress and attainment and spotting any problems encountered in learning, but they should also be investigating those problems diagnostically. Unfortunately, diagnostic assessment is time-consuming and not easy. Applying informal methods of diagnostic assessment usually depends on many years of experience, especially in teaching SEN pupils. Formal diagnostic assessment typically involves mastery of several complex assessment tools: skills in which educational psychologists are trained, but few teachers get this opportunity. Fortunately, in recent years the development of computer-based diagnostic assessment tools has come to the aid of teachers, and has enabled easier identification and deeper understanding of children’s learning problems as well as the development of educational
solutions that can be effective in the mainstream classroom. This chapter discusses these tools and their potential for teachers.

**The advantages of computer-based assessment**

Computer-based assessment (CBA) has been defined as ‘any psychological assessment that involves the use of digital technology to collect, process and report the results of that assessment’ (British Psychological Society 1999). CBA is employed extensively in business and industry, especially for the purposes of recruitment, selection and promotion. In education it is used widely for selection at college level (particularly in the USA, but also in several other countries), for monitoring progress in many areas of the curriculum and for ‘paper-less’ examinations. In the UK, one of the most notable applications of CBA is within Integrated Learning Systems (ILS), which are computer-based training programs designed to provide learning practice for large numbers of students simultaneously via networked computer systems. The computer has to assess the progress of each student in order to map a route for them through the learning materials offered by the program (see Wood, Underwood and Avis 1999, for a review). It is not the purpose of this chapter to review the use of computer-based assessment (CBA) in education: this has been done elsewhere (see Singleton 1997b, and Singleton 2001). However, it is worth examining the benefits that CBA can bring to special needs education, particularly in relation to diagnostic assessment of learning problems.

**Savings in time, labour and cost**

In CBA the computer does most of the work of assessment, including administering items, recording responses and scoring results. Hence labour and cost savings in using CBA compared with conventional assessments delivered by human personnel can be significant. In comparisons of conventional and computerised versions of tests, teachers generally prefer the latter, mainly because results are immediately available, which saves time in scoring responses and calculating standard scores (Woodward and Rieth 1997). Time savings are considerable when CBA is adaptive, that is, where the difficulty of items selected from a test bank is varied in response to the student’s progress on the test. The term ‘adaptive testing’ refers to any technique that modifies the nature of the test in response to the performance of the test taker. This can be achieved in a variety of ways, although typically it is used in connection with tests that are developed by means of Item Response Theory (Hambleton and Swaminathan 1985). Conventional tests are static instruments, fixed in their item content, item order, and duration. By contrast, CBA can be dynamic. Since the computer can score performance at the same time as item presentation, it can modify the test accordingly, tailoring it more precisely to the capabilities of the student taking the test. In conventional tests, for some part of the time, the student’s abilities are not being assessed with any great precision because the items are either too difficult or too easy (which can easily lead to frustration and/or boredom). In a computerised adaptive test, however, because the program contains information about the difficulty level of every item in the item bank (based on pass rates in the standardisation population) the individual taking the test can be moved swiftly to that zone of the test that will most efficiently discriminate his or her capabilities. This makes the whole process speedier, more reliable, more efficient, and often more acceptable to the person being tested. It has been shown that an adaptive CBA can take only a quarter of the time taken to administer an equivalent conventional test (Olsen 1990).

Adaptive testing has been implemented in Lucid Assessment System for Schools (LASS), a multifunctional assessment suite used for both diagnosing and monitoring students’ progress. There are two versions: LASS Junior (Thomas, Singleton and Horne, 2001) for ages 8:0 – 11:11, and LASS Secondary (Horne, Singleton and Thomas, 1999) for ages 11:0 – 15:11. Both of these programs include adaptive tests of reading, spelling, memory, phonological processing and non-verbal reasoning. In these tests adaptivity is usually achieved by means of ‘probe technique’, in which the student is first given a series of items of sharply increasing difficulty (‘probes’). As soon as the student fails a probe item, the main part of the test commences at a level determined by the difficulty of the last correct probe
item. The program can then move the student back to easier items or forward to more difficult items if it turns out that the probe resulted in the test being commenced at an inappropriate level (e.g. due to passing or failing probe item by chance). Finally, when a set criterion is reached (e.g. failing a given number of items consecutively), the test is automatically discontinued.

An alternative approach to adaptive testing was employed in CoPS Baseline Assessment, an on-entry assessment program for children aged 4:0 to 5:6 (Singleton, Thomas and Horne 1998). The challenges in developing this program were considerable, since in order to be accredited by the Qualifications and Curriculum Authority for use in schools in England, strict criteria had to be adhered to. These criteria specified assessment in four key components of the early learning curriculum (communication skills, literacy, mathematics, and personal and social development) and a total assessment time of no longer than 20 minutes. This meant that assessment of each component could not take greater than five minutes. It was found that young children could not complete more than about 16 computer-based test items in five minutes, and so an adaptive algorithm was developed to overcome the problem. Banks of 56 items of known difficulty were created for both the literacy and mathematics modules, each being subdivided into eight different skill/concept areas (e.g. for the literacy module these included knowledge about print, letter recognition, phonological awareness, and simple reading and spelling), with seven items of increasing difficulty in each area. The child attempts only two items from each area, and progress through the test is determined by item-to-item performance, so that the computer administers items which are most appropriate for that child’s ability level. The success of this approach was demonstrated by the finding that the adaptive form of the test (16 items) correlated highly (0.81) with the full form (56 items). Baseline scores derived from the adaptive form were also found to give good prediction of development in both literacy and mathematics over the first year of schooling (correlations \( r = 0.75 \)) (Singleton, Horne and Thomas 1999). Although government regulations regarding baseline assessment in state schools in England were changed in 2002, removing the requirement for on-entry assessment, CoPS Baseline Assessment is still widely used elsewhere, including independent schools across the UK, state schools in Scotland, and British and International schools around the world. This illustrates the advantages of adaptive test theory in the creation of new assessment tools that are brief enough to be practicable for teachers and stimulating to young children, while still yielding results that satisfy educational needs and meet psychometric standards. CoPS Baseline provides a snapshot of the child’s level of development in the component areas at the time of school entry. Although not primarily intended for diagnostic purposes, it can nevertheless identify children who are weak in various aspects of learning and thus can be used to in decision-making about subsequent teaching and learning approaches for such children. Hence it can have certain limited diagnostic value. However, the similarly named program Lucid Cognitive Profiling System (CoPS), with which CoPS Baseline Assessment should not be confused, is designed specifically for diagnostic purposes. The specific features of this CBA are discussed later in this chapter.

Lucid Adult Development Screening (LADS) is a computerised test designed to screen for dyslexia from age 16 and older that is used in further and higher education and in many other settings (Singleton, Horne and Thomas, 2002). In this test, adaptivity is achieved by means of ‘CAST’ technique (Computerised Adaptive Sequential Testing), in which blocks of items of similar difficulty are administered sequentially (Drasgow and Olson-Buchanan 1999). LADS incorporates assessment of speeded lexical access, phonological coding, and working memory — skills that are typically weak in dyslexia (Singleton 2002; Snowling 2000), even in bright adults who have developed excellent compensatory techniques and who have been educated to a high level (see Singleton 1999). (‘Speeded tests’ are ones in which a set time is allowed for the assessment.) In LADS the student’s performance on each block determines which block will be administered next, until the program has established the student’s maximum level of functioning for that test. The timing of item presentation is also variable, which enables the test to take account of speed-of-processing deficits that have been
observed in dyslexia (Wolf and O’Brien 2001). The result is a relatively short test (20 minutes) that is easy to administer and non-threatening to test-takers, but which still achieves a high level of accuracy.

*Increased test motivation*

SEN pupils have been found to display negative responses to conventional tests given in pen-and-paper format or administered by a human assessor (Wade and Moore 1993). By contrast, many studies have reported that children and adults, particularly those with low ability or who have ‘failed’ educationally, feel less threatened by CBA than by conventional assessment, and hence prefer CBA (Watkins and Kush 1988; Singleton 1997b). In an adaptive test, students are not exposed to items that would be ridiculously easy nor impossibly difficult for them, which also enhances test motivation. In a study comparing CBA of verbal and non-verbal ability with assessment of the same cognitive domains using conventional methods, Singleton (2001) found that children displayed a clear preference for the CBA over the conventional assessment. In part, this was because the CBA was designed to be attractive and enjoyable (including use of colourful graphics, animation and sound), and consequently was widely perceived by the children to be ‘more fun’. Similar preferences were expressed by teenagers (both male and female) being assessed on LASS Secondary, where 72% of those assessed preferred the computer tests to equivalent conventional tests.

It is important to appreciate that although able and successful pupils may be self-motivated in a conventional assessment situation, many SEN pupils are not. Assessment is likely to be perceived as yet another potential failure experience for them, and therefore their motivation and interest are low. A human assessor must provide the motivation. In CBA, there is no human assessor to encourage the child and therefore motivation is dependent on the content and structure of the program. CBA that is perceived by students to be boring, unstimulating and uninteresting will not elicit strong test motivation, and consequently the validity of the results will be questionable. Delivery of CBA as games, or the use of amusing animated sequences as rewards for test completion, may be viewed by some teachers with suspicion. These devices, both pioneered in the diagnostic assessment program CoPS Cognitive Profiling System (Singleton, Thomas and Leedale, 1996), may be thought of as a gimmick or ‘edu-tainment’ when in reality they are essential to keep children motivated and on task in the absence of a human assessor.

For older individuals who feel that they have ‘failed’ at school, confidence in an assessment situation tends be very fragile indeed. Being assessed by a teacher (or another adult who takes on a role equivalent to that of a teacher, such as a psychologist) can evoke painful memories of humiliation at school, which can result in complete loss of motivation or emotional breakdown. A CBA (such as LADS, mentioned above) is usually perceived as less threatening than conventional assessment, and enables adults to be assessed in a confidential and non-stressful manner (Singleton and Horne, submitted). Similar findings have been reported by Horne, Singleton and Thomas (submitted, b), where teenagers preferred the computer tests in LASS Secondary to equivalent conventional tests, and this preference was much more pronounced in SEN students. Amongst the non-SEN students, 67% preferred CBA, but amongst the SEN students 92% preferred CBA.

*Greater precision and standardisation of administration*

In conventional assessment some variation in test administration is inevitable. By contrast, in CBA the test is *exactly the same* for all recipients, which helps to improve reliability of measurement. In CBA the timing and delivery of test items and measurement of responses is much more precise than in conventional assessment. This is particularly important where timing is critical, e.g. in presentation of items in memory tests or in speeded tests.
Is CBA as good as conventional assessment?

Despite the considerable advantages outlined in the previous section, some teachers may feel that CBA is somehow a ‘second best’ — something to be used because it is quick and easy, and because children find it enjoyable — rather than a technique to be valued in its own right. Sceptics may argue that human assessors will always be better than computers because they can detect aspects of performance that the computer cannot possibly be aware of — such as the state of health of the student, their level of confidence or attention, or the effort that they are putting in. Some important aspects of behaviour generally determined by observation, such as social and emotional behaviour, cannot be directly assessed by computerised means. Abilities that depend on reading and understanding large amounts of text are also problematic for CBA due to the difficulties that some people experience when reading text on a computer screen, which results in reading from the screen being 20% to 30% slower than reading from paper (Dillon 1992) and can for some individuals can lead to symptoms of visual discomfort (Wilkins 1986). Tasks that require use of expressive language (including speech production and phonological skills) are also problematic for CBA. However, imaginative CBA design can circumvent many of these problems. Assessment of social and emotional behaviour is amenable to CBA using on-screen questionnaires and rating scales (an example of this is found in the program CoPS Baseline Assessment, mentioned above). When large amounts of text have to be read, these can be provided in conventional printed format with the questions being delivered by the computer and responses being made via the keyboard (or mouse or other suitable input device). Singleton, Horne and Vincent (1995) developed a computerised reading comprehension test for primary age children where the text was presented in conventional illustrated book form, while the child listened to comprehension questions spoken by the computer and made responses using the mouse. Although the accuracy and sophistication of voice-recognition systems has developed substantially in recent years, we still await the introduction of voice recognition software that is sufficiently reliable for all students to be assessed by speaking to the computer. Nevertheless, some aspects of language that are conventionally assessed by verbal interaction are still susceptible to CBA. Two examples are the phonological awareness and phonemic discrimination tests in CoPS Cognitive Profiling System (Singleton, Thomas and Leedale 1996), in which the language skills are assessed by the children using the mouse to click on objects corresponding to spoken words that have rhyming or alliterative features, or on characters who have spoken the sounds correctly. The tests in CoPS show significant concurrent and prospective correlations with equivalent conventional tests, and the whole suite was also validated by means of statistical analysis of prospective longitudinal data predicting literacy difficulties and dyslexia from age 5 to age 8 (Singleton, Thomas and Horne 2000).

It should be self-evident that no psychometric test can supply all the information that a teacher requires in order to make sensible educational decisions. The test results must be integrated with other information about the student, including how he or she behaves in class, the effort put into class work and homework, and any emotional problems being experienced. But these provisos apply to all psychometric tests, not just to CBAs. The particular advantage of psychometric tests is that they can provide objective information about the student’s performance compared with population norms, and so remove some of the limitations that might otherwise cloud educational judgements. As we have seen above, computerised tests not only make assessment easier for the teacher and often more acceptable to the student, they also enable many aspects of assessment to be more sophisticated and thus more useful in diagnostic contexts.

One way of determining whether CBA is as good as conventional assessment is to directly compare the two with the same sample. Singleton (2001) reported on a study in which children were given conventional and computerised tests of verbal and non-verbal ability. Ninety children aged 6–7 years were administered CBA of verbal ability (verbal concepts) and nonverbal ability (mental rotation), and the scores were compared with measures of verbal and nonverbal ability derived from conventional psychological assessment. The results
revealed an expected pattern of significant intercorrelations indicating that the different assessment formats did not significantly affect the ability being assessed. Similar findings have been reported by Horne, Singleton and Thomas, submitted a). Contrary to some suggestions that computer activities may favour boys (see Crook 1994; Singleton, Horne and Thomas 1999), no gender differences were found in either the conventional or computer assessment formats. Horne, Singleton and Thomas (submitted, c) reported a study of 176 secondary school students (102 boys and 74 girls). No significant gender differences were found in any of the tests in the CBA suite LASS Secondary.

In many respects, CBA can offer better assessment than conventional approaches. In addition to being able to make use of game formats to deliver assessments, thereby being able to assess children who would otherwise be difficult to assess effectively by conventional means, CBA enables assessment of many aspects of performance that would be impractical to measure conventionally. An example is response time, which is tricky for human assessors to control or measure but which can easily be managed by CBA. An example of a CBA is which response time is central to the assessment is the Dyscalculia Screener (Butterworth 2001). Dyscalculia is a specific learning difficulty in mathematics, in which children experience great difficulty understanding simple number concepts, lack an intuitive grasp of numbers and have problems learning number facts and procedures. Even when these children produce a correct answer or use a correct method, they tend to do so mechanically and without confidence (Butterworth 1999). In the Dyscalculia Screener diagnosis of dyscalculia is achieved by measuring response times to test items involving enumerating, understanding number size, numerals and simple arithmetic, in comparison with basic reaction time. Particular profiles on this test correspond to dyscalculia, but since the program gives information on performance in various subtests, in some cases the information could, in principle, be used to help plan intervention.

Use of response time in CBA enables a clear diagnostic distinction to be made between children whose performance is accurate and fast, those who are accurate but much slower in their responses, and those who are fast but inaccurate (the latter maybe because of attentional problems or high impulsivity). One diagnostic program that incorporates this feature is CoPS Cognitive Profiling System (Singleton, Thomas and Leedale, 1996). Such data enable the teacher to gain an understanding of the child’s speed of information processing in different modalities. When delivered by conventional means, speeded tests typically specify an overall time for a test comprising many items. It will not be possible to deduce from the results of such tests which items were hard and thus took the child longer and which were easier and hence took a shorter time. All that will be known is the overall number of items that the student passed in the time allowed, and which items were passed, failed or unattempted. However, in a speeded CBA, it is possible to control the time allowed separately for each individual item, thus providing more sophisticated diagnostic information about the child’s abilities (or inabilities).

Another example of assessment that is impractical by conventional means is that of allowing more than one answer. In a multiple choice test, if a child gets the answer wrong it may be helpful to know whether allowing them a second choice would enable them to get the answer right. A child who gets the right answer on the second choice knows more than one who gets neither the first or the second choice right. In CBA the computer can score the first choice before deciding whether to offer a second choice; that option is not practical in conventional assessment (see Singleton, Horne and Vincent 1995, for a report on a study of this approach). Furthermore, because responses can be by means other than speech or writing, CBA can provide for the assessment of students with severe physical disabilities or profound sensory impairments (for review see Woodward and Rieth 1997).
Identification of learning problems using CBA

In educational contexts, diagnostic assessment refers to any process that seeks to identify componential factors in an individual’s cognitive abilities or educational attainments in order to understand why that individual experiences difficulties in learning. The purpose of this identification is to enable the teacher to select or develop the most appropriate techniques for addressing that individual’s difficulties and for promoting more effective learning. Sometimes these techniques will involve training (e.g. in decoding strategies for children with poor phonic skills); sometimes practice is the main requirement (e.g. in reading text in order to develop fluency in word recognition and increase comprehension); and sometimes support is the principal objective (e.g. word processing with speech feedback for a child with poor writing skills). Often, a combination of these approaches is needed. To decide which approach or strategy is most likely to be beneficial, it is necessary to have fairly detailed information about the nature of the problem. For example, if the teacher assumes that the pupil needs more practice at reading text without first checking that s/he can use phonic strategies to decode unfamiliar words, then such practice may result in frustration for the child and not lead to improved reading comprehension. Furthermore, if the teacher establishes that a child cannot decode unfamiliar words, it will also be important to try to discover why the child has poor phonic skills. If the fundamental cause is cognitive, such as poor phonological processing ability and/or poor working memory (both of which can be determined by diagnostic assessment), this will have different implications for subsequent improvement than if the problem is due mainly to the way in which phonics has been taught in the first place (e.g. too fast and with little monitoring of individual progress).

In diagnostic assessment, it is helpful to distinguish two broad types of component factor: generic factors are those that contribute to a variety of general problems in learning (e.g. language skills, memory, perception); specific factors are those that impinge directly on certain delineated aspects of learning (e.g. phonic and word recognition skills on learning to read, or place value and number fact knowledge on learning arithmetic). Secondary learning problems may be consequential upon difficulties in specific skills (e.g. poor phonic skills affects the development of reading, which in turn has repercussions on the ability to cope with new vocabulary in various parts of the curriculum).

A longitudinal CBA study reported by Singleton, Thomas and Horne (2000) showed that cognitive assessment by means of computer-delivered tests is a valid and practical method for identifying children who are at risk of reading difficulties. The tests in the computer suite CoPS Cognitive Profiling System (Singleton, Thomas and Leedale 1996) were administered at age 5 and were later found to correlate significantly with conventional reading measures given at age 6 and 8 years. CoPS is a suite of eight CBAs that measure various cognitive abilities, including visual and auditory memory, phonological awareness and phoneme discrimination. The CoPS tests of auditory memory and phonological awareness yielded the highest correlation coefficients with reading development, but phoneme discrimination was found to be a significant predictor of phonic skills and listening skills. The CoPS measures of visual memory were also significantly correlated with later word and text reading. Regression analyses revealed that the CoPS tests given at age 5 accounted for 31% of the variance in reading scores at age 6, and 37% of the variance in reading scores at age 8. Conventional assessments of general ability perform less well than the cognitive measures as early predictors of reading attainment, and CoPS was found to outperform the conventional tests on all counts in predicting poor readers at age 8. Levels of false positives and false negatives were low or at zero for the CoPS measures, while the conventional tests produced unacceptably high levels of false positives and moderate levels of false negatives. (‘False positives’ were those children predicted to have problems in literacy who subsequently did not have problems, while ‘false negatives’ were those who were not predicted to have problems who subsequently did have problems in literacy. For further discussion of issues in accuracy in educational screening see Singleton, 1997a.) It was concluded that as components of a diagnostic procedure for identifying children at risk of reading failure, the conventional
tests employed in this study would be unsatisfactory and inferior to cognitive measures such as those in CoPS.

Horne, Singleton and Thomas (submitted, b) reported a study in which 176 students aged 11-15 attending 12 different schools were tested by their teachers using LASS Secondary. 129 students had no identified special educational needs, 30 had diagnosed dyslexia and 17 were on the SEN register for reasons other than dyslexia. Significant differences were found between the dyslexic and the non-SEN group on CBA measures of reading, spelling, auditory sequential memory, phonic skills (nonword reading) and phonological processing (syllable segmentation). This follows the expected cognitive pattern for dyslexia reported in the literature (see Snowling 2000; Singleton 2002). The ‘other SEN’ group also scored lower than the non-SEN group on all of the above five tests as well as on CBA measures of reasoning and visual memory. By contrast, there were no significant differences between the dyslexic and the non-SEN group on CBA measures of reasoning or visual memory. Hence students’ profiles on LASS Secondary enabled a clear differentiation between students in the three groups, demonstrating the utility of the CBA approach in diagnostic assessment in the classroom. In fact, in accuracy of identification of the dyslexic students, LASS Secondary out-performed conventional assessments also used in the study.

Case studies

The investigations reported above demonstrate the validity of CBA in diagnostic assessment. However, statistical findings frequently fail to put across the practical benefits of this approach for teachers. The following case studies illustrate how CBA can help the teacher to identify both generic and specific factors that are hindering learning, and to develop appropriate strategies for learning and teaching to address these

Ewan, aged 6 years 7 months

After for a little over 18 months in school, Ewan was making very slow progress in literacy. He could not reliably recognise all the letters of the alphabet and could write fewer than a third of them. His formation of letters that he was able to write was generally very poor. He could read a few simple words (including his name). He could write his name but his attempts at writing other words were mostly indecipherable. Yet he was orally bright, responded eagerly to the teacher’s questions and played a lively part in class discussion. About six months ago his teachers had begun to suspected that Ewan was dyslexic but he had not yet been seen by an educational psychologist. Given the assumption of dyslexia, it was regarded as problematic to attempt phonic work with him before a more solid base of letter- and word-recognition skills had been established, and so teaching focused mainly on Ewan’s visual skills, in the attempt to build up a basic sight vocabulary. This approach had not worked. Ewan was then tested using the CoPS Cognitive Profiling System (Singleton, Thomas and Leedale 1996), which has been described earlier in this chapter. This is a CBA which assesses cognitive abilities that are critical to development of literacy, such as phonological awareness, phoneme discrimination, and auditory and visual memory (Singleton 2002). Ewan found the CoPS tests fun and was enthusiastic about them. His results are shown in Figure 1.

The tests in CoPS are generally known by their shorthand names, but it is not necessary to go into full details here. Broadly, the first four tests (shown on the left-hand side of Figure 1) assess various aspects of visual memory, while the remaining four tests (shown on the right-hand side of Figure 1) measure auditory/verbal abilities including phonological awareness (‘Rhymes’), phoneme discrimination (‘Wock’), auditory sequential memory (‘Races’) and auditory-visual associative memory (‘Zoid’s Letter Names’).
Ewan’s CoPS results came as a surprise to his teachers. As well as showing a clear problem with remembering visual information (which had not been suspected before the assessment), they also confounded the assumption of dyslexia. Typically, children with dyslexia have difficulties mainly in phonological processing and auditory working memory (Singleton 2002; Snowling 2000), and Ewan’s skills in these areas are extremely good. Arguably, Ewan falls within a category that might be termed ‘visual dyslexia’, although that rather vague nomenclature may also be applied to visual disturbances associated with the perception of print and which can often be treated by use of coloured overlays or tinted lenses (see Evans 2001; Whiteley and Smith 2001). However, the label for Ewan’s difficulties is much less important than what is done about them. Stuart, Masterson and Dixon (2000) found that visual memory affects acquisition of sight vocabulary in young children, and this appeared to be what was happening in Ewan’s case. His strengths in phonological processing and auditory working memory suggested that an immediate switch to phonically-based teaching would be beneficial, and that is what was implemented. Although progress was rather slow at first, Ewan’s word recognition skills expanded significantly, and he is now (at age 10½) ahead of most of his peers in reading accuracy and reading comprehension, although he still reads rather slowly and his spelling of irregular words is unreliable. At age eight, Ewan began to use a ‘talking’ word processor, which spoke back the text as he typed it in. Drawing on his good auditory-verbal skills, this helped Ewan to problem-solve his writing difficulties largely without teacher intervention, and to self-correct most of his errors in writing. Currently his writing is still not quite commensurate with his oral intellectual ability, but he is well on the way, and his prospects for success in secondary education are now good.

Emily, age 12 years 2 months

Emily’s father was in the army and her family had recently moved back to the UK after several years of being stationed abroad. Emily started her education in an independent kindergarten in England, and has since attended a succession of English-speaking schools in
various parts of the world. She recently joined the local comprehensive school, and almost immediately the head of year identified a problem. Emily was not happy (perhaps the move had unsettled her), but also her written work and mathematics were well below expected levels. Her previous reports suggested that she was fairly intellectually able, and no early problems had been recorded. But it had been noted that she did not put a great deal of effort into her school work, and so consequently her performance across most of the curriculum had been slipping for some time. She had never been assessed before, nor provided with any additional help. It had been assumed that the problem was motivational. Emily was administered **LASS Secondary**, which she did not find in the least bit intimidating (in fact she enjoyed the tests). The results are shown in Figure 2.

![Figure 2 LASS Secondary results for Emily, age 12 years 2 months.](image)

Emily’s *LASS Secondary* results shed a great deal of light on her problems. Space does not allow a detailed analysis of the results here, but it can be seen that, unlike Ewan, her visual memory (‘Cave’) is satisfactory, but her auditory working memory (‘Mobile’) is poor. Her Reasoning test score indicates that she is bright, but clearly under-performing in both reading and spelling. She has very limited phonic skills (‘Nonwords’), which her parents later admitted could have been due to the de-emphasis on phonic teaching in her previous schools, where a ‘real books’ approach was in vogue. However, that is not the whole story, because she has extremely poor phonological processing ability (‘Segments’), which, taken together with her poor auditory working memory and her general profile, points to a diagnosis of dyslexia. Her competence in visual memory has probably sustained her through the primary school, enabling her to rely on visual recognition of words as whole units. Her inability to tackle unfamiliar words was now letting her down in both reading and writing, especially when confronted with large numbers of subject-specific words that were new to her. The head of year decided that it would be necessary to improve Emily’s phonic skills and try to increase her reading and writing abilities before she reached the start of GCSE work. A special needs teacher at the school began to help Emily work on her phonics, backed up by regular computer practice activities using the program *Wordshark* (Savery and Burton 1995; see also Singleton and Simmons 2001). It was also recognised that because of her weak auditory memory she would be likely to encounter problems in revising and remembering information.
for examinations, so she was taught how to create mind-maps for this purpose, capitalising on her visual memory strengths.

Emily’s problems in mathematics were not so much in understanding the concepts as in remembering number facts and calculation procedures. This now made sense in the light of her *LASS Secondary* profile, and so her mathematics teacher created differentiated activities that gave Emily additional practice in these areas. Now, after a year in her new school, Emily’s parents and teachers have noted that she has settled down and is making better progress. Her reading had improved substantially and she is now reading for pleasure, something she never did before. She is gaining confidence in her maths and in her writing, and has started to use a word processor when doing her homework. Perhaps most importantly, Emily now enjoys school and is formulating career plans that will involve going to college and so she is working hard to achieve her ambitions.

**Conclusions**

CBA is now a rapidly growing area in education. The two case studies reported in the previous section illustrate how use of CBA can assist the teacher to diagnose learning problems and develop classroom solutions for those problems. The tests employed are quick and easy to administer, produce immediate results, and the children find the assessments enjoyable and stimulating. The profiles obtained can often throw up unexpected findings, as in Ewan’s case, or sometimes they confirm the teacher’s suspicions. In either event, the teacher has obtained solid evidence not only on which specific skills children need to acquire, but also about their learning strengths. The pattern of these underlying skills has a significant effect on learning; it is important for teachers to appreciate them and make appropriate adjustments in teaching. In some cases a diagnostic label (such as ‘dyslexia’) may be helpful in promoting wider awareness of a child’s problem (for example, amongst all teachers in the school) and in indicating the most promising educational approaches to be adopted. But this is not as important as reaching a deeper understanding of the difficulties so that appropriate strategies for learning and teaching can be implemented. Computer Based Assessment appears to be able to help teachers gain this deeper understanding and to point to key difficulties at which to aim special educational support.

**References**


**Suppliers of software mentioned in this chapter**

**Lucid CoPS Cognitive Profiling System**

**CoPS Baseline Assessment**

**Lucid Assessment System for Schools (LASS Junior and LASS Secondary)**

**Lucid Adult Dyslexia Screening (LADS)**

Lucid Research Limited, 3 Spencer Street, Beverley, East Yorkshire, HU17 9EL. Tel. +44 (0) 1482 882121. Fax. +44 (0) 1482 882911. [www.lucid-research.com](http://www.lucid-research.com)

**Dyscalculia Screener**

NFER-Nelson, Darville House, 2 Oxford Road East, Windsor, Berkshire, SL4 1DF. Tel. +44 (0) 1753 858961. Fax. +44 (0) 1753 856830. [www.nfer-nelson.co.uk](http://www.nfer-nelson.co.uk)

**WordShark3**

Whitespace Limited, 41 Mall Road, London, W6 9DG. Tel/Fax. +44 (0) 20 8748 5927. [www.wordshark.co.uk](http://www.wordshark.co.uk)