Jarlskog, L. (2016). Survey of adult students with mathematical difficulties. *Adults Learning Mathematics: An International Journal, 11*(2), 41-51

Survey of Adult Students with Mathematical Difficulties

Linda Jarlskog

Komvux, Lund, Sweden

<linda.jarlskog@lund.se>

Abstract

This paper relates to one of the test procedures being used in Sweden, used to establish if students need a more thorough investigation of their mathematical difficulties. This paper mainly describes the test process and the results from 10 test subjects. The paper also refers to parts of the research forming the basis for the test process. The paper shows how teachers in their everyday work can use the understanding researchers have of mathematical difficulties and the methods they have developed. The purpose is not to drive the research on mathematical difficulties.

Key words: mathematical difficulties, survey, levels of knowledge

About Mathematical Difficulties

As early as 1919 mathematical difficulties were observed by the Swedish doctor Salomon Eberhard Henschen, who later, in 1925, made connections to damages in the brain. Henschen, practicing in Uppsala, Sweden, characterized the difficulties he observed as acalculia (http://en.wikipedia.org/wiki/Salomon_Eberhard_Henschen, 2014-11-01). It was not until the mid 1970's before further comprehensive studies of mathematical learning disabilities were conducted (Kling et al, 2011). After this period developments have been rapid including the designation of dyscalculia and the causes of mathematical learning disabilities scrutinized, formulated and discussed (Östergren, 2013). Today it is self-evident that specific development disorders and dyscalculia are defined in the most established systems for diagnosis, DSM and ICD.

Mathematical difficulties are usually divided in four categories (Adler, 2010); acalculia, dyscalculia, pervasive mathematical disorders and pseudo dyscalculia.

According to the Swedish professor Arne Engström (Engström, 2016) researchers do not agree on how dyscalculia shall be defined or the criteria to use. Also, they are not in agreement on how common dyscalculia is. Additionally, the researchers do not know enough about the reasons. This should be kept in mind whilst reading this paper.

Acalculia

A student exhibiting acalculia lacks the ability to calculate and to learn to calculate which mostly depends on measurable brain damage. A student having acalculia lacks the ability to count to 10 or add low numbers. Acalculia is unusual and is found only in a few per thousand of the population (Adler, 2007).

Dyscalculia

Dyscalculia together with dyslexia is today regarded as a subgroup of specific learning disorders. The diagnosis for dyscalculia, within the two most established international systems for diagnosis DSM and ICD, has been modified from proven experiences over the years. Today DSM has reached the fifth version (American psychiatric association, 2013) of its definition, DSM-5:

The Diagnostic and Statistical Manual of Mental Disorders
Dyscalculia is an alternative term used to refer to a pattern of difficulties characterized by problems:

- processing numerical information
- learning arithmetic facts and
- performing accurate or fluent calculations.

If dyscalculia is used to specify this particular pattern of difficulties, it is important also to specify any additional difficulties that are present, such as difficulties with math reasoning or word reading accuracy.

Difficulties in processing numerical information means an inability or reduced ability to deal with numbers. This is due to a dysfunctional number sense and in many cases lacking the ability to connect our Arabic symbols to numbers. Inability to recognize numbers often leads to the inability to deduce which of two numbers is the largest (the mental number axis, schema for numbers) and to perceive low numbers that are larger than four (Butterworth, 2010) as anything else than a series of "ones" (Halberda et al, 2008). Students having these difficulties are often seen counting on their fingers. Processing numerical information also means being able to understand and realize how numbers are influenced by simple arithmetic operations for adding and multiplication.

Difficulties to learn arithmetic facts also include remembering arithmetic facts, like simple additions. It stems from dysfunctional processes for absorbing, storing and recalling information from the long term or working memory (Kulcian et al, 2014). Difficulties to quickly fetch arithmetic facts from the memory are called automation difficulties. Number sense and working memory are important for the ability to calculate accurately or fluently (Klingberg, 2011).

The International Statistical Classification of Diseases and Related Health Problems
Specific disorder of arithmetical skills

Involves a specific impairment in arithmetical skillsthat is not solely explicable on the basis of general mental retardation or of inadequate schooling. The deficit concerns mastery of basic computational skills of addition, subtraction, multiplication, and division rather than of the more abstract mathematical skills involved in algebra, trigonometry, geometry, or calculus.

Arithmetical difficulties:

- associated with a reading or spelling disorder (F81.3)
- due to inadequate teaching (Z55.8)

When dyscalculia is being diagnosed according to DSM-5, difficulties in mathematical reasoning and in the working memory should also be included. The mathematical reasoning that DSM-5 includes is the abilities for:

- logical reasoning when tasks are solved
- apply strategies for solutions
- apply mathematical concepts, facts, procedures and methods when tasks are solved. (Students' methods are especially noted when tasks are solved, by checking if students use the correct rule of arithmetic or when the correct rule of arithmetic is used but the result is wrong.)(Adler, written tutorial, 2014-11-04)

The latest diagnosis issued by WHO (http://dyscalculic.tumblr.com, 2014-11-01) in 2010 came three years before DSM-5.

Students having dyscalculia do have a normal level of talent as clarified by the WHO diagnosis. Later studies point out the number of students having dyscalculia can be compared to the number of students having dyslexia and this accounts for 3.6 to 6.5 per cent of the population (Butterworth, Yeo, 2010). A dyscalculia diagnosis is valid for a period of one year for children and two years for adults.

Pervasive Mathematical Disorders

There are also students with pervasive mathematical disorders. As these disorders are pervasive they are not specific for learning and understanding mathematics. They influence all learning. These students need adapted teaching where learning is allowed to consume more time and contents may be simplified. These students are more consistent in their achievements compared to students with dyscalculia.

Pseudo Dyscalculia

This fourth category (Adler, 2010) is about students with emotional blockings experiencing specific mathematical disorders. These students are discovered as they get surprised that the survey was so easy. Pseudo dyscalculia, which is most common among women, is treated with support from a psychologist, welfare officer or similar. It is also called math anxiety.

Cognitive Disabilities

Cognitive disabilities with a broad impact on many abilities are called pervasive. The cognitive disabilities specifically affecting students' abilities to learn and understand mathematics are called specific mathematical disabilities or disorders. Two examples of pervasive proficiencies are intelligence and processing speed (Adler, 2007).

Students only having difficulties specific for mathematics usually have dyscalculia. Dyscalculia assumes the specific mathematical disabilities depart from the other more functioning abilities.

Mathematical disabilities are often caused by a combination of specifically mathematical and otherwise pervasive difficulties. Rickard Östergren (2013) proposes weak working memory in combination with weak number sense is a risk for students to develop MLD. Others have reached different conclusions. For example Deary, et al, (2007) suggest reduced intelligence combined with reduced number sense is a common reason for development of MLD. However, it has also been suggested intelligence is the same as working memory capacity (Ackerman, et al, 2005). In addition it is noted that general abilities like phonological consciousness, processing speed and executive attentional processing have great importance for MLD, (Östergren, 2013).

According to DSM-5, a weak number sense and its limitation in understanding digits and numbers is the main difficulty contributing to dyscalculia.

The Pedagogical Survey

Execution

The pedagogical survey that scores for pervasive and for mathematics specific development disorders was done in four phases; three screenings and one skill test in mathematics using the following material from Kognitivt Centrum in Malmö.

- Reading screening III (from 16 years), Adler, 2012
- Writing screening III (from 16 years), Adler, 2012
- Mathematics screening III (from 16 years), Adler, 2010
- Skill test for mathematics (secondary school and adults), Adler, 2008

Every screening lasts approximately one hour. The skill test takes exactly 5 minutes.

The test material has been bought from Kognitivt Centrum in Malmö. The authorized distributor prohibits further distribution. Therefore, it cannot be included as an annex. Due to this the article focuses on the students' results rather than the questions asked. Choosing this test material is a consequence of Sweden being a small country and this is the test material that is readily available in Swedish.

All tests were done individually even if the skill test may be done in a group. Doing them individually enables observing aspects such as how easy students understand instructions and the time taken to complete different tasks. The most time consuming duty for the teacher is to compile the results and write recommendations for more thorough investigations and the bases for these.

Testing students' reading and writing abilities is done since these are important to know about. For example, if students don't have the fine motor skills to write and understand what they have written themselves, of course, the situation is made more complicated. The same applies if they cannot sketch or understand geometrical shapes. Students having difficulties to read may have problems to understand what the question is in a problem solving task. Also, texts may become incomprehensible when words are pronounced wrongly. These are a few examples.

Professor Arne Engström has the opinion that calling three of these tests screening is wrong because the word screening is used when a complete population is tested. (Engström, 2016)

About the ten students

I came in contact with eight of the ten students that were surveyed at my place of work (Komvux, Lund). The remaining two students, Josefin and Elise, heard about my investigations and wanted to take advantage of the opportunity to be in the survey and get more help for their difficulties. These two additional students were younger. Four of the students at Komvux were my own. The other students at Komvux were recommended for the survey either by a teacher or by the welfare officer. The designation *Ma Gr* in the table means a pre-secondary school course in mathematics. The other designations are courses at secondary school.

Table 1 shows background information about the 10 tested students. It displays age, if there are previous diagnoses, which course they are taking and how they describe their own difficulties.

Table 1.
About the ten students.

Name	Age	Previous diagnosis	Studying	Student's own description
Marie	24	Dyslexia	Ma 2b	Bad memory. Good at per cent because of much shopping. Developed math disliking called "ouch-math".
Jan	24	No	Ma 2b	Difficult to multiply simple numbers. Difficult to concentrate. Likes calculus. Dislikes writing. Reads a little, excellent self confidence.
Mårten	31	No	Ma 2c	Likes calculus despite difficulties. The four basic operations are difficult and he forgets what has been heard /seen. Good image memory. Good problem solver, curious, patient and positive.
Carina	21	No	Ma Gr	Needs calm to make concentration and persistence work. Units are difficult. Memory works sometimes. Daily math like prices when buying candy is difficult.
Amanda	24	No	Ma 3b	Tried to study Ma 3b three times. Easily stressed and quits when feeling pressured. Counting fingers. Daily math works well.
Emma	27	Dyslexia	Ma 1a	Never learned the multiplication table. Text based tasks are difficult. Lacks linguistic understanding. Problems with daily math.
Jonny	21	Post traumatic stress, probably dyscalculia	Ma 1a	Tried to get approval for Ma A 7 times. No problem with daily math like per cent and rough estimates since he spent a lot of time on this. Developed discontent against math. Strong reader and did proofread several texts. Problems with concentration.
Josefin	15	No	Ma Gr	Developed a distinct blank out mechanism also excluding what she is supposed to learn. Concentration difficulties, to plan, textual tasks, to remember, to write and reading the watch. Writing and reading works well.
Elise	16	Dyscalculia	Ma 1b	Concentration and planning difficulties. Good at reading and writing and likes it. Easily forgets. In math everything is difficult including writing digits and numbers. Don't know multiplication table and counts on fingers. Otherwise good self confidence.
Johan	20	Dyslexia	Physics 1a	Difficulties to remember how methods are executed and names on mathematical concepts, their meanings and relations. Difficulties to store and fetch information from the memory. Difficulties to read and write. Likes calculus. Wants to graduate from college.

Here is a short description about the mathematical brain before we discuss the results for the 10 students.

The mathematical brain

Mathematics encompass various cognitive processes where different help systems collaborate. Therefore, the whole brain is used for mathematics. Both difficulties in reading and doing mathematics have the origin in deficits in both halves of the brain, even though reading depends mostly on the left half and number sense and calculus ability stems from the right half. (Adler, 2014. Network meeting dyscalculia, Stockholm).

The frontal lobes are an important part when doing new calculations. The brain also has an area called IPS where number facts are stored. This area may be blocked in any person. Typically students having a dysfunction in the IPS may say "I know but I cannot get it out". Problems with IPS can be compensated by training. To succeed in mathematical studies it takes more from the brain than to succeed in reading or writing. The calculus itself encompasses more cognitive processes (Campell, 2004). At least, when looking at all the components needed for problem solving you can understand the whole brain is used for mathematics; good understanding of reading, linguistic understanding, phonological consciousness, persistence, attentiveness, a good capacity to automate, a well-functioning working memory that is not too slow, good speech recognition, mathematical reasoning etc.

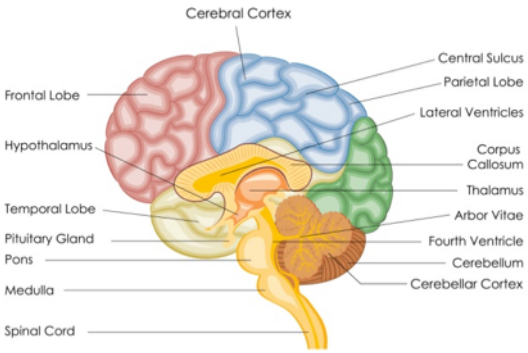

Figure 1 The brain.
(www.depositphotos.com. ID: 42346051)

Results for Ten Surveys

Tables 2 and 3 show how to interpret skill test results. The skill test consists of 50 simple calculations like e.g. 10 – 3 + 2. The skill test is normalized due to a standard population. It measures according to a profile and a normal distributed Stanine score in the range from 1 to 9. Students achieving a Stanine score of 1 or 2 are among the 11 % with the lowest result according to the standard population the test has been normalized against. Students achieving Stanine score 3 may also have great difficulties with speech recognition. These students probably have to some extent compensated their deficit number sense with a strong working memory. Stanine scores for skill tests are determined according to table 2.

Table 2.
The stanine scores.

Stanine	1	2	3	4	5	6	7	8	9
Score (No. of right – wrong)	≤1	2-6	7-10	11-14	15-19	20-24	25-31	32-40	41-50
% of students in the normalization	4	7	12	17	20	17	2	7	4

Profiles for skill tests are determined according to table 3.

Table 3.
Profiles for the skill tests

Profile	The student works…
Q	slowly and does maximum 10 tasks and makes many mistakes – four or more
R	slowly and does maximum 10 tasks but makes few mistakes – three or less
S	at normal pace and does at least 11 tasks and makes many mistakes – four or more
T	at normal pace and does at least 11 tasks but makes few mistakes – three or less
U	fast and does at least 25 tasks and makes many mistakes – four or more
V	fast and does at least 25 tasks but makes few mistakes – three or less

Table 4 shows the screening and skill test results for the 10 students. In the table well-functioning abilities are shown as "X" while a "?" means this should be investigated further. Boxes with question marks are also shaded for clarity. A "?" in any of the blue fields indicates possible dyscalculia.

Table 5 shows a summary of the results for the pedagogic surveys. The students' shortened names are given in the lilac headline. The table gives an insight into what is investigated. The yellow rectangle above the table shows the test designers' instructions for how to interpret the number of difficulties resulting from the mathematics screening.

Table 4.
Collocation of the survey

A **?**in any of the blue fields indicates possible dyscalculia. Investigate further!

mathematics
read
write and spell

Instructions for red fields
All correct: emotional blockings/knowledge gaps
2-8 errors: might be mathematically specific development disorders
≥ 9 errors: pervasive mathematic specific development disorders or complicated learning

	Ability	Ma	Ja	Må	Ca	Am	Em	Jon	Jos	Eli	Joh	Example
1	Number structure	X	X	X	?	X	X	X	?	?	X	Read and write numbers
2	Schema/series of numbers	?	?	?	?	?	?	?	?	?	?	Mental number axis
3	Simple operations	?	?	?	?	?	?	?	?	?	X	e.g.: 15-7=
4	Complex operations	?	?	?	?	X	?	X	?	?	X	e.g.: 35-5+8=
5	Understand sign	X	X	?	?	X	?	?	?	?	X	
6	Number concept/ perception	X	X	?	?	X	X	X	?	?	X	Largest, ordinal number
7	Reading digital clock	X	X	X	?	X	?	X	?	X	X	
8	Reading analog clock	?	?	X	?	?	?	X	?	X	?	
9	Numbers on clock	X	X	X	X	X	X	X	X	X	X	
10	Hand on clock	X	X	X	X	X	X	X	?	X	?	
11	Recognizing letters	X	X	X	X	X	?	X	X	X	X	Read different fonts
12	Phonological consciousness	X	?	X	?	X	?	X	X	X	?	Rhyme simple words
13	Read single letter words	X	X	X	X	X	X	X	X	X	X	
14	Read complex words	X	?	X	?	X	?	X	X	X	?	
15	Mobilize words	X	X	X	X	X	X	X	X	X	X	State words that...
16	Name things	X	X	X	X	X	X	X	X	X	X	
17	Order word sequences	X	X	?	X	X	X	X	X	X	X	Order texts
18	Read text	?	?	?	X	X	X	X	X	X	?	
19	Understand read text	?	?	?	X	X	?	X	X	X	X	
20	Retell	?	?	X	X	X	?	X	X	X	X	
21	Writing ability	X	?	X	?	X	X	X	?	X	?	Copy text and figure
22	Free writing	X	X	X	X	X	X	X	X	X	?	
23	Spelling ability	?	?	?	?	X	?	X	X	X	?	
24	Motional quickness	X	X	X	?	X	X	X	?	X	X	Copy model
25	Motional rhythm	X	X	X	X	X	X	X	X	X	X	
26	Copy geometrical figure	?	?	X	?	X	X	?	?	?	X	
27	Visually scan	?	?	?	?	?	?	?	?	?	?	Find similar / errors…
28	Perceptual completeness	X	X	X	X	X	X	X	X	X	X	See details in

													complete pictures
	29	Visual sequential ability	X	X	?	X	X	X	X	X	X	X	Order images
	30	Room perception	X	X	X	X	X	?	X	X	X	X	Words for position
31	31	Shape perception	?	X	X	?	X	?	?	?	?	?	Fonts, similar figures
	32	Perceptual speed	X	X	X	?	X	X	X	?	X	X	Digit patterns
	33	Eye-hand coordination	X	X	X	X	X	X	X	X	X	X	Tracing with a pen
	34	Spatial ability/relations	?	?	?	?	X	?	?	?	X	X	Copying, triangle test
	35	Visio-spatial memory	X	X	?	X	?	X	?	?	?	X	
36	36	Audible working memory	?	?	X	?	X	?	?	?	?	X	
37	37	Visual working memory	?	?	?	?	X	?	?	?	?	?	
38	38	Attention	?	?	X	?	?	?	?	?	?	?	
39	39	Split attention	?	?	X	?	?	?	?	?	?	?	Compare, find pairs
40	40	Persistence/concentration	?	?	?	?	X	?	X	?	?	?	
	41	General knowledge	X	X	X	X	X	X	X	X	?	?	
	42	Learning ability/strategies	X	?	?	?	X	X	?	?	X	?	
43	43	Planning abilty	X	?	X	?	X	X	X	?	X	?	
	44	Time planning/time perception	X	X	X	X	X	?	X	?	?	?	
45	45	Time concepts	?	?	X	?	?	?	X	?	X	?	
		Stanine	2	2	1	3	8	2	6	1	2	8	
		Profile	S	U	S	S	V	S	S	Q	S	V	

Table 5.
Summary of the ten pedagogical surveys

Marie	Marie shows signs of mathematically specific development disorders and problems with the working memory.
Jan	Jan needs support to train his basic abilities for his own benefit and to definitely exclude his deficiencies depend on mathematically specific development disorders. Jan also needs encouragement to read more. If this training does not give the desired effect a more thorough investigation is required.
Mårten	Mårten has automation difficulties and problems recognizing numbers. He almost certainly has dyscalculia or mathematically specific development disorders.
Carina	The survey indicates Carina is not a weak student but she has a complicated learning as she is concerned about several pedagogical building blocks. A deepened psychological and medical judgment shall then be conducted as a complement.
Amanda	The survey shows there are problems with the mental number axis, and there may be difficulties with the working memory and concentration. Perhaps could some of these contribute to the resistance against math studies. The difficulties with the mental number axis, which in her case are apparent when the numbers are not written, should be possible to remove by number axis training. Therefore, currently no deeper pedagogical investigation on mathematical difficulties is recommended. Instead a working memory test is recommended to find out how Amanda could train mainly the visual working memory.
Emma	The survey clearly points out the already known dyslexia and mathematically specific development disorders that should be dyscalculia. A deeper dyscalculia and dyslexia investigation along with psychological and medical judgment is needed. It is also necessary to further define Emma's dyslexia to prevent her being hindered in future studies at teachers college.
Jonny	The survey shows Jonny has and mathematically specific development disorders and possibly also dyscalculia. A complementary deeper psychological and medical judgment shall then be conducted. Not the least, the reasons for Jonny's concentration problems need to be established. The survey also show Jonny has a lack of concentration, reduced visual working memory, shape comprehension and ability to visually scan. A working memory test

	is required.
Josefin	Josefin has mathematically specific development disorders (since her mathematical difficulties deviate that much from her ability to read and write) and problems with the working memory, especially the visual, which in this context indicates complicated learning. Emotional blockings magnifies her learning problems. A psychological and medical judgment is needed as a complement.
Elise	Elise has mathematically specific development disorders (since her mathematical difficulties deviate that much from her ability to read and write) and problems with the working memory, especially the visual, which in this context indicates complicated learning. Strong feelings she has difficulties to control may also aggravate her learning problems. A psychological and medical judgment is needed as a complement.
Johan	Johan has read and write difficulties hindering him to succeed in math and physics. To alleviate these difficulties Johan needs to meet a specialist that can support him in using tools to ease taking notes, structure texts and understand concepts and explanations he has written himself. To get concepts and texts read out loud to him may also help since words he reads often are pronounced erroneously and become completely different words. Johan also needs a new, fresh dyslexia investigation prior to his studies at college.

Discussion

Each of these students exhibits issues with the mental number line, even when the ability test shows a high Stanine score. For some of the students the difficulties with the mental number line are a clear sign of difficulties associated with their number sense. The two students that achieved well in the ability test show problems with attention. One of them also showed problems with persistence/ concentration which may explain the difficulties with the mental number axis.

Six of the seven students having Stanine score 1-3 showed apparent signs for mathematics specific development disorders. One might have practiced too little. Out of these students Mårten exhibits signs of dyscalculia since there was a limitation in specific difficulties, except those linking to the visual. For Mårten the mathematics specific development disorders deviated a lot from his better functioning pervasive abilities. The survey showed Mårten had difficulties with persistence/ concentration and learning ability. Despite this, I see as a teacher of this student, these two general abilities function well. After the survey the student was allowed to use multiplication tables when doing written tests, which probably relieved some stress! After this he has been doing well.

For another student, Emma, having a low Stanine score (2) using multiplication tables when doing written tests was imperative for her to succeed with the course. It is obvious corrective actions do not have to be far away!

For the two students that produced a Stanine score of 8, one clearly exhibits dyslexia and the other shows a lack of attention and not being used to confront obstacles with problem solving.

The student with a Stanine score of 6 showed signs of mathematics specific development disorders and troubles with the working memory and concentration. These students' difficulties are similar to those Östergren gives as an important source for mathematical difficulties, MLD.

Several students showed pervasive development disorders in combination with mathematics specific development disorders. One of these students, Carina who I have in my class, does not work at all in the large group where she is currently placed, since the size of the group hinders her from speaking up and communicating her thoughts. Her pedagogical survey made my headmaster act by offering her individually adapted support.

The ability for mathematical reasoning has not been investigated. This ability will be put forward in later investigations when instructive material for this has been developed. More investigations are needed to be able to exhaustively link results to contemporary research.

About more thorough pedagogical investigations

The pedagogical screenings investigate cognitive building blocks needed for students reading, writing and spelling. Depending on what is pointed out by the screenings deeper pedagogical investigations might be needed. These should be conducted by a team consisting of a medical doctor, a psychiatrist and possibly also a speech therapist and a social worker. For adults, in case it is not possible to engage all these staff, a medical doctor shall conduct a complementary investigation. The doctor's role is to establish if there is anything else that can explain the difficulties. Today the requirement for a psychologist has been relaxed.

Memory tests, *Rey-complex figure test* and *Rawens matrix* is often used by more exhaustive investigations. *Rawens matrix* is a logical non-linguistic intelligence test. *Rey-complex figure test* shows if the spatial ability is defective.

When doing the survey it is important to remember that a poor educational experience can influence the results. In these cases the lack of previous education should be made up. If this does not help a deeper investigation shall be called upon as fast as possible so the required support can be provided as soon as possible.

Experiences from the surveys

Some of the students benefited directly from the survey as they were allowed to compensate difficulties in written tests and by doing so were able to attend higher mathematics classes. Other students have finally been offered support, although unfortunately not by remedial teachers. Another experience was the tests and the collected results made clear to the school management what students mathematical difficulties may look like and which help they might need. This has contributed to the decision that Komvux in Lund will hire a remedial teacher.

References

Ackerman P, Beir M.E, Boyle M.O (2005). Working memory and intelligence: The same or different constructs? *Psychological Bulletin, 131, 30-60.doi: 10.1037/0033-2909.131.1.30*

Adler, B. (2007). Dyskalkyli&Matematik – En handbokidyskalkyli.*NU-förlaget, Malmö*.

Adler, B. (2010). Matematikscreening III. *Kognitivt centrum, Malmö*.

American psychiatric association (2013).*Diagnostic and statistical manual of mental disorders, fifth edition, DSM-5*.

Butterworth, B. (2010). Foundational numerical capacities and origins of dyscalculia.*Trends in Cognitive Science, 13, 534-541.doi: 10.1016/j.tics.2010.09.007*

Butterworth, B., Yeo, D. (2010). Dyskalkyli: atthjälpaelever med specifikamatematiksvårigheter. *Natur&Kultur, Stockholm*.

Campell, J. (2004). Handbook of mathematical cognition.*Taylor and Francis group, UK*.

Deary, I., Strand, J., Smith, P., Fernandes, C. (2007). Intelligence and educational achievement.*Intelligence, 35, 13-21.doi: 10.1016/j.intell.2006.02.001*

Halberda, J., Feigenson, L. (2008). Developmental change in the acuity of the "number sense" in 3-, 4-, 5- and 6-year olds and adults.*Developmental Psychology, 44, 1457-1465.doi: 10.1037/a0012682*

Kling, L., Martinsson, U. (2011). Dyskalkyli, *Specialpedagogiskainstitutionen, Stockholmsuniversitet.*

Klingberg, T. (2011). Den Lärandehjärnan. Natur&Kultur, Stockholm.

Kulcian, K. et al. (2014). Developmental dyscalculia: a dysconnection syndrome? *Brain StructFunct. 2014 Sep;219(5):1721-33. doi: 10.1007/s00429-013-0597-4*

Kucian, M. et al. (2011).Mental number line training in children with developmental dyscalculia.*NeuroImage 57 (2011) 782-795*

Östegren, R. (2013).Mathematical Learning Disability, Cognitive Conditions, Developments and Predictions, *Department of Behavioral Sciences and Learning, Linköping.*

http://dyscalculic.tumblr.com (2014-11-01) (WHO, Specific disorder of arithmetical skills)

http://en.wikipedia.org/wiki/Salomon_Eberhard_Henschen (2014-11-01)

Abbreviations

DSM The Diagnostic and Statistical Manual of Mental Disorder
ICD The International Statistical Classification of Diseases and Related Health Problems (WHO)
IPS Intraparietal Sulcus
ANS Approximate Number System
MLD Mathematical Learning Disability