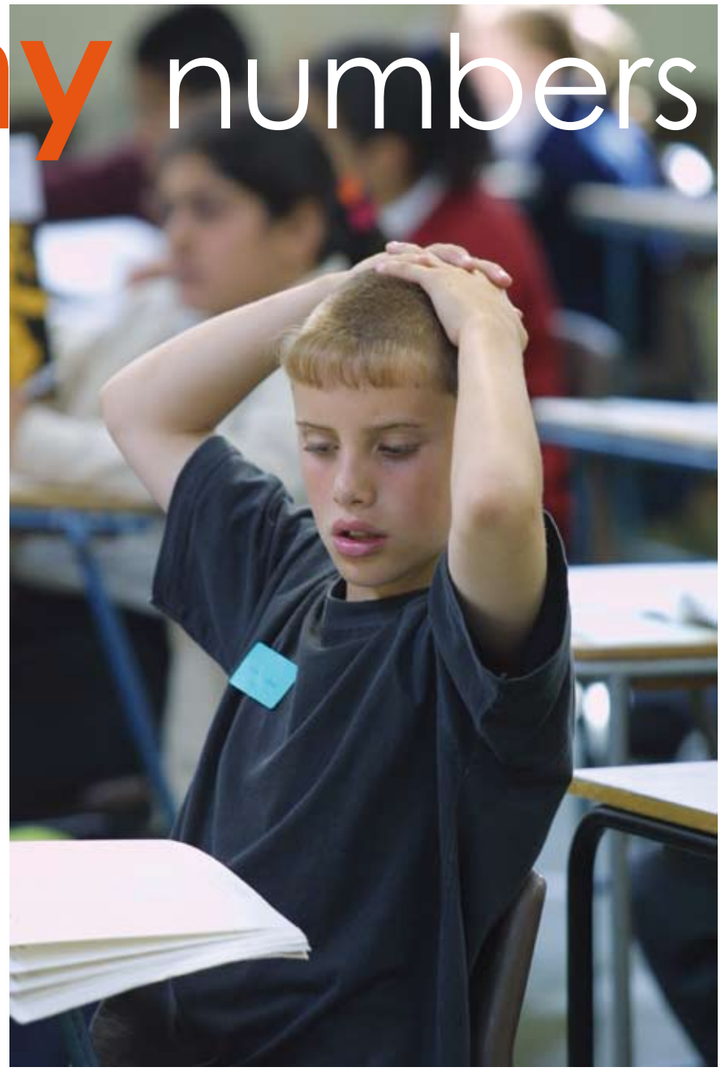
Funny numbers

'Dyscalculia', or 'number dyslexia', affects about 6% of the population. Here, **Hassan Baajour** and **Professor Diana Laurillard** discuss their Becta-funded computer game development project - that offers personalised learning to dyscalculic students in mainstream primary classrooms.



What is 'dyscalculia'?

The DCSF[1] has described dyscalculia as: "A condition that affects the ability to acquire mathematical skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers and have problems learning number facts and procedures." Colloquially it is called 'a lack of number sense'.

Dyscalculic children and adults have a very particular disability – they are otherwise perfectly capable in thinking and learning. Many are professionals and some achieve post-graduate degrees. But it's important for teachers to be aware that dyscalculics think about numbers in a unique way. This creates learning difficulties if they have to learn in a conventional maths class.

For example, it's hard for dsycalculics to recognise number patterns, so many of them always count the number of hearts on a playing card. And they don't easily remember number facts. An intelligent dyscalculic 10 year-old we met, when asked to count down from 10, did it by counting all numbers up to 10 to find out the one that came before it, then counted all the numbers up to 9 to find the one that came before that, and so on.

It means that children and adults with dyscalculia are very slow at simple number tasks in comparison with normal people. The 'Dyscalculia Screener', available to schools, will provide an assessment for any child you're worried about.

The project: 'Digital interventions for dyscalculia and low numeracy'

It is very difficult for teachers with a large class to help children with severe maths learning difficulties. The problem motivated us at the London Knowledge Lab2, a research institute combining two universities, to help teachers by developing single player computer games. So, with a small grant from Becta, we developed several exemplars of teacher-customisable personalised programs with a small group of SEN teachers in London schools.

The programs are simple interactive games that teach basic mathematical skills. There are many educational software programs available for school maths, of course, but unfortunately they are of little help to dyscalculics, because (a) they have busy, distracting screens, (b) they randomly generate the tasks, (c) questions are multiple choice - which prompts guessing and (d) feedback is mainly right/wrong - which is no help to a learner who cannot yet make sense of the concepts.

By making the programs adaptive to the learner, we are trying to offer the same kind of personalised help a small group SEN teacher can give. What the programs cannot do is engage the learners in dialogue about what they are doing. This is a very important part of the pedagogy used in SEN groups and, of course, computers are no good at natural language. But they are good at repetition and instant feedback.

If the child is working slowly or inaccurately, our programs keep the tasks simple. If they start getting it right or working more quickly, it progressively changes the difficulty of the task. That is what 'personalised learning' ought to mean – and computers can offer it.

Game one: Dots2Track

The Dots2Track game is one of these programs. It is designed to help learners recognise a dot pattern without counting it. The game displays a number pattern (1 to 10) and asks the learner to key in how many dots they see. If they get it right, the pattern is transferred instantly to a number line. If they get it wrong, it is counted onto the line dot by dot (visually and with sound). The student can see their response next to the correct response, then fix theirs by adding or taking away until it matches.

By counting the pattern onto a number line, the program makes a meaningful link between the pattern and the digit. Then, once the learner has become familiar with this relationship, the program (or the teacher) can adjust how many seconds the pattern will be displayed for before it disappears. This technique motivates the learner to memorise the pattern, without counting, to identify it.

Game two: Numberline

Dyscalculic children asked to count in 10s will often make the mistake of counting "70, 80, 90, 100, 200, 300…" as they expect a number with a '2' in it to come after 'one hundred'. The Numberline game was designed to show learners how the number line is organised.

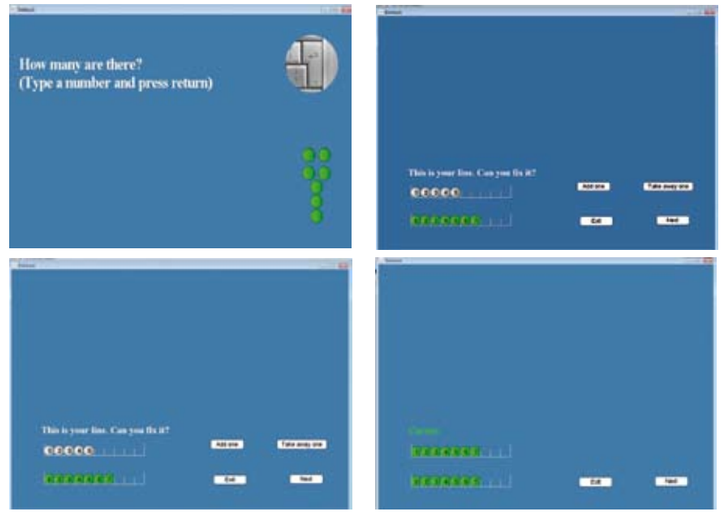
We wanted to give learners a concrete experience of 'navigating' the number line, controlling their movement along it to find a target number. The students do this by using the on-screen controls to 'steer' - 'zoom out' to see only tens, hundreds or thousands marked, or 'zoom in' to see the units. Whenever the learner clicks on the target number, they are awarded a flower and a new target number is displayed. The program gradually increases the difficulty of the task (to more distant numbers) as the learner's performance improves.

Teacher control in the games

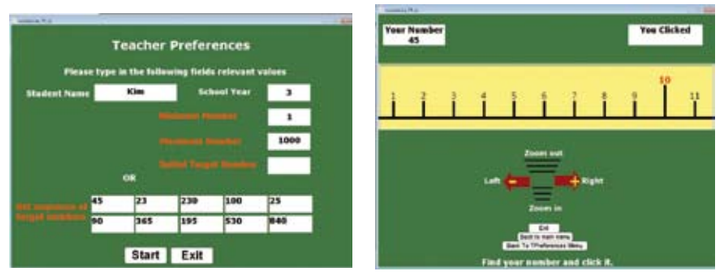
An additional feature of these programs is that the teacher can control the pedagogy. Each program has a 'teacher preferences' page where the teacher can change how the program operates. For example, in *Dots2Track*, the teacher can decide how many times the learner has to get a pattern right before the program moves on to the next.

Numberline is the same. The teacher can set the maximum and minimum numbers, and the sequence of numbers to be displayed as targets, in case there are particular types of numbers they want the learner to rehearse. They can decide whether the program goes up into the thousands or tens of thousands, or back into negative numbers, or into decimals.

All these games collect and monitor learners' data - counting how many wrong or right answers were given and how long they took to choose. This data can be analysed to measure the childrens' progress. That helps our designers make new versions of the programs.



Screenshots of Dots2Track. The text is also spoken, and the dots are counted audibly as they move onto the number line.



Screenshots of the Numberline program.

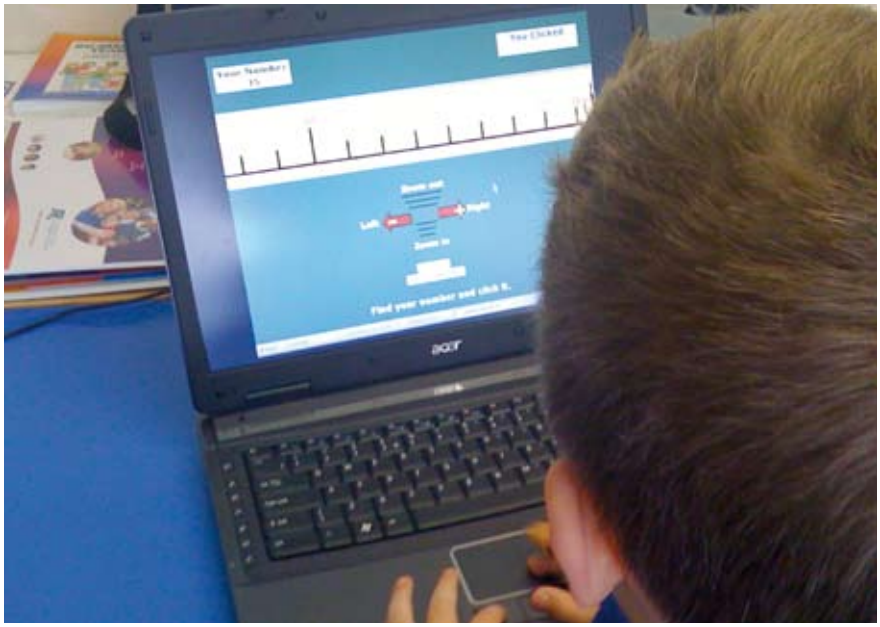
The website is also a hugely valuable resource for getting ideas for improvements from the teachers who download and use the programs. Comments for *Numberline* include:

"Could it work with a part-filled number line as an extension/further activity? E.g. just the multiples of 10?"

"The number line exercise could be extended to finding a number within unmarked intervals in order to test sequencing and understanding, estimating as well as part-filled".

What's next?

It's early days for this project, but so far children who are struggling with maths are responding very positively to these programs, returning to them many times to practice the basic concepts in ways that are difficult in the mainstream classroom. Teachers like the programs too because they are targeted. In future developments,



teachers will be able to view their learners' progress reports.

Many of the programs have also proved effective with mainstream learners. Teachers have said that the programs are good for year four children who still need to do year one activities – so they also work well for year one children.

Another advantage of the very simple screen designs is that they are not childish. These programs would be equally valuable for adult dyscalculics – many of whom have found ways of getting round their problem for years but still lack basic understanding.

We are continuing our research and developing more games like this. We aim to capture the imagination of schools, organisations and teachers. If we succeed in this, and get the funding we need, we intend to develop intelligent personalised applications to cover all the fundamental arithmetic concepts.

1. http://shop.gl-assessment.co.uk/home.php?cat=314

2. http://www.lkl.ac.uk

Hassan Baajour and Professor Diana Laurillard work for the London Knowledge Lab on the BECTA funded project 'Digital interventions for dyscalculia and low numeracy'. They would love for readers to help by testing and commenting on the programs, so please register at **low-numeracy.ning.com**.