Learning Difficulties Australia

Learning Difficulties Australia is an association of teachers and other professionals dedicated to assisting students with learning difficulties through effective teaching practices based on scientific research.

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1

Hi, I'm Erin Rollason

BSc, GradDipEd(Sec), MLI (SLD)
Learning Interventionist
LDA council member

I currently work at a very large mainstream, government secondary college in South East Melbourne. My leadership role encompasses Literacy and Numeracy interventions, with a supportive direction in positive learning for students with disabilities and SLD's.

Being neurodiverse, myself, I am passionate about providing students with disabilities and SLD's skills to ensure equity in the school context.

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2

Numeracy language promotion in Secondary School

Objectives

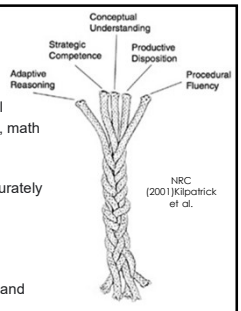
To understand why the language supporting numeracy can be challenging in Secondary School.

To learn/revisit the language that supports numeracy knowledge promotion in secondary school students with learning difficulties.

How to support numeracy language promotion at school and home.

3

The 5 strands of math proficiency



NRC (2001)Kilpatrick et al.

1) Conceptual understanding- comprehension of mathematical concepts, operations, and relations (involves modelling maths, math vocabulary, concept mapping).
2) Procedural fluency- computing (carrying out procedures accurately and efficiently).
3) Strategic competence- represent and solve math problems.
4) Adaptive reasoning- capacity of logical thought, explanation and reflection.
5) Productive disposition- to see maths as worthwhile and useful, coupled with self efficacy.

4

"It's not just the vocabulary words that matter, but understanding the relationships that underlie the words--the fact that 'eight' is one more than 'seven' and one less than 'nine,'

~Goldin-Meadow (2011).

5

The use of language in mathematics differs from the language of ordinary speech in three important ways:

1) Unaffected by time (a slight difficulty lies in forming strong examples of logical principles using ordinary subjects) (Math discourse- It just "is").
2) Lacks emotional content.
3) Distinguishes mathematical from ordinary language (causes enormous difficulty).

Therefore, students need to learn the different tools of language in mathematics in order to be successful.

https://wac.colostate.edu/docs/llad/v4n1/jamison.pdf

6

The National Numeracy Review Report, 2008 (COAG)- Research evidence about the role of language in numeracy learning.

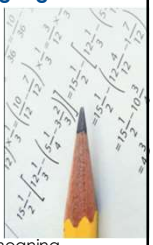
Several issues relating to language and literacy were identified:

1) The specialised symbols and expressions of mathematical language.
2) The use of everyday English terms that have different meanings in mathematics classrooms.
3) Language-based factors in solving mathematical word problems.
4) Communication in the mathematics classroom.
(COAG, 2008)

7

A summary of key linguistic features of the mathematics register is indicative of the different aspects of language involved.

Features in a mathematics classroom:



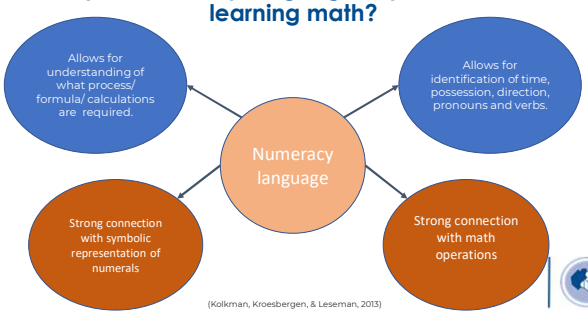
Multiple semiotic register
- mathematics symbolic notation
- oral language
- written language
- graphs and visual displays

Grammatical patterns
- technical vocabulary
- dense noun phrases
- being and having verbs
- conjunctions with technical meaning
- implicit logical relationships.

(Schleppegrell, 2007)

8

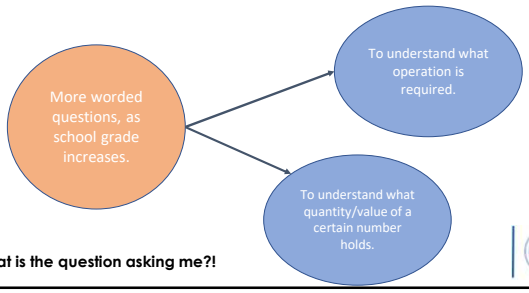
Why is numeracy language important when learning math?



(Kolkman, Kroesbergen, & Leseman, 2013)

9

Why is numeracy language important when learning math?



What is the question asking me?!

10

Decoding worded problems

https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/english/literacy/Pages/lim_translatingwordstosymbols.aspx

11

12

The first step in learning the formal communication of mathematics is in learning definitions (Jamison, 2000).

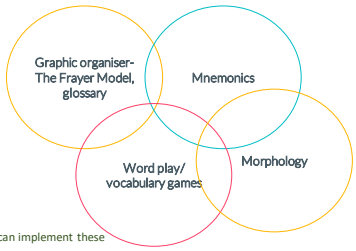
Di Gisi and Fleming (2005) describe three types of vocabulary that students need to be able to solve word problems:

- mathematics vocabulary
- procedural vocabulary
- descriptive vocabulary

https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/english/literacy/Pages/developing_mathematical_understanding.aspx

13

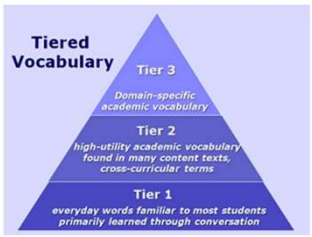
Evidence-based Vocabulary Strategies for SLD students



Teachers, allied health and parents can implement these strategies

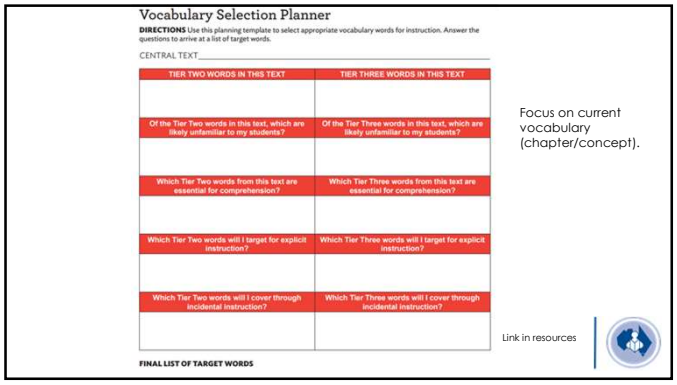
14

Language supporting the learning of mathematics.



Beck, McKeown, and Kucan (2002).

15



Focus on current vocabulary (chapter/concept).

Link in resources

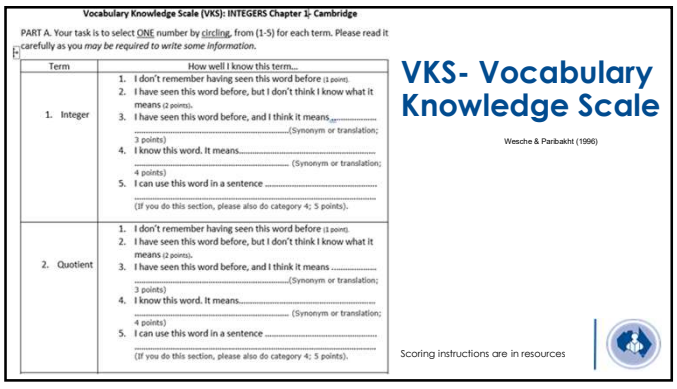
16

Math terms in the classroom:

Frequently ask the student/s:

1) Have you seen this word before?
2) What does it mean in everyday language?
3) What does this mean in the maths classroom?

17

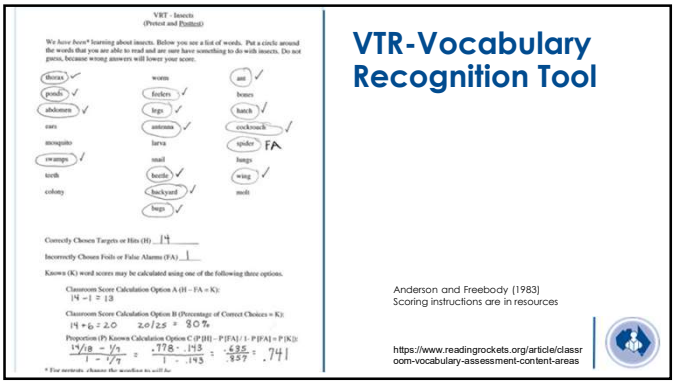


VKS- Vocabulary Knowledge Scale

Wesche & Paribakht (1996)

Scoring instructions are in resources

18


VRT - Insects
(Pretest and Posttest)

We *have been* learning about insects. Below you see a list of words. Put a circle around the words that you are able to read and are sure have something to do with insects. Do not guess, because wrong answers will lower your score.

thorax ✓ | worm | ant ✓
pond ✓ | feelers ✓ | bones
abdomen ✓ | legs ✓ | hatch ✓
ears | antenna ✓ | cockroach ✓
mosquito | larva | spider FA
swamps ✓ | snail | fangs
teeth | beetle ✓ | wing ✓
colony | backyard ✓ | molt
bugs ✓

Correctly Chosen Targets or Hits (H) 19
Incorrectly Chosen Foils or False Alarms (FA) 1
Known (K) word scores may be calculated using one of the following three options.
Classroom Score Calculation Option A (H – FA = K):
19 – 1 = 18
Classroom Score Calculation Option B (Percentage of Correct Choices = K):
19 ÷ 6 = 2.0 20/25 = 80%
Proportion (P) Known Calculation Option C (P[H] - P[FA] / 1- P[FA] = P[K]):
19/19 – 1/1 / 1 – 1/7 = .778 – .143 / 1 – .143 = .635 / .857 = .741

* For materials, choose the wording he will be

VTR-Vocabulary Recognition Tool

Anderson and Freebody (1983)
Scoring instructions are in resources

https://www.readingrockets.org/article/classroom-vocabulary-assessment-content-areas

19

Glossary

Word	Everyday (dictionary)	Mathematical definition (from Mathematics Glossary)
mean	nasty	Also called the **average**. The sum of values in a data set divided by the total number of values in the data set. For example, if a data set consists of the values then the mean is defined as: For example, for the following list of five numbers {2, 3, 3, 6, 8 } the mean equals
average	ordinary or even less than ordinary	Average: Also called the mean. (see above)

In secondary school, textbooks are generally too difficult for struggling readers and require a level of content-specific prior knowledge not typical of this group (Hirsch, 2003).

https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/english/literacy/Pages/lim_everydayandtechnicalterms.aspx

20

MATHEMATICAL HOMONYMS & HOMOPHONES

WORD	MATHEMATICAL MEANING	This word also sounds like _____ but the spelling and meaning is different.	This word can also mean_____ in everyday use.	Dictionary link
add	Number & Algebra (verb) The process of finding the total of two or more numbers or quantities. 'Four add three' would be written as 4 + 3.	ad (abbreviation of advertisement)		https://www.merriam-webster.com/dictionary/add https://www.merriam-webster.com/dictionary/ad
allowed	Permitted To make possible.	aloud		https://www.merriam-webster.com/dictionary/aloud https://www.merriam-webster.com/dictionary/allowed
angle	Measurement & Geometry The measure of turn between two straight lines that meet. A protractor is used to measure an angle. Angles are usually measured in degrees.	ankle	a viewpoint or a standpoint	https://www.merriam-webster.com/dictionary/angle

https://www.westernsydney.edu.au/mesh/mesh/support_and_resources/mathematics_terminology

21

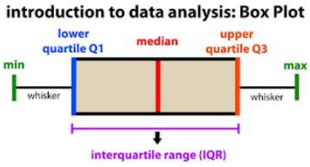
"In terms of meaning-making systems, students must move between written language, oral language, symbolic notation, and graphs and visual displays. They must also become familiar with mathematical grammatical patterns relating to technical vocabulary, use of synonymous verbs, and implicit logical relationships."

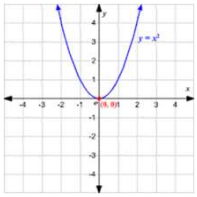
(Schleppegrell, 2007)

22

Language in graphs and statistical displays.

Understanding the language surrounding graphs/statistical data is imperative in order to deconstruct meaning/interpretation.



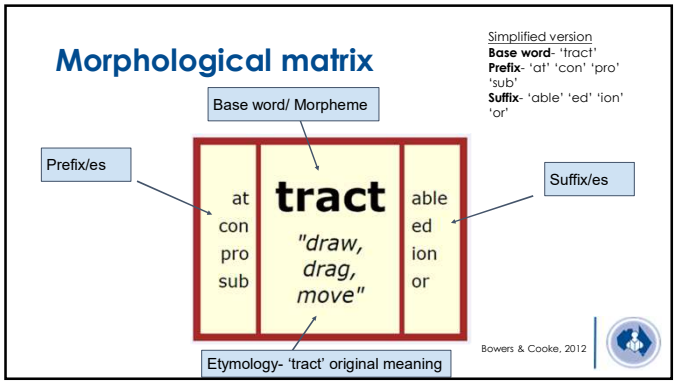


23

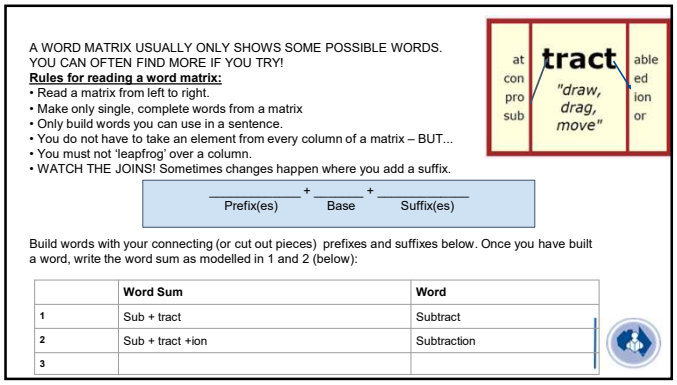
Language in graphs and statistical displays.

Graphs:	Box and whisker:	General:
Axes	Median	Mean
Axial intercept	Outlier	Mode
Axes intercepts	Range	Quantitative data
Turning point	Interquartile range	Qualitative data
Origin	Quartile range	Frequency distribution
Gradient		Population
Plot		Central tendency

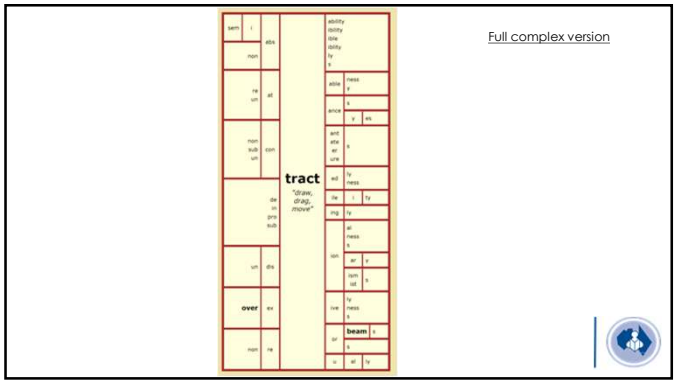
24


Morphological matrix
Simplified version
Base word- 'tract'
Prefix- 'at' 'con' 'pro' 'sub'
Suffix- 'able' 'ed' 'ion' 'or'
Base word/ Morpheme
Prefix/es
Suffix/es
at
con
pro
sub
tract
"draw, drag, move"
able
ed
ion
or
Etymology- 'tract' original meaning
Bowers & Cooke, 2012

25


A WORD MATRIX USUALLY ONLY SHOWS SOME POSSIBLE WORDS.
YOU CAN OFTEN FIND MORE IF YOU TRY!
Rules for reading a word matrix:
• Read a matrix from left to right.
• Make only single, complete words from a matrix
• Only build words you can use in a sentence.
• You do not have to take an element from every column of a matrix – BUT…
• You must not 'leapfrog' over a column.
• WATCH THE JOINS! Sometimes changes happen where you add a suffix.
_____ + _____ + _____
Prefix(es) Base Suffix(es)
Build words with your connecting (or cut out pieces) prefixes and suffixes below. Once you have built a word, write the word sum as modelled in 1 and 2 (below):
at
con
pro
sub
tract
"draw, drag, move"
able
ed
ion
or
Word Sum
Word
1
Sub + tract
Subtract
2
Sub + tract +ion
Subtraction
3

26


Full complex version
tract
"draw, drag, move"
over
beam

27

Math Morphemes (Ron Yoshimoto compilation)

morpheme	meaning	sample word	morpheme	meaning	sample word
alt	high	altitude	nom	name	denominator
circum	around	circumference	numer	number	numerator
col/com/con	with/together	collinear	oid	resembling	trapezoid
de	down/away	denominator	para	beside	parabola
dia	across	diagonal	pend	hang	perpendicular
digit	finger	digital	peri	around	perimeter
equi	equal	equilateral	ply/plic	fold	multiply
fer	bring/carry	circumference	put(e)	think	compute
fract	break	fraction	radi	ray	radius
gon	angle	polygon	rect	right/straight	rectangle
grade	step	centigrade	sect	cut/divide	bisect
gram/graph	write	kilogram	sphere	ball	spherical
hedron	sided object	tetrahedron	sub	below/under	subtract
hypo	under	hypotenuse	sym/syn/syl	with/together	symmetric
inter	between/ among	intersect	tang	touch	tangent
			therm	heat	thermometer
iso	equal	isosceles	tract	drag/pull	protractor
lat	side	collateral	verse/vert	turn	vertex
lin	line	collinear			
medi	middle	median			
meter/metry	measure	symmetrical			
mut	change	commutative			

(Morphology Matters, William Van Cleave, 2019)

28

Math Morphemes (Ron Yoshimoto compilation)

Number Prefixes

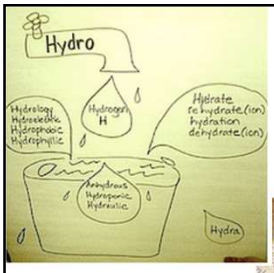
#	*Latin*	*sample word*	*Greek*	*sample word*
1	uni-	unicorn	mono	monopoly
2	bi	bicycle	di	digraph
	du(o)	dual		
3	tri	tricycle	ter	tertiary
4	quadr/quar	quarter	tetra	tetragon
5	quint	quintuplets	pent	pentagon
6	sex	sextuplets	hex	hexagon
7	sept	septuplets	hept	heptagon
8	octa/octo*		octa/octo*	octagon
9	nona/nove	November		
10	dec/deca/deci*		dec/deca/deci*	decade
100	cent	cent	hect	hectogram
1000	mille	millipede	kilo	kilometer

* same for Latin and Greek

(Morphology Matters, William Van Cleave, 2019)

29

Word Parts: Ceiling Spiders



https://keystoliteracy.com/blog/using-morphology-to-teach-vocabulary/

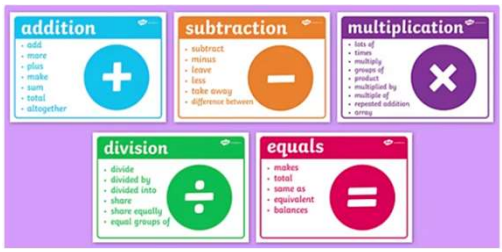
30

Language continues to help students move from concrete math skills based in physical objects toward a more symbolic math ability focused on numerals.

(Kolkman, Kroesbergen, & Leseman, 2013).

31

Learning math symbols = knowledge of context



Via Twinkl.com

32

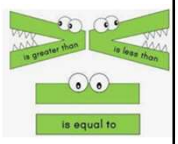
Symbols with no context…

✚	+ 24	32 + 567	+406 567 502
▬	-98	73 - 23	-7°C
✖	5 x 4	5 + 5 + 5 + 5	3 x 150ml beakers
➗	$\frac{10}{5}$	8 ÷ 4	8/4

What does this all mean?

33

Variations on the equals sign:



$\neq$ which means 'is not equal to'

$\approx$ which means 'is approximately equal to'

$\geq$ which means 'is greater than or equal to',
e.g. $x \geq 2$ means that x can equal 2, but it might also be any value larger than 2.

$\leq$ which means 'is less than or equal to',
e.g. $y \leq 7$ means that y might equal 7 or might be any number less than 7.

http://www.mathcentre.ac.uk/resources/uploaded/mc-ty-mathlanguage1-2009-1.pdf

34

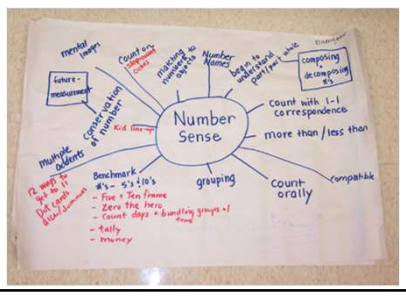
Mathematical symbols- student sheet

x^2	x^3	$\sqrt{x}$	$\sqrt[n]{}$	^	$\sqrt[3]{x}$	≤	≥	<	>
squared	cubed	square root	radical	exponent (raise to a power)	cube root	less than or equal to	more than or equal to	less than	more than
=	≠	{ }	( )	[ ]	$\bar{x}$	≈	∴	||	|||
equal to	not equal to	brackets	brackets	brackets	mean	approximately equal to	therefore	parallel	similar
≅	/	÷	·	×	.	∞	°F	°C	θ
congruent	divide by	fraction bar	multiply by	*	decimal point	infinity	degrees Fahrenheit	degrees Celsius	theta
°	AB	∠	∑	∫	π	+	−	±	⊥
degrees	ray AB	angle	sum of	integral	pi 3.14159...	addition or positive	subtraction or negative	plus or minus	perpendicular to
!	%	$	£	€	¢	:	Δ	∪	∩
factorial	percent	dollars	pounds	euros	cents	ratio	discriminant	union	intersection

Via Twinkl.com .au

35

Concept mapping



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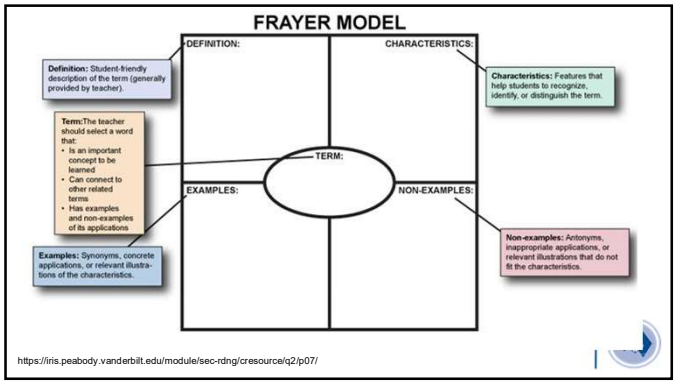
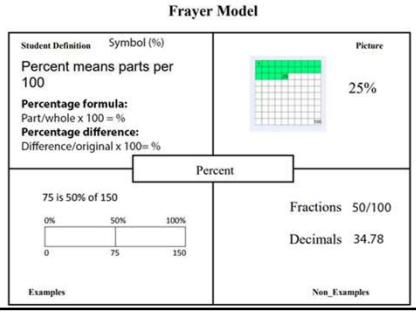


37

Frayer model to build vocabulary



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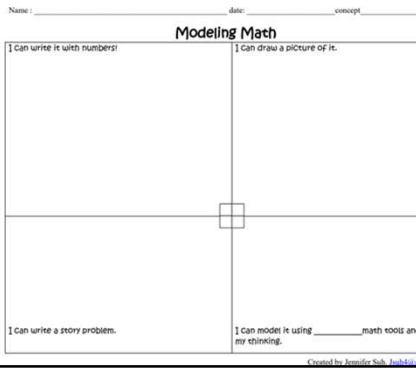

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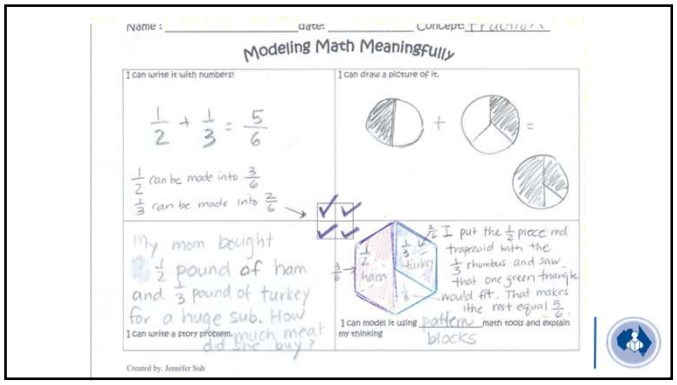

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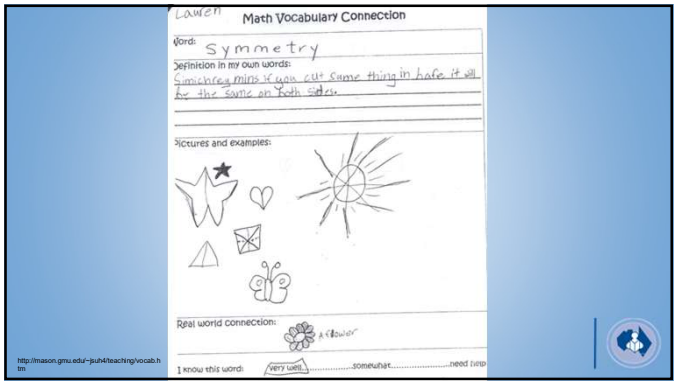
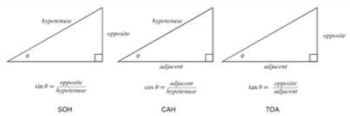


41

Mnemonics

SOHCAHTOA



"SOHCAHTOA" is a helpful mnemonic for remembering the definitions of the trigonometric functions sine, cosine, and tangent i.e., sine equals opposite over hypotenuse, cosine equals adjacent over hypotenuse, and tangent equals opposite over adjacent,

42

BIDMAS (acronym)

Order of Operations

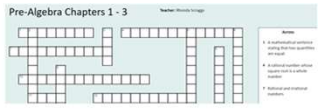
B	Brackets	$10 \times (4 + 2) = 10 \times 6 = 60$
I	Indices	$5 + 2^2 = 5 + 4 = 9$
D	Division	$10 + 6 \div 2 = 10 + 3 = 13$
M	Multiplication	$10 - 4 \times 2 = 10 - 8 = 2$
A	Addition	$10 \times 4 + 7 = 40 + 7 = 47$
S	Subtraction	$10 + 2 - 3 = 5 - 3 = 2$

43

https://www.educationquizzes.com/knowledge-bank/what-are-bodmas-bidmas-and-pemdas/

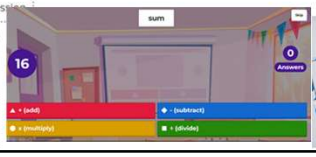
44

Game play- supporting numeracy language



Jeopardy- define, synonym, antonym and sents

KAHOOT



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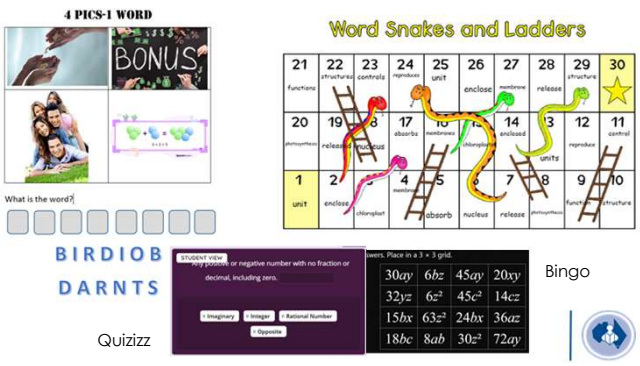


46

Environment- supporting numeracy language for SLD students

- Glossary poster with definitions and accompanied pictures/diagrams.
- Quick reference cards.
- Repetition of important terms or concepts over an extended period of time.
- Incorporate Interleaved practice.
- Explicit instructions.
- Ongoing planned revision, and purposeful use of key mathematical vocabulary(e.g. talking, listening, writing), is key for ensuring all students retain use of language.
- Giving mathematical concepts relevance to everyday life.
- Promoting numeracy language throughout all subjects in secondary school (i.e., Goos, Geiger, and Dole (2014) model).
- Highlight/underline key vocabulary terms in a question and unpack the meaning.
- Hosting Numeracy nights with parents/students- playing games.

47

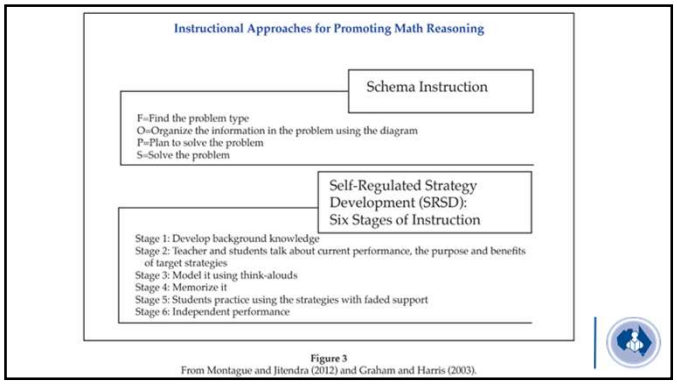
Lastly, supporting math reasoning…

In the classroom to assist with math reasoning skills of students who struggle with Math (who have specific learning difficulties) use:

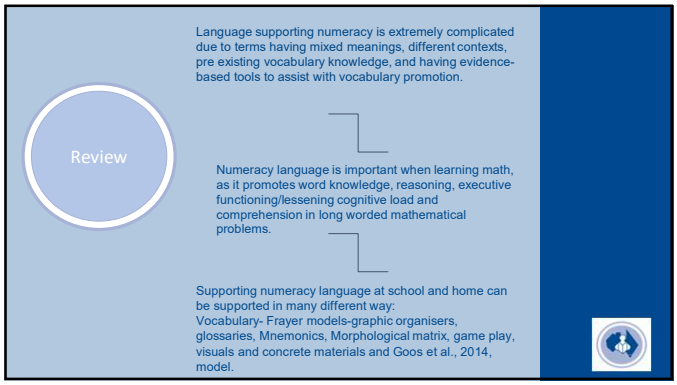
1) Explicit instruction.
2) Student verbalization of their reasoning.
3) Visual representations to solve word problems.
4) Heuristics.
5) Range and sequence of examples.
6) Peer-assisted learning.

Kiuhara et al., 2014

48


Instructional Approaches for Promoting Math Reasoning
Schema Instruction
F=Find the problem type
O=Organize the information in the problem using the diagram
P=Plan to solve the problem
S=Solve the problem
Self-Regulated Strategy Development (SRSD): Six Stages of Instruction
Stage 1: Develop background knowledge
Stage 2: Teacher and students talk about current performance, the purpose and benefits of target strategies
Stage 3: Model it using think-alouds
Stage 4: Memorize it
Stage 5: Students practice using the strategies with faded support
Stage 6: Independent performance
Figure 3
From Montague and Jitendra (2012) and Graham and Harris (2003).

49

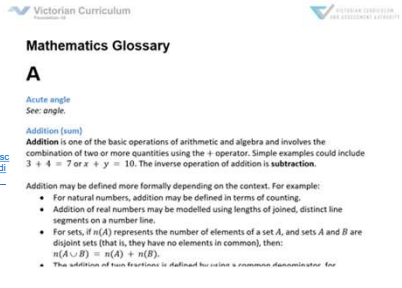

Review
Language supporting numeracy is extremely complicated due to terms having mixed meanings, different contexts, pre existing vocabulary knowledge, and having evidence-based tools to assist with vocabulary promotion.
Numeracy language is important when learning math, as it promotes word knowledge, reasoning, executive functioning/lessening cognitive load and comprehension in long worded mathematical problems.
Supporting numeracy language at school and home can be supported in many different way:
Vocabulary- Frayer models-graphic organisers, glossaries, Mnemonics, Morphological matrix, game play, visuals and concrete materials and Goos et al., 2014, model.

50


Thank you
Questions?
www.ldaustralia.org
enquiries@ldaustralia.org
@LearningDifficultiesAustralia
@LD_Australia

51

Helpful Resources


Victorian Curriculum

Mathematics Glossary

A

Acute angle
See: angle.

Addition (sum)
Addition is one of the basic operations of arithmetic and algebra and involves the combination of two or more quantities using the + operator. Simple examples could include $3 + 4 = 7$ or $x + y = 10$. The inverse operation of addition is **subtraction**.

Addition may be defined more formally depending on the context. For example:

- For natural numbers, addition may be defined in terms of counting.
- Addition of real numbers may be modelled using lengths of joined, distinct line segments on a number line.
- For sets, if $n(A)$ represents the number of elements of a set A, and sets A and B are disjoint sets (that is, they have no elements in common), then: $n(A \cup B) = n(A) + n(B)$.

https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/english/literacy/Pages/lim_everydayandtechnicalterms.aspx

52

Helpful Resources- glossaries:

Statistical terms and concepts (ABS):
https://www.abs.gov.au/statistics/understanding-statistics/statistical-terms-and-concepts

Homonyms and homophones mathematical glossary:
https://www.westernsydney.edu.au/__data/assets/pdf_file/0009/1628244/Mathematical_homonyms_and_homophones.pdf

Etymology assist with base word origins):
https://www.etymonline.com/

Mathwords (An interactive math dictionary with enoughmath words, math terms,math formulas, pictures, diagrams, tables, and examples)
http://www.mathwords.com/

MathCentre (gives information on the appropriate use of symbols)
http://www.mathcentre.ac.uk/resources/uploaded/mc-ty-mathlanguage1-2009-1.pdf

53

Helpful Resources- graphic organisers:

Frayer model template
https://iris.peabody.vanderbilt.edu/wp-content/uploads/modules/sec-rdng/pdfs/sec_rdng_07_link_Frayer.pdf#content

Vocabulary Selection Planner
https://www.learningforjustice.org/sites/default/files/2017-07/6-12WW_Vocabulary%20Selection%20Planner.pdf

Morphology Matrix- maker
http://www.neilramsden.co.uk/spelling/matrix/

Modeling maths graphic organiser
http://mason.gmu.edu/~jsuh4/teaching/Modeling%20Math.pdf

54

Helpful Resources- game links

Crossword maker- maths (make or print FREE math crosswords- hundreds to choose from)
https://mycrosswordmaker.com/Browse/Math

Word Search- maths (make or print FREE math word searches)
https://mywordsearch.com/Browse/Math

Mathstaters BINGO
https://mathsstarters.net/bingo

Kahoot
https://kahoot.com/schools-u/

Quizizz
https://quizizz.com/admin

55

Helpful resources- VKS Scoring

Scoring:

1= 1 point, 2= 2 points, 3 (Synonym or translation) = 3 points, 4 (Synonym or translation)= 4 points & 5 = 5 points per word.

Incorrect response:

- Incorrect response in category 3 = **2 points** for the total item even if the student attempted category 4 and category 5 unsuccessfully.
- If the sentence in category 5 demonstrates the correct meaning but the word is not used appropriately in the sentence context= **3 points**.
- **4 points** are given if the wrong grammatical form of the target word is used in the correct context.
- A score of 5 reflects semantically and grammatically correct use of the *target* word.

56

Helpful resources- VKS Scoring

Scoring:

Any incorrect response:

- In category 3 yields a score of 2 points for the total item even if the student attempted category 4 and category 5 unsuccessfully.
- If the sentence in category 5 demonstrates the correct meaning but the word is not used appropriately in the sentence context, a score of 3 is given.
- In category 5, a score of 4 is given if the wrong grammatical form of the target word is used in the correct context.
- A score of 5 reflects semantically and grammatically correct use of the *target* word.

57

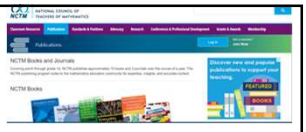
Helpful resources- VRT Scoring

Scoring:

- A correction formula was applied to obtain a score that adjusts for possible guessing.
- A student scored a "hit" (H) when the word was circled correctly
- A student scored a "false alarm" (FA) if an unrelated word was incorrectly circled.
- The proportion of words truly known, P(K), was determined with the following formula: P(K) = P(H) - P(FA) / 1 - P(FA)

58

Further reading



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- Evans, David. (2017). Examining the Literacy within Numeracy to Provide Access to the Curriculum for All. 10.1108/S1479-363620170000011003.
- Extensive collection of published writings on many aspects of mathematical language https://www.nctm.org/Publications/Publications-Main-Page/
- Mathematics Instruction for Students with Learning Disabilities or Difficulty Learning Mathematics https://files.eric.ed.gov/fulltext/ED521890.pdf

59

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60