# Chapter 15 : The neurodiverse mathematics student

**Clare Trott**

## Abstract

There is an increasingly diverse population of students entering mathematics courses in higher education. While this enriches the environment it can bring challenges that higher education institutions need to address. This chapter will introduce the idea of neurodiversity and provide further details about four of these: dyslexia, dyspraxia, Asperger's syndrome and attention deficit hyperactivity disorder. The main focus of the chapter will be to consider the impact for neurodiverse students of four factors in undergraduate mathematics: notes, lectures, assessment and departmental provision. The chapter will explore the barriers that higher education institutions often pose for the neurodiverse student and suggest ways in which mathematics can be made more accessible and departments achieve greater inclusivity. The discussions are illuminated through vignettes of individual neurodiverse students and their journey through mathematics.

## The legal context

In the U.K. the Disability Discrimination Act (DDA) (1995, 2001, 2005) made provision for Employment, Goods and Services, and Post 16 Education. According to the DDA, it is illegal to discriminate on the grounds of disability. It is mandatory for public sector bodies to identify how they will eliminate discriminatory barriers as well as how they will promote positive attitudes towards disability. The Act specified that:

> *"A person has a disability … if he has a physical or mental impairment, which has a substantial and long-term adverse effect on his ability to carry out normal day-to-day activities."*
>
> DDA (1995:1.1)

> *"It is unlawful for the body responsible for an educational institution to discriminate against a disabled student in the student services it provides, or offers to provide."*
>
> DDA (1995:F3.28R(2))

> *"In relation to student services provided for, or offered to, students by it, disabled students are not placed at a substantial disadvantage in comparison with students who are not disabled."*
>
> DDA (1995: F5.28T(1b))

The Equality Act (2010) built upon the foundations laid down by The Special Educational Needs and Disability Act (SENDA, 2001). It covered nine 'protected characteristics' including disability. Under parts 2 and 4 (SENDA) of the DDA (carried forward in the Equality Act), it is legally required for institutions to make *"reasonable adjustments"* for disabled students to enable access to their goods and services. In addition, institutions are required to ensure disabled students are not unjustly disadvantaged and are not less favourably treated by way of reasons related to their disability. Institutions are further entrusted to put in place *"anticipatory measures"*. These might include, for example: the provision of assistive technology, adapting accommodation to meet individual needs, the provision of notes in an appropriate and accessible format or arranging alternative examination and assessment arrangements for students where required.

The legislation is designed to ensure the removal of unnecessary barriers and promote best practice for the inclusion and equality of opportunity for all. Areas to be considered fundamental to this are those such as curriculum delivery, appreciation of different learning styles and provision of a variety of teaching methods. Indeed, putting in place good *"anticipatory measures"* will pre-empt potential barriers for disabled students so that *"reasonable adjustments"* can then be implemented more readily (see also Chapter 20 which considers technology for inclusive access within the mathematical sciences).

## Terminology

Throughout this chapter, the term 'neurodiversity' (Oliver, 1990) will be used which is *"an umbrella term, for it encompasses a range of specific learning differences, including dyslexia, dyspraxia, dyscalculia, ADD, AD(H)D and Asperser's"* (Grant, 2009:35). Neurodiversity is preferred to *"Specific Learning Difficulty"* (SpLD), since it perceives learning differences as a positive statement about differentiation, rejecting the notion that differences are dysfunctional (Grant, 2009). Such a stance clearly has implications for departments and curriculum delivery since all neurodiverse students must have same level of opportunity and choice as their neurotypical peers. The term 'neurotypical' refers to the non-neurodiverse.

In the UK, Disabled Students' Allowances (DSAs) provide extra financial help to students with a disability, mental health difficulty, medical condition or specific learning difference, such as dyslexia or dyspraxia. They are designed to help meet the extra costs students can face as a result of their disability or specific learning difference. This includes specialist equipment needed for studying and a non-medical helper, such as a study support tutor (Loughborough University, 2013a). For neurodiverse students in general, specialist study support through DSA is predominantly focused on text-based material, time management and organisational skills. However, when supporting neurodiverse mathematics students it is preferable for the tutor to have some subject background since there are frequently specific issues associated with reading mathematics, writing mathematics and memory for mathematics. Mathematics study support follows the same ethos, principles and methods as the text-based specialist study skills support but focuses more on working with non-text material such as equations and proofs.

There are frequent overlaps of the neurodiversities but, in the context of this chapter, they will be considered individually. Each individual will have a unique profile of strengths and weaknesses. Trott (2013a) emphasises the importance of acknowledging and embracing the strengths and recognising and rewarding neurodiverse contributions and abilities.

## Neurodiversity

This chapter will consider four neurodiversities: dyslexia, dyspraxia, attention deficit hyperactivity disorder (AD(H)D) and Asperger's syndrome. Each will now be considered, giving indications of some of the issues involved as well as the strengths which often accompany students with these neurodiversities.

### Characteristics of dyslexia

> *"Dyslexia...mainly affects the development of literacy and language related skills. It is characterised by difficulties with phonological processing, rapid naming, working memory, processing speed"*
>
> (British Dyslexia Association, 2010).

In particular, working memory acts as an information-processing unit essential to learning particularly in conventional educational settings (McLoughlin, Leather & Stringer, 2002). The Singleton Report (1999) notes some of the issues resulting from dyslexia include reading, retaining the meaning of text, difficulty gathering learned facts effectively in examinations as well as disjointed written work or omission of words. However, the report also highlights *"distinctive talents"*.

Cooper (2006) notes that dyslexic people are likely to think more visually while neuro-typicals would be more likely to think verbally. A dyslexic student might therefore approach a problem from a more visual perspective, make atypical connections and develop new ideas (Cooper, 2009).

Trott (2013b) suggests that dyslexic students may be particularly drawn to STEM subjects, where the perception is that literacy skills are less demanding. She further notes the implications of the dyslexic strengths and weaknesses for mathematics, a logical and analytical system with hierarchical structures.

### Characteristics of dyspraxia (Developmental Co-ordination Disorder, DCD)

> *"Dyspraxia affects the planning of what you do and how you do it. It is associated with problems of perception, language and thought."*
>
> (Dyspraxia Foundation, 2008).

Drew (2009) reports that as a consequence, the dyspraxic student is likely to spend longer on work and sometimes not hand it in on time. They may struggle to keep up in lectures and struggle to arrive in time. Issues with memory will result in slower retrieval of information especially when placed in a more stressful situation such as a test or examination. Further issues may arise in holding a plan in the working memory while executing it (Drew, 2009). This will have implications for longer problem solutions in mathematics.

Dyspraxia is associated with inattentiveness and disorientation, together with 'messy' work and issues with illegible handwriting, typing and mouse control. This can sometimes be similar to dysgraphia, which is characterised by difficulties in writing (Nicolson & Fawcett, 2011). With reference to mathematics, Drew (2009) notes a tendency to reverse or mistype numbers, signs or decimal points as well as issues with drawing and spatial awareness, such as drawing tables and graphs. On numerous occasions in undergraduate mathematics, sketch graphs are given or expected to be produced by the student.

In contrast to the above, Drew (2009) describes the strengths that dyspraxic students bring to higher education. These strengths include persistence coupled with a strong determination to succeed. They are hard-working and highly motivated. As original thinkers, working 'outside the box' will often lead them to more creative solutions and imaginative answers to problems (Drew, 2009).

**Characteristics of Asperger's syndrome**

> *Asperger's syndrome is a form of autism. It is mainly characterised in three ways: communication, flexibility of thought and the social environment.*
>
> (Martin, 2009).

With regard to communication, Martin (2009:159) contends there is a *"need for order and clarity"* so that institutions communicate meaning with exactness and precision. Students with Asperger's can find it more difficult to follow social conventions, so that they may appear to invade someone's personal space or interrupt at a seemingly inappropriate moment. They may not be able to read and interpret facial expressions or emotions. The National Autistic Society (2013) emphasise the need to keep sentences short and be clear and concise. This is essential when giving instructions at both an academic and everyday level.

Martin (2009:160) emphasises the importance of *"a level of flexibility around the way services are delivered"*. Asperger's students may be more inflexible in their thinking than their neurotypical peers and adhere to a routine. Adaptability is likely to be an issue, seeing or doing in the same way. This is likely to include Asperger's students having difficulty seeing things from another point of view and empathising with their peers.

A social environment can be difficult. The Asperger's student may also experience high sensitivity to even moderate levels of sensory stimuli and processing information from the social world can be challenging. It follows that friendships may be difficult to form as other people can seem confusing. Further, some neurotypical students may find it uncomfortable to work with Asperger's students. This can lead to further isolation.

Asperger's students can be very focused and engage whole-heartedly with their mathematics. They are likely to be logical in their thinking and can appreciate the details and complexities of mathematical arguments.

**Characteristics of Attention Deficit Hyperactivity Disorder (AD(H)D)**

AD(H)D has three key indicators: inattentiveness, hyperactivity and impulsivity. ADD is similar but without the hyperactivity indicator.

Inattentiveness or attention inconsistency (Hallowell & Ratey, 2006, cited in Colley, 2009) results in students becoming easily bored and distracted and so shifting from one incomplete task to another. Further, there may be planning or organisational barriers and a tendency to lose or forget equipment (BRAIN.HE, 2006).

> *"It is not that ADDers do not attend - they just attend to everything."*
>
> Derrington (2005)

BRAIN.HE (2006) describes hyperactivity as being restless and fidgety, frequent talking and doing several things at once. The behaviours associated with impulsivity are interrupting others and difficulty awaiting a turn in a group, often making seemingly inappropriate comments.

Colley (2009) extols the strengths of students with AD(H)D. These include: creativity and originality, being good problem-solvers since they are often able to see the 'bigger picture'. They are likely to have an ability to focus intensely for a time, have high levels of energy, be intuitive and adopt a 'risk-taking' approach that can lead to important discoveries (BRAIN.HE, 2006).

## How to foster equity

This section focuses upon the ways in which barriers faced by neurodiverse students in mathematics can be addressed. Four areas will be considered: notes, lectures, assessment and departmental provision.

**Notes**

It is essential that neurodiverse students have access to lecture notes. It is good practice for these to be available in advance of the lecture. In particular, dyslexic or dyspraxic students will frequently struggle to read notes which are seen for the first time in a lecture. The expected reading speed of students in lectures is usually determined as that which is representative of their neurotypical peers. Furthermore, the neurodiverse student will need longer to process the information presented in the notes. It is not merely an issue of reading comprehension. Obtaining mathematical meaning from the text requires the different variables to be recognised, become related to each other and to, as yet, unknown data or further variables. Thus, more time is required to both read and process notes.

Many neurodiverse students will find writing notes difficult, both in terms of the handwriting and also the speed of writing. This is particularly relevant to both dyslexic and dyspraxic students. If required to take notes, they are likely to have many gaps and become increasingly illegible. Providing a neurodiverse student with full notes in advance of a lecture will enable them to read these in advance and keep pace with the class. It will also enable the student to listen more attentively, process the information, and avoid the struggle to write their own notes. In the same way, an AD(H)D student may also have gaps in their notes as a result of inconsistencies in attention during lectures. Providing notes will ensure the neurodiverse student has a full and useful set to work or revise from. If different solutions to the same problem are possible, then these should also be provided as many neurodiverse students see a problem in different ways.

> As a first year dyslexic mathematics student, Adam found it extremely difficult to take notes in his classes. He frequently missed out large sections. In a tutorial Adam found it impossible to keep pace with the problems and solutions discussed. When alternatives were offered he found this useful but when the solutions appeared electronically sometimes several days or weeks after the tutorial, only one version of a solution was given.

Neurodiverse students often experience visual stress when reading. Wilkins (1995) defined visual stress as the inability to see comfortably without distortion and discomfort. It affects approximately 12% of the general population but around 65% of people with dyslexia (Evans 2002). The result is that the text may appear to move around or appear to fall off the end of the page, making it difficult to access the material. However, there are a number of ways in which material can be presented in order to minimise visual stress. Such ways include changing the colour of the background or the font, altering the font size or font to a sans-serif font that is easier to read, increasing the line spacing and not justifying text which causes irregularity in the gaps between words. The exact specification of these factors will vary from student to student and be an individual preference. For example, one student may have a blue colour preference, experiencing less visual stress when using a blue overlay or blue background. A second student may find that green gives the same effect for them.

It is therefore important that electronic versions of all notes and handouts are made available to students and not as pdf documents. Pdfs create a barrier to making documents more accessible, particularly in terms of the ability to manipulate those features that help to reduce visual stress.

The organisation of the content of notes can also provide greater accessibility. Neurodiverse students need a well-defined structure with a logical flow through the material. It is important that diagrams, tables and charts are placed in the correct position in relation to the words in the text that link to the diagram and should be clearly labelled. Furthermore, if the notes are organised into manageable parts, they become more accessible to students with reading and processing issues. The use of a bullet point format is useful. Appropriate headings create greater clarity too. Such features enable the dyslexic or dyspraxic student to access the material more easily and also aid an AD(H)D student to focus their attention and aid concentration. The headings could be, for example, Definition, Theorem, Proof, Explanation, Limitations, Key Points and Worked Example.

The notes should always give clear definitions of all notation and terms used. Providing a separate list is particularly useful as a reference point for the neurodiverse student who may experience issues with working memory and need to more frequently check the meaning of each variable used.

Michael Faraday, who was believed to have had dyslexic tendencies, in 1851 wrote:

> *"Mathematical formulae, more than anything else, require quickness and surety in receiving and retaining the true value of the symbols, and when one has to look back at every moment to the beginning of a paper, to see what H or A or B mean, there is no making way. Still, though I cannot hold the whole train of reasoning in my mind at once, I am able fully to appreciate the value of the results..."*
>
> West (1991:107)

The provision of full notes ahead of lectures for the neurodiverse student is therefore an essential requirement. Considerable opposition is voiced in some communities, who postulate that such a provision would result in students not attending lectures and thereby missing further information. One solution suggested by Linehan (2012) is to provide neurodiverse students each with a memory stick containing a few weeks worth of notes. Regardless of the means, for the neurodiverse student the availability of notes that can be transformed into an accessible format (for technical and practical considerations regarding accessible formats see Chapter 20) means they can attend lectures and engage with the material in a more meaningful way.

**Lectures**

Another essential aspect to consider is the degree to which lectures are accessible to neurodiverse students. In the same way that notes allow the student to prepare, it is important for the neurodiverse student to know what the pre-requisite mathematics is so that they can recap these aspects. Retrieval of information from previous modules or from earlier in the current course may be an issue for some dyslexic and dyspraxic students who are likely to have issues with memory. By providing the opportunity to revise the required topics, the student will be more fully prepared. It is further recommended that in-built and frequent recaps will enable the student to fully assimilate material.

If material relates to real and practical scenarios, the neurodiverse student is likely to relate to it in a more tangible way. Dyslexics have strong visual memory and are readily able to visualise situations, often seeing solutions in their mind. They tend to be holistic rather than sequential in their approach. Cooper (2006) found that 80% of dyslexics preferred to solve problems in a visual way, as did 55% of non-dyslexics:

> *"...what should we do with students for whom the easy things are hard and the hard things are easy – those who naturally jump to the end and skip over the beginning, those who jump to the world of intuitive images without having mastered the basic elementary steps?"*
>
> West (1991:241)

---

Tom, a second year dyslexic student studying mathematics and physics, was able to visualise second order partial differential equations such as the heat equation in terms of real physics-based problems and the practical experiences and phenomena that he has observed in the lab. This helped him to 'see' the problem and more fully realise the mathematics. Tom used this visualisation at each step in the mathematical solution, ensuring it made sense to him.

---

It is recommended that non-linear formatting be employed whenever possible. This could include a tree diagram for partial differentiation (Trott, 2006a). Although accepting that mathematics essentially requires the development of a linear argument, a longer problem solution places a substantial load on the working memory since it is necessary to retain and manipulate several intermediate outcomes in order to achieve a final solution (Trott, 2003). This will discriminate against students with weaker working memories. As McLoughlin (2001:124) states: *"An inefficient working memory system will clearly undermine skill acquisition and learning…"*.

Information presented in bullet point format enables the dyslexic student to *"keep in mind the steps of a procedure and follow it"* (Meehan, 2010:47). Further, Cooper (2009) maintains:

> *"…assuming that everyone can take in and remember sequences of information (particularly auditory information) is disabling and entirely unnecessary. The point is to understand and use, not to remember."*
>
> Cooper (2009:70)

Colley (2009), writing in the context of AD(H)D, recommends providing videos of lectures. This allows the student to assimilate the material in smaller sections and focus on each part. It provides an aid to concentration.

Clear and unambiguous lectures are supportive for neurodiverse students, particularly for Asperger's students, who prefer *"clarity, predictability, logical explanations and tangible expectations"* (Martin, Beardon, Hodge, Goodley & Madriaga, 2008:10). This is because they *"contribute to security and underpin conditions for success"* (Martin et. al., 2008:10). Indeed such factors may be considered intrinsic to the subject of mathematics itself, although in practice, the teaching may not always concur.

A statement or slide at the beginning outlining the order of what is to follow is helpful as is a summary of the main points at the end. Further, the use of colour can greatly enhance the lecture, enabling the neurodiverse student to bring together those aspects that are similar. For example, coding the same variable in the same colour whenever it is met or using a colour for a frequently repeating equation or step can be helpful. The use of colour needs to be consistent throughout the module. Again, this will ease the load on the working memory for neurodiverse students.

In addition, the provision of a module or course glossary containing all new technical words together with their definitions, the notation used and its definition (particularly Greek characters) is good practice: for example the frequency, amplitude and period of a wave with its associated variable. Reducing the burden and the anxiety of having to recall this information will free-up working memory since anxieties deplete working memory resources (Beilock, 2008). This will then contribute to the student achieving their potential.

Alongside the lectures, the module is likely to have a recommended course textbook. Given the issues some neurodiverse students experience with reading, it is important that the chosen text not only fulfils the mathematical requirements but also presents a clear layout. It is often the case that mathematical textbooks intersperse text with non-text, both algebraic notation and calculations. Diagrams are frequently positioned out of sequence, perhaps on another page and have their own individual subtext in italic, smaller or different font. It is this irregularity that makes it difficult for the dyslexic student to access the material (Henderson, 2012). Trott, (2012) states:

> *"Examples are often worked out in the middle of information or text on how to complete the calculation, so that if you have trouble reading the connecting text you may ignore both the text and the example."*
>
> Trott (2012:25)

---

…a very able dyslexic mathematics student with a strong visual memory and a high level of numerical competence. However, she was a significantly slower reader compared to her peers and her reading was also very inaccurate. During reading she frequently lost her place, repeating or skipping lines. A specific issue for Kate was the use of a course textbook.
For example, half way down a page the text referred to a figure that was on the following page, or even a couple of pages further on. Turning over to study the required figure, Kate was unlikely to return to the point where the text had left off. The chapter was therefore rendered meaningless.

---

Finally in relation to lectures, Cooper (2009) states:

> *"Listening to long explanations is extremely difficult for most dyslexics who usually experience lectures as a poor form of education."*
>
> Cooper (2009:68)

**Assessment**

For the majority of mathematics modules within higher education it is still the case that assessment is predominantly, and sometimes exclusively, by formal examination (Iannone & Simpson, 2012). A piece of coursework worth only 10% of the module is, at best, notional. A well-constructed piece of investigative coursework may allow the neurodiverse student to develop their own ideas outside of the constraints of the examination and demonstrate their underlying mathematical ability. However, its credit-bearing tariff means that, within the full picture, it is a minimal contribution.

All too often, coursework for mathematics modules is a class test akin to a mini examination or a computer assistive assessment. The latter, and sometimes the former, are marked solely on the accuracy of the answer submitted. These forms of assessment are likely to disadvantage neurodiverse students. In transferring from one medium to another, such as from the calculator to the test paper or screen, a dyslexic or dyspraxic student may struggle to copy correctly or may reverse digits (Trott, 2003). For AD(H)D students, Colley (2009:173) commented *"because focusing on a selected task will be hard, they will tend to make so-called 'careless' mistakes"*.

The main assessment tool remains the examination (Iannone & Simpson, 2012). It is pertinent to consider how far currently set papers reflect the intended learning outcomes of the module and how far they enable neurodiverse students to display their true mathematical ability. Learning by rote and recall from memory are precisely those areas in which neurodiverse students are known to struggle.

Trott (2012) says:

> *"Definitions and theorems feature in many examination papers, often requiring students to state a particular definition or theorem, before going on to reason a proof. When statements of definitions or theorems (without proof) are assessed, it is a test of rote recall."*
>
> Trott (2012:27)

And continues:

> *"While it is accepted that certain definitions and theorems are of prime importance, their rote learning appears to place at a disadvantage those students who find such learning difficult, but who fully comprehend the mathematics and who can develop the proof and utilise it appropriately."*
>
> Trott (2012:27)

Indeed, without the recall of the theorem, a proof cannot be reasoned. Thus incurring a double penalty. Indeed as Rob, a second year dyslexic mathematics student noted in 2006:

> *"There are about 60 theorems in this module, I cannot learn them!"*
>
> Trott (2013b)

Rob is far from unique. John was another second year dyslexic student studying mathematics and accounting.

---

John's mathematical ideas, his engagement with his subjects and insight in problem solving were particularly exceptional and he had the ability to comprehend mathematical concepts easily. However, his retrieval from memory was particularly weak. He was repeatedly frustrated by examination questions that required him to state a definition or recall a formula that was not given in the standard student booklet provided. Consequently his marks did not reflect his ability.

---

John was however able to access the meaning of questions that many dyslexic students find difficult due the wordiness of the context in which the mathematics is embedded. Such questions are more frequent in statistics and probability modules. Often the context contains irrelevant or spurious information that simply increases the load on the dyslexic reader. For an AD(H)D student, such irrelevancies can act as internal stimuli that are a distraction resulting in loss of focus (Colley, 2009).

Clear instructions regarding coursework are essential. Setting and hand-in dates should be clearly stated and adhered to. Martin (2009:159), referring to Asperger's, comments *"specificity regarding assignments may need to include detailed instruction about the process, as well as the desired outcome. Lack of clarity can cause anxiety"*.

---

John was holistic in his approach to problem solving. The issue was not how to solve a problem but rather how to document this in a way that conveyed meaning to the marker.

---

However, in contrast, Colley (2009) noted that some AD(H)D students may prefer examinations to coursework, which they may struggle to prioritise and organise in order to hit deadlines.

As mentioned above, it is far from good practice to award marks on the basis of answers only, but it is equally good practice to consider less well documented solutions. This may include mathematical arguments that may be less sequentially ordered or that skip over an expected step. Other issues arise in the marking of work presented by neurodiverse students, particularly with reference to copying and transcription errors as well as issues of the neat alignment of mathematical arguments. It can be argued that the essential meaning should remain clear, as is the case with a spelling error in an essay. Another way forward is to consider the question itself and try to introduce intermediate results of the form *"show that..."*. This result can then be used in subsequent parts of the question. This will act as a checkpoint for the student who has made a copying or transcription error.

---

Karl was a dyspraxic mathematics student in his first year of undergraduate study. His difficulties were particularly associated with handwriting and alignment. He used a computer for his assessments. However, his thinking processes and working out were paper-based and frequently illegible. Through his learning support tutor he was introduced to the idea of using squared paper with large squares for his digits or characters. This enabled Karl to line up his work in a more orderly manner. Matrices were particularly prone to alignment errors.

---

Good feedback is also essential. The neurodiverse student may well become frustrated by a single grade or mark, without explanation. Good feedback should enable students to understand why a mark has been given and how to improve on this in future work. For a large class, it could be made clear to all students that such feedback can be given if requested. Furthermore, for some students, reading the information provided can be difficult and it is suggested that an audio recording supplement the written feedback.

Other forms of assessment should be considered. Group work can be advantageous to many students. However, students with Asperger's syndrome who may struggle with peer relationships and communication are likely to find it difficult to take an active part in these projects since the dynamics of the group situation may be unclear to them. The challenge is to integrate the student into the group. Madriaga and Goodley (2010:122) state: *"Responding to the apparent isolating affects of AS is a key concern for practitioners and researchers"*. It is also the case that dyslexic and dyspraxic students may process information in different ways and neurotypical students are often unclear in their communications within the peer group situation. This has implications for peer group work to be fully inclusive, ensuring all students are an integral part of the work of the group. Thus the neurodiverse student can feel side lined. It is recommended that departments emphasise the need for inclusive group working and, where possible, try to smooth the group work process. Cliffe and Bradshaw (2012) outline a possible framework for minimising barriers to group work (see also Chapter 13) in mathematics. Factors include: providing explicit educational rationales, providing scaffolding, using carefully designed group allocation, including group working skills as learning objectives, ensuring explicit rules of engagement, transparent and fair marking and explicit reflection.

There are several possible alternative ways to assess mathematics. These include open book examinations, a portfolio of work, a presentation, a poster or a project report. Allowing students to choose the means by which they are assessed, Symonds (2009:252) contends that *"introducing new assessment tools is not readily welcomed because they are unfamiliar, but this is not a reason to withhold the offer of choice"*. However, offering a choice of assessment method provides inclusive rather than alternative assessment (Waterfield & West, 2009). An exemplar case study (Easterbrook, Parker, & Waterfield, 2005), although drawn from engineering, provides a good model. Student choice is based on *"their own perceived strengths and weaknesses"* and this is *"a key component of making assessment inclusive"* (Waterfield & West, 2009:2; Symonds 2009:252) further states: *"Assessment should be an integral part of the creative process of pedagogy"*. With this in mind, it is essential to select more inclusive forms of assessment that satisfy the intended learning outcomes and allow all students to demonstrate their mathematical abilities. However it is noted that there are clear implications for staff input and time.

**Departmental provision**

Earlier in this chapter it was noted that the selection of course text books is important in order to facilitate clarity and aid students who find reading more challenging. Furthermore, prioritised reading lists help guide the student to organise their reading and time management since it enables them to *"target the most important sources"* (Du Pre, Gilroy & Miles, 2008:41). The prioritised reading list should also indicate the location and availability of the book or journal online or in the library. It is important to work with the institution's library so that a well illustrated guide to the departmental section of the library is available that will further help neurodiverse students who may confuse reference numbers or who experience difficulty with finding their way round or following directions.

Departmental, if not institutional, provision should also include a recommended calculators policy that takes account of visual stress. Loughborough University implemented such a policy following research by Trott (2006b). This policy specifies those calculators that not only satisfy the requirement *"two-line scientific"* but also states the models that minimise visual stress.

Many neurodiverse students find it useful to have a framework to enable them to better structure project reports or extended pieces of essay-style coursework. These are often available through university libraries (for example Loughborough University, 2013b). Grant (2009) contends that mathematics and physics can appeal to students who struggle with essay writing. Further, Cooper (2009), states that for those who think holistically there is no beginning, middle and end. Exemplar reports (Drew, 2009) are particularly helpful; they combine generic report or essay writing with more subject specific skills.

Another issue that sometimes arises is concurrent deadlines for multiple pieces of coursework and problem sheets. Time management and the organisation of these can pose issues for the neurodiverse student. With reference to AD(H)D, Colley (2009) noted problems in sustaining attention and completing routine tasks.

> Anton was a mathematics student with AD(H)D. He experienced particular issues with time management, organisation and concentration. Coping with lots of concurrent overlapping pieces was a concern as was hitting the necessary deadlines. Anton needed some reasonable adjustments in terms of spacing his pieces of coursework and support for managing deadlines.

Departmental mentoring is sometimes used to support students with similar issues to Anton, enabling the student to better prioritise work. With reference to Asperger's syndrome, Hughes, Milne, McCall, and Pepper (2010:12) state: *"Late submission of coursework can be frustrating for the academic and disastrous for the AS students if it is not recognised early enough"*. They go on to suggest a mentor can be of benefit in helping the student to manage deadlines. The mentor provides a means for greater engagement with their studies.

It has already been seen how valuable it is to provide the student with a list or booklet containing all necessary formulae, theorems, technical terms, notation, standardised measures and a glossary of terms used throughout the course, as in the case of John discussed earlier. To avoid further misconceptions and confusion, it is advantageous to consider a standardisation of notation across a department. John encountered a variety of notation throughout his course. Often different notation was used to represent the same concept in separate modules. When recall of notation from memory is profoundly difficult within the constraints of one module, the enormity of this across a whole course becomes apparent.

Transitions into higher education and from higher education into the workplace can be difficult for neurotypical students. Therefore it follows that neurodiverse students will benefit from the implementation of policies and initiatives to help smooth the pathways. Martin (2009) emphasised the inappropriateness of some high stimulus fresher activities for Asperger's syndrome students. The provision of a quiet and low stimulus space is essential during induction week and beyond. This would also be beneficial to some AD(H)D students who experience distraction in multi-stimuli environments. Resources that aim to ease transitions include a series of videos to enable Asperger's students to experience a more rewarding transition into higher education (Hughes, Darwen, & Coleman, 2013). Such an initiative from The Department of Physics at the University of Manchester seeks to lay inclusive foundations.

Departments of Mathematics can often provide a supportive learning environment for the neurodiverse student. A well informed designated member of staff acting as a departmental disability co-ordinator will provide a central point of contact for the student and enable any ensuing issues to be managed in a timely and effective manner, liaising between the support services, academic colleagues and students. The department as a whole should be a place where neurodiverse students are welcomed and supported at all times:

> *"…learning support is an intrinsic part of teaching and if teaching/assessment methods do not anticipate the diversity of learning styles and stances and are therefore not supportive of learning then any changes may need to start with those methods…"*
>
> Herrington (2001:172)

## Checklist

From the points raised in this chapter, a checklist has been formed (Table 1). These can be addressed at both the individual and the departmental level. When using the checklist, try to focus on each point and consider how far this aspect of good practice is currently achieved and what measures could be put in place to make the environment more inclusive for the neurodiverse student.

| **Notes: Do you…** | Yes | No |
|---|---|---|
| Provide full notes? | | |
| Offer alternative routes/solutions where possible? | | |
| Provide electronically available notes/handouts ? | | |
| Provide accessible format, for example not pdf? | | |
| Give well-structured and logical notes? | | |
| Have clearly labelled diagrams in correct position? | | |
| Use bullet points where possible? | | |
| Use clear headings throughout? | | |
| Provide definitions of all notation and terms used? | | |
| **Lectures: Do you…** | | |
| Provide a list of pre-requisite mathematics? | | |
| Build in frequent recaps? | | |
| Use real and practical scenarios where possible? | | |
| Employ non-linear mind-maps or similar? | | |
| Have video recordings of lectures? | | |
| State the aims and summarise key points? | | |
| Use consistent colour where possible? | | |
| Provide a glossary of all notation and terms used? | | |
| Recommend a text book with a clear layout? | | |
| **Assessment: Do you…** | | |
| Give due weighting to coursework other than tests/examinations? | | |
| Not use answer only coursework? | | |
| Write exam papers so that rote recall is not required? | | |
| Consider the 'wordiness' of questions? | | |
| Give clear instructions for coursework, including hand-in? | | |

| | | |
|---|---|---|
| Provide feedback as an audio recording when requested? | | |
| Offer a range of assessment to demonstrate ability? | | |
| Try to remove barriers to group work for neurodiverse students? | | |
| **Departmental Provision: Do you…** | | |
| Prioritise reading lists? | | |
| Have a departmental guide to your section of the library? | | |
| Have departmental exemplars to guide essay-style work? | | |
| Have a departmental calculator policy with advice for dyslexic learners? | | |
| Have a departmental policy to ensure notation consistency? | | |
| Provide departmental initiatives to aid the transition to higher education? | | |
| Have a designated departmental disability co-ordinator? | | |

**Table 1: A checklist for supporting the neurodiverse learner.**

## Concluding remarks

There is little doubt that an increasing number of neurodiverse students are now enrolling on undergraduate degree courses. This chapter has endeavoured to describe four common neurodiversities and some consequential transitional issues for neurodiverse students as they enter university. Consideration of points raised in this Chapter and the accompanying checklist will enable both new and experienced mathematics lecturers to adopt good practice in support of such students both at an individual and departmental level.

## References

Beilock S.L. (2008) 'Math performance in stressful situations', *Current Directions in Psychological Science*, 17, pp339 – 343.

BRAIN.HE (2006) 'Information for staff on Attention Deficit (Hyperactivity) Disorder (ADHD)'. [Online] BRAIN.HE. Available at http://www.brainhe.com/students/types/ADHDstaff.html (accessed 14 February 2014).

British Dyslexia Association (2010) 'Dyslexia Research Information'. [Online] British Dyslexia Association. Available at http://www.bdadyslexia.org.uk/about-dyslexia/further-information/dyslexia-research-information-.html (accessed 14 February 2014).

Cliffe, E. & Bradshaw, N. (2012) 'Autism Spectrum Disorders and Group Work in Mathematics', in Robinson, C. (Ed.) *Student-centred approaches in Mathematics: Case Studies of Innovative Practice*. Birmingham, UK: National HE STEM Programme and Maths, Stats & OR Network, pp45-47.

Colley, M. (2009) 'Attention Deficit (Hyperactivity) Disorder – AD(H)D', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp169-194.

Cooper, R. (2009) 'Dyslexia', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp63-89.

Cooper, R. (2006) 'Making learning styles meaningful', *Patoss Bulletin*, 19 (1), pp58-63.

Derrington, C. (2005) 'Learning Support for Students With AD(H)D', in Pollak, D. (Ed.) *Neurodiversity in FE and HE, Positive Initiatives for Specific Learning Differences: Proceedings of Two One-day Conferences*. Leicester, UK: De Montfort University.

Disability Discrimination Act (1995) London, UK: HMSO.

Drew, S. (2009) 'Dyspraxia', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp91-123.

Du Pre, E., Gilroy, D. & Miles, T. (2008) *Dyslexia at College*. Abingdon, UK: Routledge.

Dyspraxia Foundation (2008) 'Definition of dyspraxia'. [Online] Dyspraxia Foundation. Available at www.dyspraxiafoundation.org.uk (accessed 14 February 2014).

Easterbrook, D., Parker, M. & Waterfield, J. (2005) 'Higher Education Academy Engineering Subject Centre Assessment Choice Case Study'. [Online] University of Plymouth. Available at http://www.plymouth.ac.uk/files/extranet/docs/SWA/LTSN%20CS.pdf (accessed 14 February 2014).

Evans, B. (2002) *Dyslexia & Vision*. London, UK: Whurr.

Grant, D. (2009) 'The Psychological Assessment of Neurodiversity', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp33-62.

Hallowell, E.M. & Ratey, J. (2006) *Delivered from Distraction: Getting the most out of life with Attention Deficit Disorder*. New York, USA: Ballantine Books.

Henderson, A. (2012) *Dyslexia, Dyscalculia and Mathematics: A practical guide*. London, UK: Routledge.

Herrington, M. (2001) 'An approach to specialist learning support in higher education', in Hunter-Carsch, M. & Herrington, M. (Eds.) *Dyslexia and Effective Learning in Secondary & Tertiary Education*. London, UK: Whurr, pp170-192.

Hughes, M., Darwen, N., & Coleman, B. (2013) *'Induction Videos for Students with Asperger's Syndrome'*. Supporting disabled students in STEM - STEM disability committee spring conference, London, UK, February 2013.

Hughes M., Milne, V., McCall, A. & Pepper, S. (2010) *Supporting Students with Asperger's Syndrome - A physical sciences practical guide*. Hull, UK: UK Physical Sciences Centre.

Iannone, P. & Simpson, A. (2012) *Mapping University Mathematics Assessment Practices*. Birmingham, UK: National HE STEM Programme and Maths, Stats & OR Network.

Linehan, K. (2012) 'Supporting students with dyslexia studying Biomedical Science'. Supporting Bioscience Students with Dyslexia and Dyscalculia workshop, Derby, UK, June 2012.

Loughborough University (2013a) 'Disabled Student Allowance', Loughborough University Counselling and Disability Service. [Online] Loughborough University. Available at http://www.lboro.ac.uk/services/cds/disability/dsa/ (accessed 14 February 2014).

Loughborough University (2013b): 'Report Writing', Loughborough University Library. [Online] Loughborough University. Available at http://www.lboro.ac.uk/media/wwwlboroacuk/content/library/downloads/advicesheets/report%20writing.pdf (accessed 14 February 2014).

Madriaga, M. & Goodley, D. (2010) 'Moving beyond the minimum: socially just pedagogies and Asperger's syndrome in UK higher education', *International Journal of Inclusive Education*, 14(2), pp115-131.

Martin, N. (2009) 'Asperger's syndrome: empathy is a two-way street', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp149-168.

Martin, N., Beardon, L., Hodge, N., Goodley, D. & Madriaga, M. (2008) 'Towards an inclusive environment for university students who have Asperger syndrome (AS)', *The Journal of Inclusive Practice in Further and Higher Education*, 1(1), pp3-14.

McLoughlin, D. (2001) 'Adult dyslexia: assessment, counselling and training', in Hunter-Carsch, M. & Herrington, M. (Eds.) *Dyslexia and Effective Learning in Secondary & Tertiary Education*. London, UK: Whurr, pp121-126.

McLoughlin, D., Leather, C. & Stringer, P. (2002) *The Adult Dyslexic: Interventions and outcomes*. London, UK: Whurr.

Meehan, M. (2010) 'Dyslexia-friendly laboratory and benchwork', in Pavey, B, Meehan, M. & Waugh, A. (Eds.) *Dyslexia-Friendly Further & Higher Education*. London, UK: Sage, pp46-55.

National Autistic Society (2013) 'What is Aperger Syndrome?'. [Online] National Autistic Society. Available at http://www.autism.org.uk/about-autism/autism-and-asperger-syndrome-an-introduction/what-is-asperger-syndrome.aspx (accessed 14 February 2014).

Nicolson, R. & Fawcett, A. (2011) 'Dyslexia, dysgraphia, procedural learning and the cerebellum', *Cortex*, 47(1), pp117-127.

Oliver, M. (1990) *The Politics of Disablement*. Basingstoke, UK: Macmillan.

Singleton, C. (1999) *Dyslexia in Higher Education: Policy, provision and practice (The report of the Working Party on Dyslexia in Higher Education)*, Hull, UK: University of Hull.

Symonds, H. (2009) 'Teaching, learning and Assessment: 'it's not like you think'', in Pollak, D. (Ed.) *Neurodiversity in Higher Education: Positive Responses to Specific Learning Differences*. Chichester, UK: Wiley and Sons, pp243-268.

Trott, C. (2013a) *Supporting STEM students with dyslexia: A good practice guide for academic staff*. London, UK: The Institute of Physics.

Trott, C. (2013b) '*Supporting Dyslexic STEM Students*'. STEM Disability Transition Group Conference: Moving up, moving on, London, UK, July 2013.

Linehan, K. (2012) 'Supporting students with dyslexia studying Biomedical Science'. Supporting Bioscience Students with Dyslexia and Dyscalculia workshop, Derby, UK, June 2012.

Trott, C. (2012) 'Mathematics, dyslexia, and accessibility', in Cliffe, E. and Rowlett, P. (Eds.) *Good Practice on Inclusive Curricula in the Mathematical Sciences*, Birmingham, UK: National HE STEM Programme and Maths, Stats & OR Network, pp25-28.

Trott, C. (2006a) 'Mathematics and Neurodiversity', in Green, D.R. (Ed.) *Proceedings of the CETL-MSOR Conference 2006*. Birmingham, UK: Maths Stats & OR Network, pp161-166.

Trott, C. (2006b) 'The Difficulties Dyslexic Students Experience Using Calculators', DDIG Conference 2006, Loughborough, UK, April 2006.

Trott, C. (2003) 'Mathematics Support for Dyslexic Students', in Lawson, D.A., Croft, A.C., & Halpin, M. *Good Practice in the Provision of Mathematics Support Centres* (2nd edition). Birmingham, UK: Maths, Stats & OR Network, pp22-28.

Waterfield, J. & West, B. (2009) 'Inclusive Practice E-bulletin Series: Inclusive Assessment'. [Online] Higher Education Academy. Available at http://www.heacademy.ac.uk/assets/documents/subjects/psychology/8-part-Inclusive_Assessmentv3.pdf (accessed 14 February 2014).

West, T. (1991) *In The Mind's Eye*. New York, USA: Prometheus.

Wilkins, A.J. (1995) *Visual Stress*. Oxford, UK: Oxford University Press.