**References**

Disabled Students' Allowance – government funding for UK disabled/SpLD students http://www.direct.gov.uk/en/DisabledPeople/EducationAndTraining/HigherEducation/DG_10034898.

Dyspraxia Foundation Retrieved April 4th , 2011 from http://www.dyspraxiafoundation.org.

Grant, D. (2009) Formal identification of a range of specific learning differences in Pollack, D (Ed) Neurodiversity in HE: Positive Approaches to Learning. Chichester, Wiley .

SpLD Working Group 2005/DfES Guidelines, revised 2009/2010 Retrieved April 11th, 2011 from SASC www.sasc.org.uk.

SpLD Test Evaluation Committee (STEC), sub-committee of SpLD Assessment Standards Committee (SASC) http://www.sasc.org.uk.

# Dyscalculia in Further and Higher Education

*Clare Trott*

**Abstract**

*Dyscalculia is one of the newer challenges that face practitioners, particularly in the post 16 sectors. This paper will consider current definitions of Dyscalculia and its prevalence, as well as some of the issues experienced by dyscalculic students, both in academic life and more generally. The paper will then highlight DysCalculiUM, a new first-line screening tool for dyscalculia focusing on the understanding of mathematics. The final section will describe a case study of one-to-one support for a dyscalculic student working with tables of information, percentages and graphs.*

## 1. Background

### 1.1 Towards a Definition

"Most dyscalculic learners will have cognitive and language abilities in the normal range, and may excel in non-mathematical subjects" (Butterworth, 2002, p.8). Dyscalculia is a specific learning difference (SpLD) that refers to mathematical difficulties. It will have an impact on the learning of number and applications and systems that are numerically dependant. It will, however, "vary from person to person and affect people differently in school and throughout life" (NCLD,2009). Two of the most frequently quoted definitions come from the DSM-IV (2000) and The National Numeracy Strategy (DfES,2001). The former defines Mathematics Disorder "as measured by a standardised test that is given individually, the person's mathematical ability is substantially less than would be expected from the person's age, intelligence and education. This deficiency materially impedes academic achievement or daily living". The two key features of this definition are, firstly, that the mathematical level is significantly lower than expectation, and, secondly, academic achievement and daily living are impeded. However, the DSM-IV definition refers to, but does not elaborate upon the idea of mathematical ability, which is a vital component in our understanding of dyscalculia. The term "Mathematics Disorder" implies a stable cognitive root and this, in turn, is indicative of the need to assess for dyscalculia with tests that are not based on achievement or mastery, where scores are shaped by education and environment. However, it is often current practice to use such achievement tests.

The second definition, from The National Numeracy Strategy (DfES, 2001, p.2), defines dyscalculia as that which “affects the ability to acquire arithmetical skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problems learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence.” The most important aspect of this definition is the “ability to acquire” which places the emphasis clearly on the capacity to attain rather than on the mechanics of conducting arithmetic operations. This definition is more helpful in its contribution to the nature of the mathematical ability: i.e. “difficulty understanding simple number concepts, lack an intuitive grasp of numbers”. This resonates with Chinn (2006): “A lack of a true comprehension or understanding of maths will be a key characteristic of dyscalculic people”.

The definition from The National Numeracy Strategy also contains “learning number facts and procedures”. The implication here is of rote learning and recall. However, other neuro-diverse students (e.g. dyslexic learners) are likely to struggle to recall number facts such as times tables and number bonds and are likely to rely on understanding the mathematics required, rather than well rehearsed procedures.

### 1.2 Prevalence

Estimates of the number identified with dyscalculia are only available from data collected on children. Original estimates by Kosc (1974) placed this at 6.4% and more recent estimates (Butterworth, 2002) approximately agree with this, placing the number between 5% and 6%. However, Geary (2004) and Desoete (2004) both estimate the prevalence of dyscalculia in child populations to be upward to 8%.

### 2.1 Development

DysCalculiUM(Iansyst/Tribal, 2010) is a first-line screening tool for dyscalculia, developed by Trott and Beacham at Loughborough. The screener focuses on understanding mathematics and has an on-line delivery to identify students at risk of dyscalculia. The tool is designed so as to minimise staff input. After registration, the student can access the portal and complete the screening tool, which is based on a model of 11 categories, 6 of which are concerned with the understanding of number and the other 5 extend to frequent everyday applications. The tool marks the input and returns a profile, based on these 11 categories, that identifies the mathematical strengths and weaknesses of the student. The profile is accessed by the tutor who can then discuss the detail with the student or highlight students requiring further investigation. This may be an in-depth interview or referral for further testing or assessment.

Two of the six categories that relate to number include the conceptual understanding of both number and of operations. These activities relate directly to the representation and manipulation of numerical quantity with varying input modality, i.e. as a digit, a word or as a collection of items. Two further categories require comparisons of number sizes on a visual-spatial plane and with symbolic notation and are associated with visual-spatial processing, while another category, making inferences from given operations, necessitates both the manipulation of numerical quantity and visual-spatial processing. The final category within number addresses the ability to make comparisons of numerical quantity through language and thus relies on the verbal processing of terms such as “larger” or “smaller”. This employs linguistic as well as quantitative processing.

The model for the DysCalculiUM screening tool also includes some common applications of number, such as time, direction and the understanding of graphs and tables of information. The model for the DysCalculiUM screening tool is shown in figure 1.

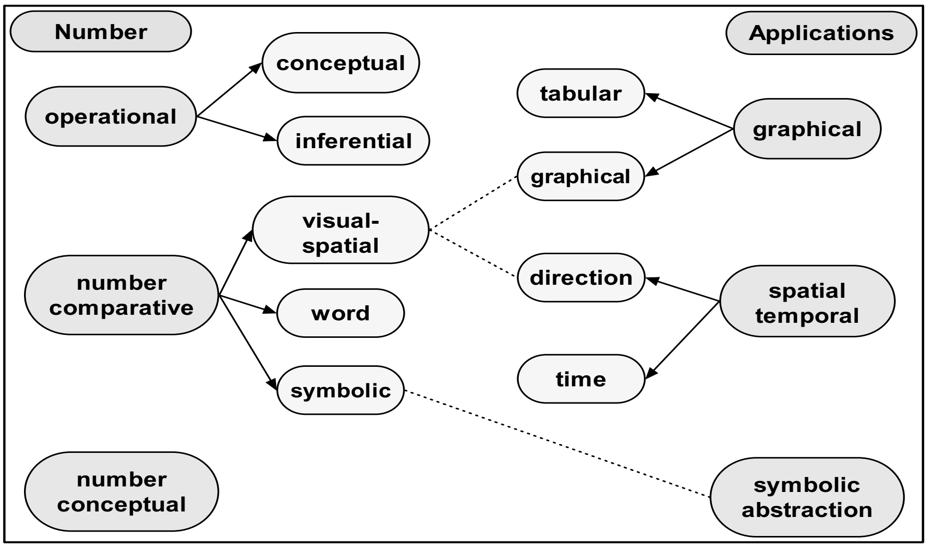


**Figure 1: the model for DysCalculiUM, showing the 6 key areas of number and the 5 key areas of applications.**

### 2.2 Trials

Several trials were undertaken during the development of the screener and modifications made as necessary. The final trials were divided into two parts. The first part provided data for the establishment of "at risk" and "severely at risk" thresholds, through administration to large groups of general populations. These were large lecture groups in both Colleges of Further Education and Institutions of Higher Education. The size of each group varied, as did the subject of study, but the total sample was 504. The 8$^{th}$ percentile rank was determined as the threshold for "at risk" with the 2$^{nd}$ percentile rank as the threshold for "severely at risk". In contrast, the second part of the final trial, enabled the tool to be verified against a known population, that is, individuals already identified as dyscalculic only, through Educational Psychologists or recognised teacher assessments. These trials were administered on a one-to-one basis with each dyscalculic student. Thus, the accuracy of the screener was established. In addition, of the 51 one-to-one trials with those participants who were known to be dyscalculic, 47 were shown to be "at risk" or "severely at risk" by the DysCalculiUM screening tool. Further information revealed that of the four individuals not identified by the screener, three were following science degree courses (biochemistry, physics and computer science). It is likely that these students had developed good coping strategies in order to be able to manage the demands of their courses. Such well developed strategies would be frequently repeated during their course, and would likely mediate the score obtained in the screener. The fourth participant had an assessment report that stated "probably dyscalculic". These four cases excepted, the screening tool provides a reliable first-line screening for dyscalculia.

In addition, the trial also included 19 individuals who were described in their assessment reports as having a neuro-diverse profile of dyslexia with mathematical difficulties. Of these 19, DysCalculiUM results showed 3 to be "severely at risk" and 5 to be "at risk" of dyscalculia.  However, 11 of this group were not at risk of dyscalculia. This serves to highlight essential differences between those who are dyslexic and have some degree of difficulty with some aspects of mathematics, such as memory for number facts or extracting key information from surrounding texts, and those who are dyscalculic with more fundamental mathematical difficulties. From this group of trials, it is not clear from the assessment reports which of these alternatives are relevant here. There are a number of effective dyslexia screening tools available, so this group are more likely to be identified. The intention of the DysCalculiUM screening tool is to identify those who are dyscalculic.

### 2.3 The Profile

The profile provided at the end of each individual screening gives an indication of “not at risk”, “at risk” and “severely at risk” for the overall score as well as for the 11 categories of the model upon which the screener is based (see figure 1). The profile follows a “traffic light” system with green indicating “not at risk”, yellow for “at risk” and red to show that the individual is “severely at risk”. Guidance is provided on how to interpret the profile and on the subsequent course of action. The profile provided by the screener can also be used to guide any subsequent one-to-one support for the learner. The clear picture of strengths and weaknesses is a useful starting point.

| | Severely at risk | At risk | Not at risk |
|---|---|---|---|
| Overall Score | | | |
| No Conceptual | | | |
| No Comparative: Word | | | |
| No Comparative: Symbol | | | |
| No Comparative: Visual Spatial | | | |
| Graphical | | | |
| Tabular | | | |
| Symbolic Abstraction | | | |
| Spatial Direction | | | |
| Time | | | |
| Operational: Conceptual | | | |
| Operational: Inferential | | | |

**Figure 2: DysCalculiUM profile for “Thomas”, showing areas of strength, “at risk of dyscalculia” and “severely at risk at dyscalculia”**

The profile shown in figure 2 is for “Thomas”, and serves as an exemplar profile. It shows that he is “severely at risk of dyscalculia” by the overall score, but there is also further evidence for this by the seven categories highlighted as “at risk” or “severely at risk of dyscalculia”. A fuller investigation of the profile suggested that Thomas’s difficulties lay primarily with the basic number categories: understanding number concepts and making numerical comparisons between numbers. It was also apparent that he had problems with understanding the concept of number operations and in making inferences from them. However, Thomas showed his strengths in the interpretation of graphical and tabular information, time and spatial directions. These are more visual areas. Subsequently, an in-depth interview with Thomas indicated that he had a history of mathematical difficulties and had been placed in lowest mathematics group at school. Thomas achieved highly in non-mathematical areas but continued to encounter mathematical barriers. Consequently, he was very low in confidence and was concerned about the numerical aspects of his course.

## 3. Dyscalculia: The Social Effects

Many of our daily routines are underpinned by number and numerical understanding, including household budgeting, checking change and telling the time. Dyscalculic learners frequently feel anxiety, frustration and low self-esteem through the every-day challenges they face. One dyscalculic student recently said that she always paid with “a purple”, meaning a £20 note, ensuring that she had tendered sufficient money to cover the cost of her purchases. She was unable to count out the correct amount or to check her change. Her embarrassment with this forced her to stop going to the cafe with her peers and socialising with them so that she became increasingly socially isolated. There is still a lack of awareness of dyscalculia as a specific learning difference, but it is important to identify effectively dyscalculia as early as possible so that support can be put in place to give greater confidence with everyday numerical situations and enable these learners to reach their full potential. The DysCalculiUM screening tool is a first-step in this process.

## 4. One-to-one Support for Dyscalculia

### 4.1 “Liam”: a case study

“Liam”, a student studying transport management, was identified as dyscalculic during his first year at University, following initial screening with the DysCalculiUM tool. An in-depth interview with Liam revealed that he had always struggled with understanding basic mathematical concepts and had been placed in the lowest set for mathematics in school. However, he had excelled at other subjects, particularly languages.

Through the screening and assessment process his strengths emerged in several areas: verbal reasoning, expressive writing and reading comprehension. However, his dyscalculia resulted in difficulties with conceptual understanding of number and operations as well as the ability to tell the time and understand graphical information. Furthermore, he found had particular difficulty with sequencing numbers in the correct order and relating them to a number line and problems with carrying out basic numerical calculations. He was unsure of basic operations and frequently used inappropriate strategies. Following the screening and assessment process, Liam received one-to-one specialist support.

### 4.2 Tables of Information

Liam had difficulty with understanding tables of information and using them to calculate the quantities he needed. Given a 4 X 4 table showing flight to four cities and the number of minutes late, he had to calculate the percentage of flights to Brussels that were more than 5 minutes late. Firstly, it was clear that he mixed up rows and columns. A simple picture of a rowing boat going across a row and a picture of a vertical architectural column enabled him to appreciate this distinction. The images worked well with this type of learner. Figure 3a shows the table that Liam was working with.

| Birmingham to | Minutes late (to nearest minute) | | | | |
|---|---|---|---|---|---|
| | On time | 1 to 5 | 6 to 10 | Over 10 | Total |
| Paris | 8 | 3 | 1 | 0 | 12 |
| Brussels | 6 | 3 | 1 | 2 | 12 |
| Munich | 4 | 1 | 0 | 0 | 5 |
| Dublin | 7 | 1 | 1 | 1 | 10 |

**Figure 3a: Table showing the frequency of flights from Birmingham to 4 cities, together with the number of minutes late**

He had difficulty identifying the relevant information he needed for the required calculation and then also found the calculation itself challenging. In order to identify and focus on the appropriate information, pieces of card were used to cover over the irrelevant information, leaving only the required data visible. This is shown in figure 3b.

| Birmingham to | Minutes late (to nearest minute) | | | | |
|---|---|---|---|---|---|
| | | | 6 to 10 | Over 10 | Total |
| | | | | | |
| Brussels | | | 1 | 2 | 12 |
| | | | | | |
| | | | | | |

**Figure 3b: Table 3a with covered cells showing only the frequency of flights from Birmingham to Brussels that were more than 5 minutes late**

Support sessions then focused on working with fractions and percentages, so that, after some time, he was able to see that 3 out of 12 was a quarter and 25%. Frequent visual representations and concrete materials were also used during this process.

### 4.3 Graphical Representations

Liam struggled to order a sequence of numbers and then place them correctly on a number line. Numbers were written on post-its, one on each, and Liam was encouraged to put them in order. After he had mastered this, he then moved on to consider a simple linear distance/time graph. The horizontal axis of which (time) was equivalent to the number lines he had been considering. He appreciated that time was on-going. The problem now was that he was unable to see that simultaneously the distance was also changing. After many attempts, an occasion occurred when, in error, Liam drew the vertical axis on the right hand side, instead of the left. Far from being “a mistake” it proved decisive as he was able to see the simultaneous increase in both distance and time and form a connective relationship. Greater confidence followed and he was able to move ahead to other aspects of his course. This included correlation and sales forecasting.

Liam’s strengths, particularly his strong literacy skills, provided a sound base for other areas of his course, although he continued to struggle with the mathematical elements. The multi-sensory based support, as described above, continued to focus on the conceptual understanding of number and time as well as the understanding of graphical information, as highlighted by the DysCalculiUM screening tool. The tool, together with the Educational Psychologist’s assessment, provided a very useful profile that enabled the support tutor to understand the nature of Liam’s difficulties and the areas that needed to be specifically addressed in relation to his current academic needs. Through the identification process and relevant specialist one-to-one support, Liam was able to successfully complete his course.

## 5. Conclusion

Dyscalculia is one of the newer challenges that face us. Support for dyslexia iswell established, but the picture surrounding the identification and support of dyscalculia is much less clear. It is hoped that further research will inform our practice in this area.

*Clare Trott, Mathematics Education Centre, Loughborough University*
*C.Trott@lboro.ac.uk*

**References**


Butterworth B (2002) Mathematics and the Brain, Opening address to The Mathematical Association, Reading 2002, http://www.mathematical brain.com/pdf (accessed 26/11/07).

Butterworth B. (2001) Educational Leadership Interview http://www.mathematicalbrain.com/int06.html (accessed 26/11/07).

Chinn S. (2006) What Dyslexia can tell us about Dyscalculia, Dyslexia Review Vol. 18 (1), pp 15-17.

Desoete A., Roeyers H. and De Clercq A. (2004) Children with Mathematics Learning Disabilities in Belgium Journal of Learning Disabilities, Volume 37 (1) pp 50-61 DfES (2001).

DfES (2001) The National Numeracy Strategy. Guidance to support pupils with dyslexia and dyscalculia.

DfES 0512/2001 http://publications.teachernet.gov.uk/eOrderingDownload/DfES-0512-2001.pdf (accessed 26/11/07).

DSM-IV (2000) Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR), American Psychiatric Association.

Geary D.C. (2004) Mathematics and Learning Disabilities, Journal of Learning Disabilities vol 37 (1) pp4-15.

Kosc, L. (1974) DevelopmentalDyscalculia Journal of Learning Disabilities, 7(3), p164-177.

National Center for Learning Disabilities (2009) Dyscalculia http://www.ncld.org/content/view/463/456174 (accessed 26/11/09).

Trott C. and Beacham N. (2010) DysCalculiUM: a first-line screening tool for dyscalculia, Iansyst/Tribal, https://dyscalculia.advancelearningzone.com/ (accessed 11/4/2011).