Sport and Exercise Science Numeracy Project

A collaboration between SES and MESH
Western Sydney University

How good is our instrument?
Rasch analysis

Outline

- Multiple choice style questions…limitations…Rasch helps
- Assess quality of instrument using Rasch analysis and Classical Theory
- Item by item… difficulty and discrimination
- Wright variable map comparing item difficulty to student ability/ latent trait
- What is the latent trait/construct?
- Develop subscales/sub domains for numeracy construct
- Modify pilot instrument based on results of Rasch analysis
- Develop developmental learning pathway/hypothetical learning trajectory based on clusters of item difficulty
- Identify best practice approach for teachers embedding some of these subdomains in SES practice

Rasch modelling in maths education

Quantitative data → Qualitative analysis

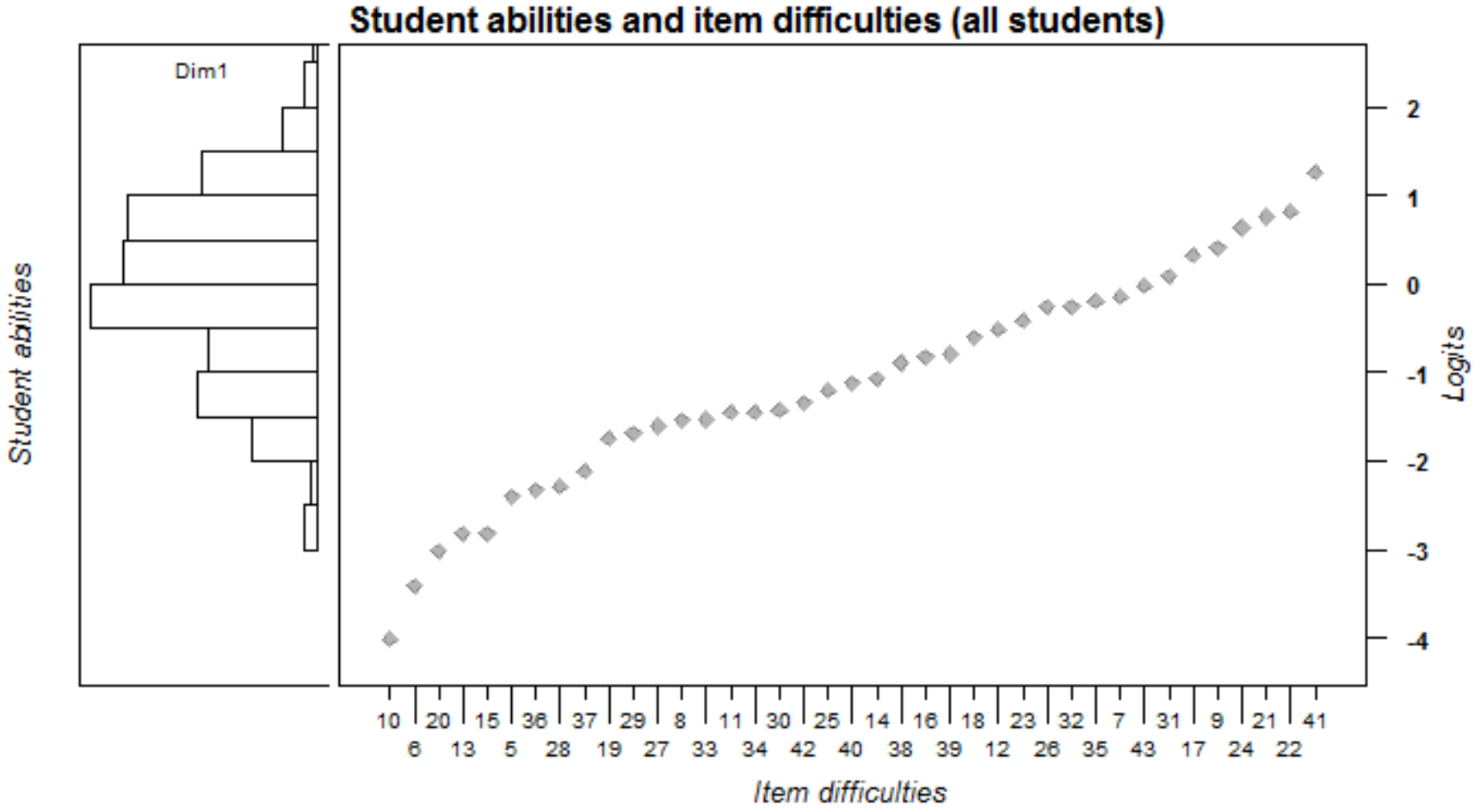
Rasch measurement is being used increasingly as a research tool by 'mainstream' researchers to identify performance interactions between persons and items.

Using the performance interactions between persons and items, we can:

- produce an ordered conjoint measurement scale of both people and items
- examine the behaviour of persons in relation to a particular set of items
- identify and examine developmental pathways
- examine the behaviour of sets of items in relation to particular sub-groups of persons in order to identify the extent to which the chosen items measure the core mathematical constructs the researcher was intending to measure.

Callingham and Bond (2006, page 1)
Mathematics Education Research Journal 2006, Vol. 18, No. 2, 1-10

Rasch analysis :
Student ability v item difficulty



A item-person map comparing student ability / latent trait to item difficulty

Can you order these by difficulty?

10. Which number is larger, 0.8 or 0.653?

    A. *0.8
    B. 0.693
    C. They are the same size
    D. Don't know

22. Jane's average improved from 25 to 40 goals per match.
    Emma's average improved from 30 to 45 goals per match.

    Who improved the most, relative to their first average?

    A. *Jane
    B. Emma
    C. They improved equally
    D. Don't know

40. If blood flow through an artery is 0.5 litres per second, how much blood (in litres) passes through the artery in 60 seconds?

    A. 120 L
    B. *30 L
    C. 60.5 L
    D. < 1 L
    E. Don't know

Item discrimination

Raw score / item score correlation can be used to determine the so-called point-biserial discrimination of an item – e.g., if an item is easy, are more of the higher ability students (than low ability students) getting it right?

The rule of thumb to identify well-performing items:

PB discrimination > 0.4

(though > 0.3 is still good for most applications)

Note that items at either end of the difficulty scale – i.e. items that most got right or most students got wrong – tend to have lower PB discrimination.

Instrument quality

- Performed Rasch analysis of data from pilot instrument 2016
- Examined item difficulty and poorly discriminating items
- In most cases an item's poor discrimination was due to factors such as:
  - too easy/difficult
  - poor wording
  - correct answer could be guessed
  - incorrect reasoning could give correct answer
- Amended questions for 2017 instrument based on the above.

Using the Rasch model

Using Rasch modelling we can:

- test for construct validity (item fit, person fit, differential item functioning)
- look for clusters of items ordered by difficulty
- look for a possible learning development continuum
- predict student success knowing their ability
- inform potential targeted teaching/ intervention.

What is the latent trait we are investigating?

Numeracy

Contemporary frameworks and models of numeracy suggest being numerate involves having:

- fluency in mathematical skills and requisite knowledge
- a clear understanding of the contextual requirements
- the disposition to choose and use the mathematics appropriate to the context with confidence
- a critical appreciation of how mathematics can be used, and misused, in order to question or judge the appreciation of its use

What do we mean by 'fluency'?

Siemon, D. et al (2015)

Fluency & number sense

The best way to develop fluency with numbers is to develop number sense and to work with numbers in different ways, not to blindly memorize without number sense.

Jo Boaler 2015

What is number sense?

Number sense is a critical component of numeracy

(AAMT 1997)

'Number sense' as used by maths educators refers to a capacity based on meaningful relationships between numbers and number operations as these are variously represented in different contexts

Siemon page 202

- A disposition to make sense of number
- Flexible mental computation
- Numerical estimation
- Compose and decompose numbers
- **Recognise and deal with relative and absolute magnitudes**
- Use benchmarks to estimate
- Make connections between different representations
- Understand effects of arithmetic operations and invent strategies

Sowder1992 in Siemon 2015

Fluency Australian curriculum def.

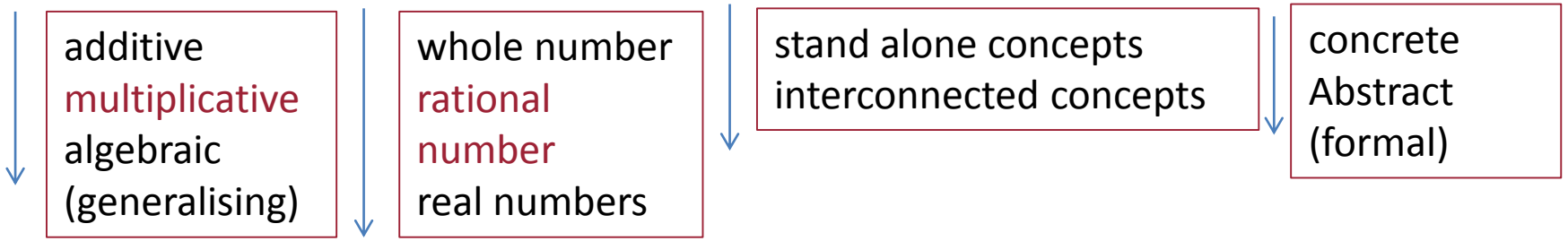
Students develop skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily.

Students are fluent when they

- calculate answers efficiently
- recognise robust ways of answering questions
- choose appropriate methods and approximations
- recall definitions and regularly use facts
- can manipulate expressions and equations to find solutions

http://v7-5.australiancurriculum.edu.au/mathematics/content-structure

Number sense & progressive conceptual fields



The *multiplicative* conceptual field includes:

- rational number
- ratio and rate
- describing change

Proportional reasoning:

Proportional reasoning is a threshold concept

Lesh, Post & Behr, (1988) view proportional reasoning as a pivotal concept.

- it is the capstone of children's elementary school arithmetic
- it is the cornerstone of all that is to follow.

Proportional reasoning:

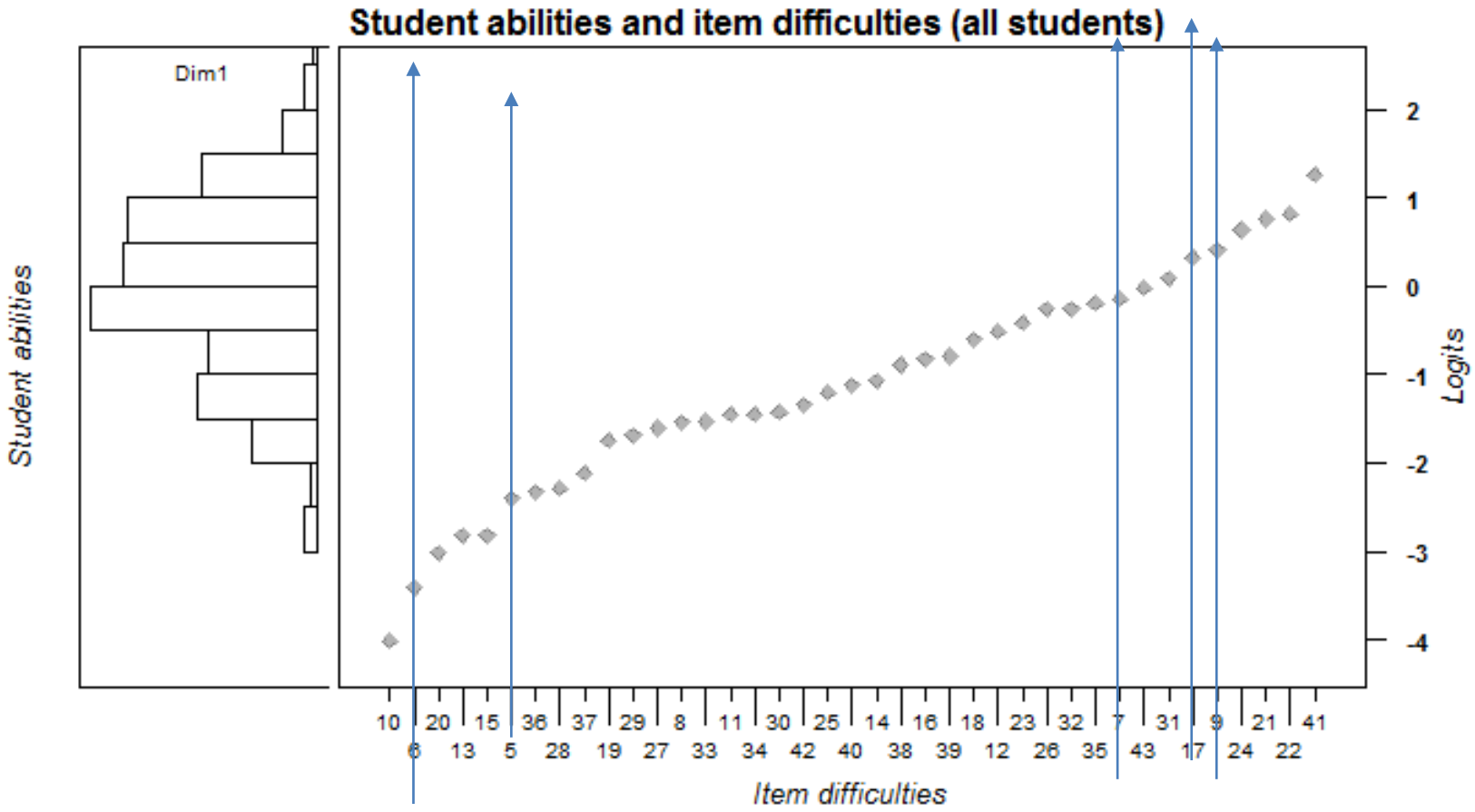
- a threshold concept (Frith)
- pervasive in science (Dole)

Our ‘working’ sub-domains

Sub-domains of number sense relating to proportional reasoning arising from our instrument:

- fractions
- decimals, place value, converting metric units
- percentage
- ratio, rates and proportional thinking
- rate graphs (linear and non-linear)
- coordinate geometry (relating to gradient) algebraically and graphically
- algebra (change the subject & evaluate the subject)
- binary question (know / don’t know definition, formula, procedure etc.)
- number of steps/ interconnected concepts
- procedural/formula

Example: fraction sub-domain



Thank you and questions

Some of our references

Declines
Wilson R & Mack
Gordon and Nicholas
Barrington
Nicholas, Poladian, Mack, Wilson R
McPhan, Morony, Pegg, Cooksey, Lynch

Numeracy testing at tertiary level
Jennings
Groen, Coupland, et al

Testing Numeracy in SES
Anderton et al
Wilson T
McNaught & Hoyne

Numeracy at FY university
Brady
Varsavsky
Wilson T and MacGillivray

Rasch modelling
Griffin
Wu
Mayes

Rasch modelling in Maths education research
- Callingham & Bond
- Watson
- Long, Wendt & Dunne
- Misailidou
- Siemon

Maths Education research into numeracy and proportional reasoning
- Lamon
- Siemon
- Dole
- Boaler
- Hilton G, Hilton A , Goos, Clarke D, Wright