Supporting Students with Maths Impairment in Higher Education

Abstract

This paper follows on from David Grant's paper. Grant's paper (ibid) asserts that assessment should be for intervention. Here, an overview of some possible interventions for students with dyscalculia or maths impairment is presented. The paper seeks to highlight issues and offer suggestions. It discusses some reasonable adjustments and then focuses on numerical issues in number (both integer and non-integer), operations, algebra, statistics and time and money, offering some ideas for appropriate interventions. Numeracy permeates both academic programmes and everyday life. For the student with dyscalculia or maths impairment, there is a need for support that addresses the issues and helps overcome the barriers.

Introduction

In his paper, Grant describes maths impairment and dyscalculia. He notes the importance of having a sense of number. If a student does not have a sense of number, then maths impairment or dyscalculia is a highly likely outcome. Chinn (2006, p. 16) agrees: "A lack of a true comprehension or understanding of maths will be a key characteristic of dyscalculic people."

Dyscalculia and maths impairment can pose many difficulties for students. Those who reach Higher Education (H.E.) have achieved much; They will have overcome difficulties in school and everyday life. They may have been embarrassed or belittled in class and been considered ‘stupid’ (Trott, 2015, p. 412). Although, it is often seen as acceptable to be poor at mathematics, as opposed to poor reading, it can be demoralising to have weak maths skills and struggle academically and in everyday life. If their H.E. course contains mathematics or statistics, they may require some reasonable adjustments in order to progress and succeed.

Reasonable Adjustments

Such reasonable adjustments may include extra time in exams, one-to-one support sessions to help go through mathematics at a slower pace, use of squared or coloured paper and perhaps the use of a calculator; the latter being for non-numeracy examinations and everyday usage. Drew (2016, p. 228) found that one-to-one support was “overwhelmingly endorsed” by all the dyscalculic students in his sample. Trott (2015, p. 411) states that one-to-one study skills support for dyslexic students is commonplace in HE; however, similar provision for dyscalculic students is not often available. Furthermore, Trott (2015, p. 411) contends that this specialist support should be an essential part of what an HEI offers. Several Higher Education Institutions (HEIs) have Mathematics Support Centres that offer support to any student on a drop-in basis, but dyscalculic students and those with maths impairment need one-to-one support so that the sessions can be individualised for each student’s needs. This enables the sessions to move at the student’s own pace and aids understanding (Trott, 2009, p. 143). She warns that making an initial approach can be the cause of much anxiety and embarrassment for those students who really struggle.

Mann et al. (2015, p. 124) promote the idea of learning experientially using practical multisensory situations. They state that multisensory approaches with the help of manipulatives (practical equipment, such as Cuisenaire rods) aid students in transitioning from the concrete to the abstract (Mann et al., 2015, p. 126). Hornigold (2017, p. 112) agrees that teaching in a multisensory manner that uses aural, visual and kinaesthetic ways will aid understanding. Chinn (2004, p. 17) emphasises the point that the choice of manipulatives is important and this will be dependent on the concept that is the focus of the session as well as the learner's needs and preferences. In parallel with a hands-on approach, Hornigold (2017, p. 112) suggests that visual strategies to aid learning should include the use of colour to highlight key information, enlarging key numbers for emphasis and mind maps to see the mathematical connections and relationships. Indeed, colour can be very effective if each operation or each variable is displayed in a different colour. For example: Multiplication could always be in blue and division always in green. However, this needs to be consistent throughout to give emphasis to each variable or operation and distinguish it from the others.

Support

Number

Dyscalculic students or those with maths impairment will have difficulties at a fundamental level. This could include having a weaker innate sense of number, referred to as numerosity or sense of number. In order to succeed in mathematics, students need to have an understanding of numbers, their inter-relationships and how they can be manipulated. Poor number sense can lead to difficulties with place value, the number system and non-integer numbers such as fractions or decimals. Chinn (2015, p. 8) contends that a poor understanding of the number system will have far-reaching consequences. Such difficulties include distinguishing between hundreds, tens and ones and with naming numbers. Students may struggle to name longer, larger numbers such as those with two, three or four digits. Additionally, Drew (2016, p. 178) notes that some dyscalculic students have difficulty enumerating the number of zeroes in numbers such as 10, 100, 1000 and that students have to physically count them.

Drew (2016, p. 178) states that difficulty in counting is an example of a fundamental issue that is indicative of dyscalculia. Drew cites one student who used her fingers for counting but was then unable to recognise the number of fingers raised. Drew includes not only sequential counting, but also counting in intervals greater than one (e.g. 2,4,6… or 3,6,9…) and counting backwards. In his sample, Drew (2016, p 176) quotes from one dyscalculic student who could count up to about twenty and then "stumbled with the numbers." He concluded that counting goes beyond a simple recall of number words, and requires a conceptual understanding of a number system. Students also need to have a correct mental number line and be able to place numbers correctly on the line. Some students with dyscalculia or maths impairment will have insecure mental number lines. Practice in activities such as counting in different intervals, perhaps using coins such as 5p's or physically placing numbers on a number line (see figure 1), can help to aid understanding.

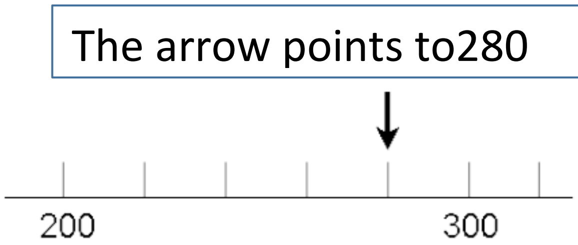

Figure 1: placing numbers on a number line

Furthermore, as Grant (Ibid) notes these skills are essential for correctly comparing numerical values. Sometimes, it is helpful to focus on comparative phrases such as: more than, less than, is smaller than, is greater than. Drew (2016, p. 171) notes that some of the students in his sample struggled with four digit numbers and considered all such numbers as "large", while one student commented: "I could sit there and count the digits, but just from looking, I would not notice that" (Drew 2016 p. 171).

Fractions, Decimals and Percentages

An even greater challenge is presented by non-integer numbers. The difficulties presented with whole numbers escalates. Fractions are the least understood. Trott (2009, p. 130) cites one student, ‘Kate’, who struggled to understand fractions. ‘Kate’ says: “*I couldn’t understand the concept of the number between nought and one, I couldn’t understand the fractions.*” Dyscalculic students and those with maths impairment nearly all struggle with the concept of fractions, although some will have a familiarity with a half or even a quarter. The use of manipulatives and fraction diagrams (see figure 2) can help students conceptualise fractions but it is likely to be a slow route to understanding. Chinn (2004, p. 44) notes that fractions incorporate a disguised division sign that separates the numerator from the denominator. Chinn also highlights the language of fractions as challenging. For example: “four fifths” can be interpreted as four out of five or as four divided by five. All the interpretations need to be comprehended and related together. In support sessions students will need practice with naming and writing fractions. Furthermore, the relationships between fractions needs to be understood. This may include the concept of equivalent fractions as well as operations with fractions. Some dyscalculics may never come to fully understand fractions but practice with fraction diagrams and cut out fractional sections can help. It can be useful to overlap, for example, half a strip with two quarters of the same strip (see figure 2).

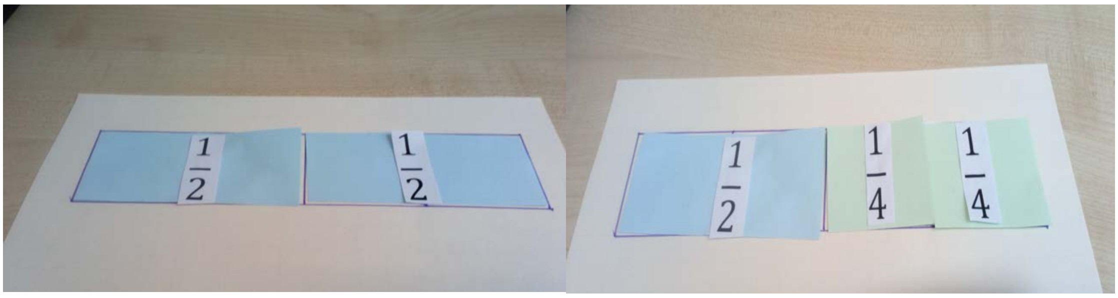

Figure 2: fraction diagram showing 1/2 = 2/4 with cards

An alternative is circles (or ‘pizza’) that can be divided up into fractional proportions. Paper plates are helpful for this. Decimals can also pose some issues for dyscalculic students or those with maths impairment. A popular misconception is that the number of digits after the decimal point is indicative of the size of the number. One example of this is apparent in social sciences or in psychology where students study statistics. The critical p value is 0.05, but sometimes this is given as 0.050 (such as in the output from statistical packages). For students who struggle this is frequently read as “five” and “fifty”, leading to misunderstanding in the interpretation in the results of statistical tests. Practice in the interpretation of statistical output and always using three decimal places can help to break down the barrier. A few students will be more confident with the money system and this can be a useful tool in developing a conceptual understanding of decimals. Chinn (2004, p. 17) highlights that money can be an effective manipulative. However, some caution needs to be heeded as the coinage does not match physical size to value e.g. a 2p coin is physically larger but worth less than a 5p coin.

Another area of difficulty is percentages. Drew (2016, p. 172) points out that all the participants in his study had some degree of difficulty with percentages, although he reports that many suggested a greater level of comfort than with fractions or decimals. Drew (2016, p. 171) points out that this is due, in part, to the use of percentages as an academic grading system whereby 80% is understood to represent a high achievement. However, beyond this, students struggled to comprehend and to calculate percentages. Often, calculating 10% or 20% discounts or price increases can be a source of difficulties. In one-to-one support, it is helpful to consider such practical exemplars with everyday objects (see figure 3). It is useful to begin with 10% of a round amount, then change the percentage or the amount by small steps of increasing difficulty. The use of visual representations is again helpful and a ten by ten grid is invaluable.

Figure 3: Using everyday examples for percentage calculations

Operations

Chinn (2004, p. 44) states that the four operations of number (addition, subtraction, multiplication and division) are closely inter-related. He contends that a student needs an understanding of each operation and how it is related to the other operations. Students frequently have little idea which operation is appropriate in any given situation and further, how to apply that operation. In most disciplines in H.E. a calculator is permitted and this can remove the need to recall number facts. However, the student still needs to be able to select the appropriate numerical operation and, furthermore, they will need to gauge the answer in terms of it being a good estimation of the solution to the particular problem. This is a skill that students with maths impairment will struggle with. Indeed, this is often a key indicator of significant mathematical issues.

One area where calculations have to be conducted without a calculator is in nursing. Particular concerns in nursing have been raised (MacDougall, 2009; Kirk and Payne, 2012). Kirk and Payne point out that dyscalculia has serious implications for pre-registration nurses where drug-dose calculations are essential. The student needs to competently carry out the calculation and apply the result in clinical practice. Nursing students are required to achieve 100% in numeracy tests. This is, in almost all cases, an insurmountable barrier for those students who struggle with maths. One-to-one support can enable some progress towards conceptual understanding as well as procedural competency.

Algebra

Murray et al. (2015, p. 393) state that even students who were previously successful in maths, can have issues with algebra. It is also possible that the reverse is true and that a few students who struggle with numerical work can succeed in algebra. Grant's paper notes that issues with working memory may lie at the heart of this. Abstraction relies heavily on symbols and students need to have a good understanding of what each symbol represents. Indeed, the meaning of any given symbol can change from one algebraic problem to the next. It is also dependent on memory, holding in your mind what x or what y stand for. There is also the idea that a variable, say x, can stand for more than one value and that x in one question may be different to an x in another question. E.G. x=2 in one question but x=5 in the next question. Murray et al. (2015, p. 404) conclude that algebra is a complex cognitive process going beyond arithmetical ability. It can involve working with patterns, variables and generalisations. Murray et al. (2015, p.404) claim that such reasoning requires flexibility. In one-to-one support sessions, it should be remembered that some students with dyscalculia or maths impairment may find symbols preferable to numbers. Robertson (2004) cites one engineering student who worked through algebraic reasoning until the point where numbers had to be inserted and then had difficulty. In such cases, symbolic reasoning can remove the difficulties experienced with number and operations. For those students who do struggle with algebraic notation, it is often helpful to start to approach algebra as a "missing number" situation, using a box to represent the variable. After the student becomes familiar with this, letters can slowly be introduced. So the above becomes X + 5 = 17

One source of difficulty can often be the use of Greek letters in mathematics, although these could be changed to more familiar letters.

Statistics

Trott and Chinn (2016) conducted a survey of Maths Support Centre staff and those who work one-to-one in student support. The survey focused on the 'Hidden Maths' in H.E. Their results show that in Higher Education, Statistics was the most common mathematical topic encountered. The range of different courses in which maths appeared was unexpectedly large with over 40 different courses involved. The most frequently cited course was Social Sciences, closely followed by Business, Psychology, and subjects allied to Medicine. Statistics is particularly inherent in the Social Sciences and in Psychology.

Trott et al. (2013, p. 21) cite the case of 'Fiona', a dyscalculic student who struggled with the statistical elements of her Countryside Management course. She needed to understand the data she collected in the field and to process it. Whilst she was able to collect the data, she struggled to understand why she needed to process it as well as how to create a frequency table for the number of different types of tree and how to draw a bar graph based on the table. Trott et al. (2013, p. 21) state that 'Fiona' found it helpful to keep the charts as uncluttered as possible. 'Fiona' also liked to talk through what she was being asked to do which helped her with understanding what statistical techniques were required. Once she had completed the statistical elements she had to interpret the information. The visual information in the bar chart was particularly challenging for her. She struggled to see how the visual representations stood for the data she collected. It should be noted that dyslexic students, by contrast, often have a preference for pictorial representations, which are more visual (Cooper, 2006).

A second case study, ‘Liam’, is cited by Trott (2010, p. 72). ‘Liam’ also needed to work with tables and graphs. These related to his Transport Management course. He struggled to understand number concepts and their inter-relationships. From tables of information, he was expected to calculate percentages. In one-to-one support sessions he was able to go through these at his own pace, taking several sessions to follow the procedures required. When he was faced with graphical representation, he struggled to understand that the graph related to both the axes simultaneously. Liam worked on placing numbers on a single number line (see figure1) and later on the line graphs themselves. It took many examples to cement understanding and, by chance, he drew a graph with the vertical axis on the right hand side and saw that the graph was “climbing up the wall”: i.e. the variable on the vertical axis was increasing simultaneously with the variable on the horizontal axis (see figure 4).

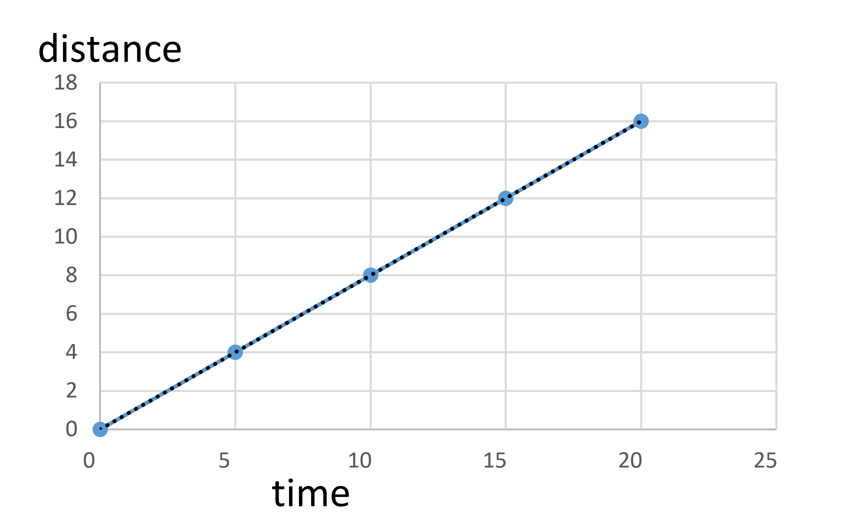

Figure 4: shows a line graph for distance/time

The two case studies illustrate that a clear conceptual understanding is needed for the statistical and graphical components of many courses in H.E.

Time and Money

Students with dyscalculia or maths impairment can frequently feel isolated and not part of the “effective learner group” (Trott, 2009, p. 143). They may experience high maths anxiety and consequent low maths confidence, feeling that the rest of the class understand the material that they are struggling with. This can lead to a sense of being outside the main class group and to feeling isolated. This feeling can be made worse by difficulties in understanding how to tell the time and manage money, since social activities often involve time or money. Such activities can include arranging to meet friends at a certain time or going shopping together or to the coffee shop. These barriers can lead the student to avoid such activities, adding to their sense of isolation (Trott, 2009, p.142).

All 14 of the participants in the study by Drew (2016) expressed having problems with time. This included both telling the time and estimating the passage of time. With regard to telling the time, students had a preference for digital clocks and for avoiding the 24-hour notation (such as 17:15), opting for the 12-hour system (5:15pm). Many students rely on their mobile phones for time and these can also be used to set up a series of alarms to prompt the student to certain actions (such as going to a lecture). This can partially circumvent the need to tell the time. When working one-to-one with a student, it is helpful to use a phone, analogue and digital clocks in parallel, setting each one to the same time.

Another issue associated with time is the ability to gauge how much time has elapsed or the duration of an activity. Drew (2016, p. 190) refers to this as a 'sense of time'. One of the students in his study says: "*I really didn't know how long 15 minutes was and I still don't."* Drew (2016) also found that students tended to either under or over estimate how long tasks take. Concern was expressed about arriving punctually for appointments. Many of the students who struggled with time estimation adopted the strategy of always leaving very early, arriving ahead of time and waiting (Drew, 2016, p.192).

Drew (2016, p. 191) suggests that an inability to judge the passage of time impacts on daily life. Mann et al. (2015, p. 118) agree that poor time management can affect an individual's life and employability. Time management involves planning and this inevitably relies on numeracy. It is important to support the student with time management. In sessions the focus can be on estimating how long a task takes, progressing to a series of tasks in sequence. Colour-coding and the use of detailed timetables and planners can be helpful.

As mentioned earlier, issues with money can cause difficulties with everyday tasks such as shopping and budgeting. Chinn (2004, p. 135) states that competence in money is a desirable outcome of education. Paying for items in a shop can be problematic. Many students with dyscalculia or maths impairment will choose to pay with a large note such as a £20 note or use a credit/debit card. Trott (2010 p. 17) discusses the case of one student who always paid with 'a purple', this being a £20 note which is sufficiently large to cover the cost of her shopping. Students are frequently too embarrassed to try to check change. In support sessions, it is often helpful to focus on counting out money and giving change, the latter usually being conceived as a counting-on process. One tutor used the menu from a coffee shop to practice ordering, paying and counting change. This provided a real, everyday context.

Conclusion

Grant (ibid) highlights the philosophy of assessment for intervention. The current paper has focused on support interventions for dyscalculic students and those with maths impairment. Numeracy permeates both academic programmes and everyday life. Sometimes the mathematical content of H.E. courses is “hidden”, creating unexpected challenges for the student. Dyscalculic students are also likely to have consequent maths anxiety that complicates the picture (Grant, ibid). This can lead to low self-esteem and low mathematical confidence. The following summarise the interventions that can help students move forward:

- Use of squared or coloured paper
- Utilising manipulative with a hands-on approach
- Use of colour in a consistent way for variables or operations
- Counting activities with coins
- Placing numbers on number lines
- Use of fractional diagrams or ‘pizza’
- Use of practical, everyday examples of percentages
- Setting alarms on mobile phones to aid time management
- Practice in monetary transactions with coins

One-to-one interventions can aid understanding, increase confidence and enable the student to move forward.

References

Chinn, S. (2015). The Routledge international handbook of dyscalcula and mathematical learning difficulties, (pp. 406–419). Routledge: Abingdon, UK.

Chinn, S. (2006). What dyslexia can tell us about dyscalculia. *Dyslexia Review, 18*(1), 15-17.

Chinn, S. (2004). The trouble with maths. Routledge Falmer, London, Uk.

Cooper R. (2006). Making Learning Styles Meaningful. Patoss Bulletin 19(1) 58-63

Drew, S. A. H. (2016). Dyscalculia in higher education (Doctoral thesis). Loughborough University, UK.

Hornigold, J. (2017). Understanding maths learning difficulties: dyscalculia, dyslexia or dyspraxia? OUP, London, UK.

Kirk, K., & Payne, B. (2012). Dyscalculia: Awareness and student support. *Nursing Times*, *108*(37), 16–18.

MacDougall, M. (2009). Dyscalculia, Dyslexia, and Medical Students' Needs for Learning and Using Statistics. Medical Education online, 14(2), 1087-2981. Retrieved November 2017 from http://www.tandfonline.com/doi/abs/10.3402/meo.v14i.4512

Mann V., Machin E., and Woodrow E. (2015) The Impact of Dyscalculia on students in Higher Education in Journal of Neurodiversity in Higher Education, June 2015 (1), p114-128

Murray, E., Hillaire. G., Johnson, M., and Rappolt-Schlichtmann, G. (2015). Representing, acting and engaging. UDL and mathematics. In S. Chinn (Ed.), The Routledge international handbook of dyscalcula and mathematical learning difficulties, (pp. 393–405). Routledge: Abingdon, UK.

Robertson J. (2004). Dyslexia, Dyscalculia and Engineering: a case study. Presentation given to DDIG conference, University of Leicester March 2004

Trott C., & Chinn, S. (2016) The hidden maths content in HE courses: A survey. Presentation given to the British Dyslexia Association International Conference, Moving forward: Challenges and transitions. Oxford, UK.

Trott, C. (2015) Dyscalculia in higher education. In S. Chinn (Ed.), The Routledge international handbook of dyscalcula and mathematical learning difficulties, (pp. 406–419). Routledge: Abingdon, UK.

Trott, C., Drew, S. A. H., and Maddocks, H. (2013). A hub service: extending the support provided by one institution to students from other local institutions. MSOR Connections, 13(1), 18-23.

Trott, C. (2010). Dyscalculia in Further and Higher Education. CETL-MSOR Conference Proceedings 2010, University of Birmingham, 68-73. September 2010.

Trott, C. (2009). Dyscalculia. In D. Pollak (Ed.), Neurodiversity in higher education: Positive responses to specific learning differences (pp. 125–148). Wiley-Blackwell.