Characterising the underlying dysfunctional attitudes and stances students in biology and medicine adopt when faced with calculations

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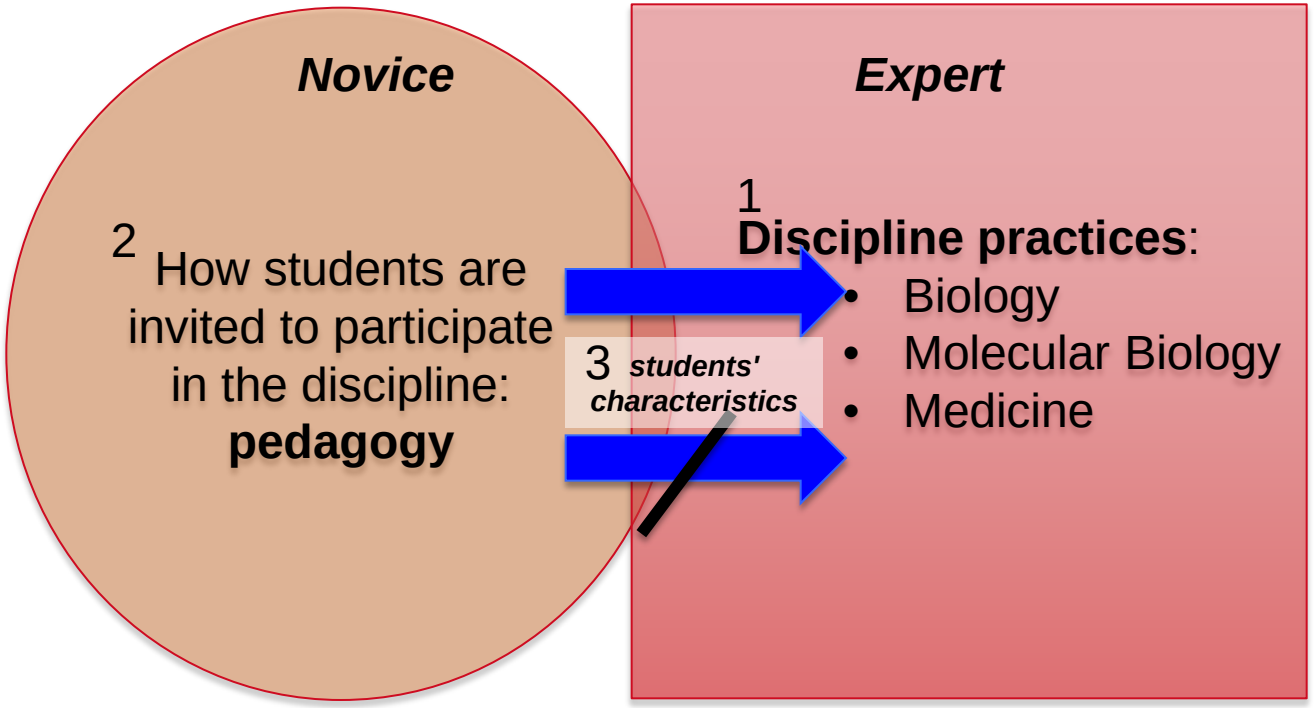
Academic Numeracy in Undergraduate Science and Medicine

Classroom observations and conversations with our students tell us that many (up to 50%) of our students are maths anxious and/or maths avoiders and/or lack confidence.

Maths as a disabling **transferable anxiety** rather than an enabling transferable skill.

- **When People Worry About Math, the Brain Feels the Pain**
- ScienceDaily (Oct. 31, 2012) — Mathematics anxiety can prompt a response in the brain similar to when a person experiences physical pain, according to new research at the University of Chicago.

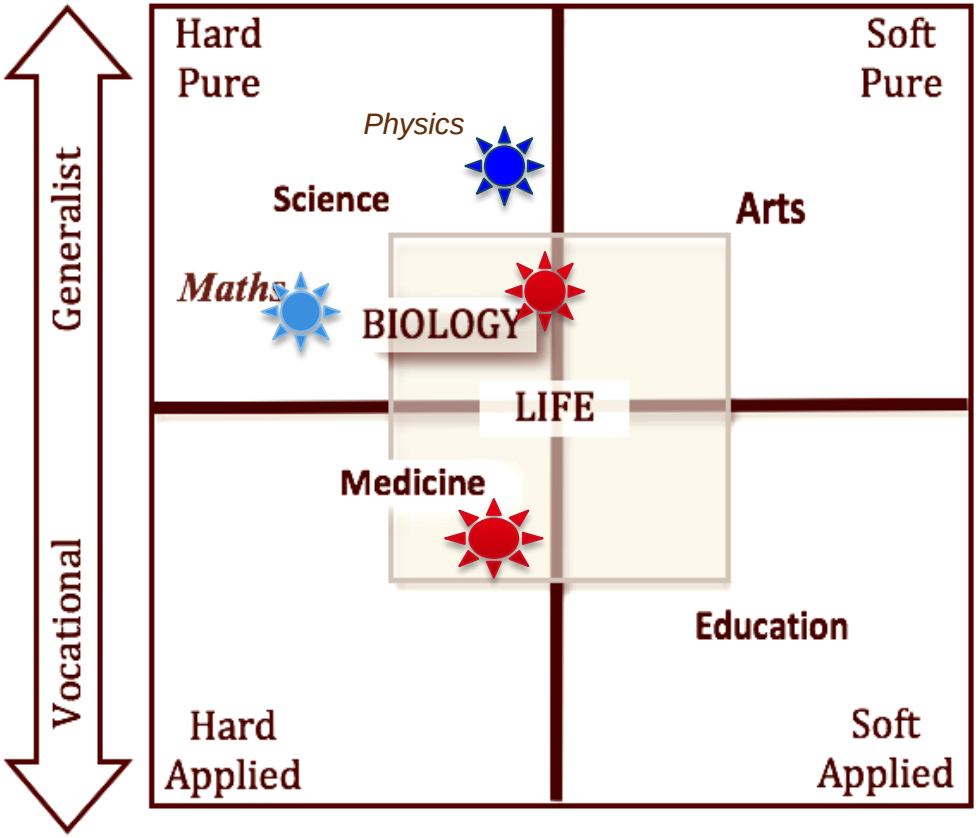
Aligning our discipline practices with the pedagogy of our discipline



Episteme or system of understanding discipline (hypothesis testing); discipline teaching practices/pedagogy; examine students' abilities, inclinations and sensitivities.

Exploring what lies at the heart of students reluctance to participate, with reference to our disciplines.

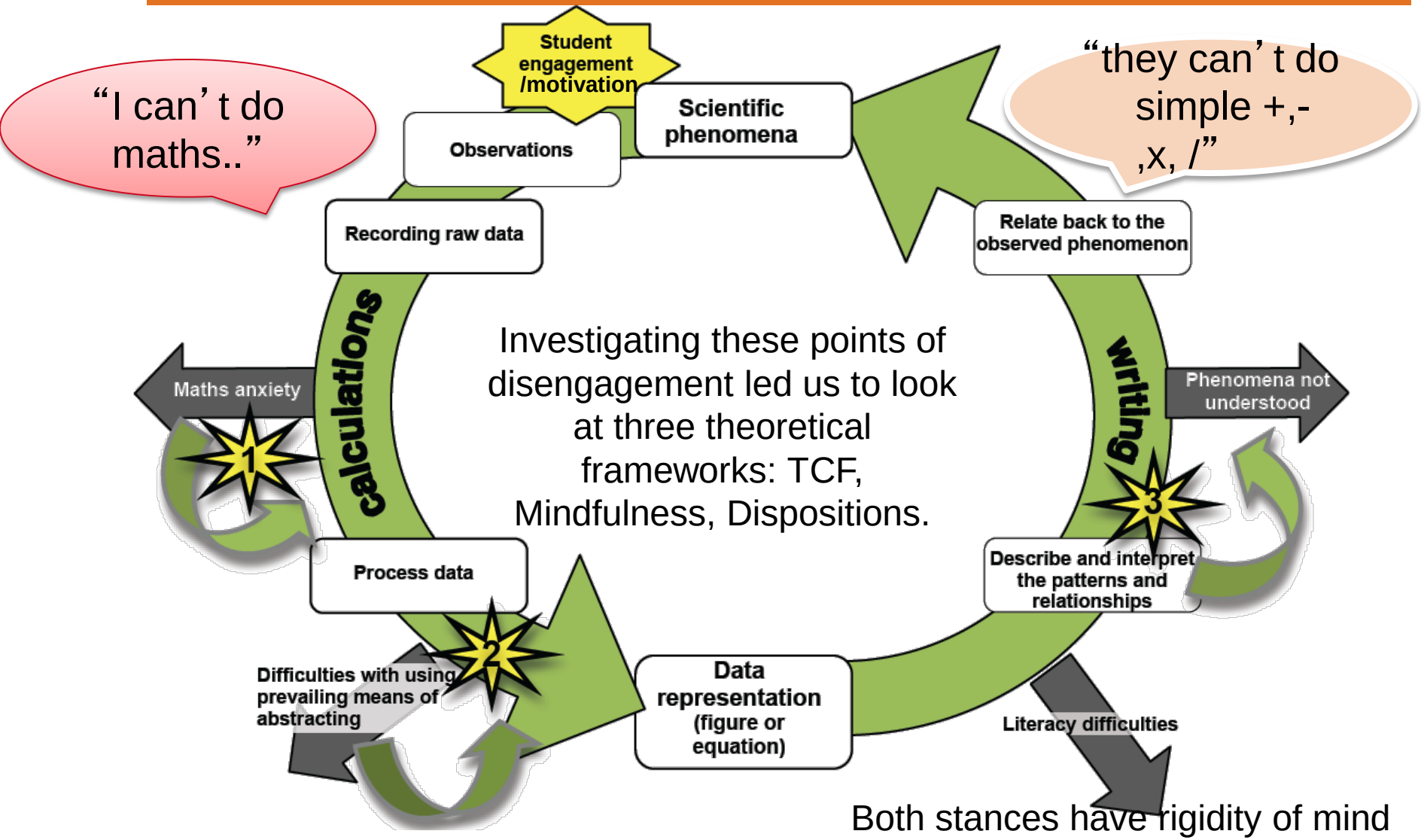
•Biglan's (1973) work examined academic practices and found differences between those practicing in *applied* and *pure* disciplines, and *soft* and *hard* disciplines; maths, physics and biology all "hard, pure". Medicine *hard, applied*



•'life' disciplines 'team' practices.

- Why is having to work with numbers a surprise for students in *Science*? Working with measurements seems to be seen as 'maths' rather than 'science'.
- Why are we so surprised that some students find calculations so problematic?
- Are both teacher and student assuming rigid and so dysfunctional postures?

Quantitative Skills in Science – experiential learning



"I can't do maths.."

"they can't do simple +,- ,x, /"

Investigating these points of disengagement led us to look at three theoretical frameworks: TCF, Mindfulness, Dispositions.

Both stances have rigidity of mind

Essentially this is asking students to write a lab report – biology this starts in first year; Med students this is critical evaluation of the literature (stat. inference).

THRESHOLDS, MINDFULNESS, DISPOSITIONS

Meyer & Land

Transformative: Once understood, a threshold concept changes the view of the discipline.

Troublesome: Threshold concepts are likely to be troublesome for the student.

Irreversible: Given their transformative potential, threshold concepts are also likely to be irreversible, i.e. they are difficult to unlearn.

Integrative: Threshold concepts, once learned, are likely to bring together different aspects of the subject.

Bounded: A threshold concept will probably delineate a particular conceptual space, serving a specific and limited purpose.

Discursive: Meyer and Land suggest that the crossing of a threshold will incorporate an enhanced and extended use of language.

Reconstitutive: may involve dismantling and then re-learning.

Liminality: Meyer and Land have likened the crossing of the pedagogic threshold to an ethnographic initiation or crossing a transitional or liminal space and may involve messy journeys back, forth and across conceptual terrain.

Thresholds Concepts Framework was useful to start to think about why some students disengage from our classes.

THRESHOLD CROSSED - ENGAGEMENT

Particularly the pre-liminal/liminal space, how to get students to threshold?

PRE-LIMINAL

LIMINAL SPACE

THRESHOLDS, MINDFULNESS, DISPOSITIONS

Langer +Yeganeh & Kolb

MINDLESSNESS

MINDFULNESS

Langer's description of *mindlessness* resonates with *preliminality*; both describe a rigidity of mind and lack of awareness.

'Mindfulness is a flexible state of mind in which we are actively engaged in the present, noticing new things and sensitive to context…"

With respect to numeracy mind*less*ness equates to students professing not to be able to "do maths" or not seeing its relevance and therefore not being motivated to exercise mathematical thinking or reasoning in the context of biology.

"I can't do maths…"

"they can't do simple +,-,x, /"

The notion of 'Mindlessness' was useful to begin to characterise the rigidity of mind of students who disengaged.

PRE-LIMINAL

LIMINAL SPACE

THRESHOLDS, MINDFULNESS, DISPOSITIONS

Perkins et al.

Triadic component of Dispositions

Abilities **are about what someone "can do" - being critical, strategising and demonstrating rigour.**

Sensitivities **are about "alertness" to lack of rigour, adopting the thinking of a discipline expert.**

Inclinations **are about motivation to engage, intrinsic and/or extrinsic.**

The framework of *thinking dispositions* proposed by Perkins and his colleagues offers insight into how to characterise thinking in the ***liminal space*** when students are learning about the discipline; the triad, comprising *inclinations* and *sensitivities* in addition to the *abilities*, are required for *good thinking*.

PRE-LIMINAL

LIMINAL SPACE

Triadic components of dispositions

inclinations	sensitivities	abilities
Positive inclination here seem to align with attributes of one who is "intrinsically" motivated and/or sees relevance of academic numeracy. • Negative inclinations would be student who is amotiviated*, disengaged. "I can't do maths", "this isn't relevant" etc. Inclination to engage.	These sensitivities are about "alertness" to lack of rigour, adopting the thinking of an expert. • Students to be able to practice our practice; plot data appropriately, troubleshoot protocols; design experiments. Adopting the thinking of the expert.	Abilities are about being critical, strategising, and demonstrating rigour and being able to do the prac work. • Students to develop not only their ability "to do" but confidence with practicing their abilities. Practicing like an expert.
Motivated, open, flexible, ready to be liminal (?)	Sensitivities developed…	…by doing the pracs

*__amotivation__: disengagement happens when students are asked to do something they don't like or they are uncomfortable with "grappling"... Revert to the rigidity of mind that characterises the preliminal space.

THRESHOLDS, MINDFULNESS, DISPOSITIONS

Meyer & Land, Langer +Yeganeh & Kolb, Perkins et al.

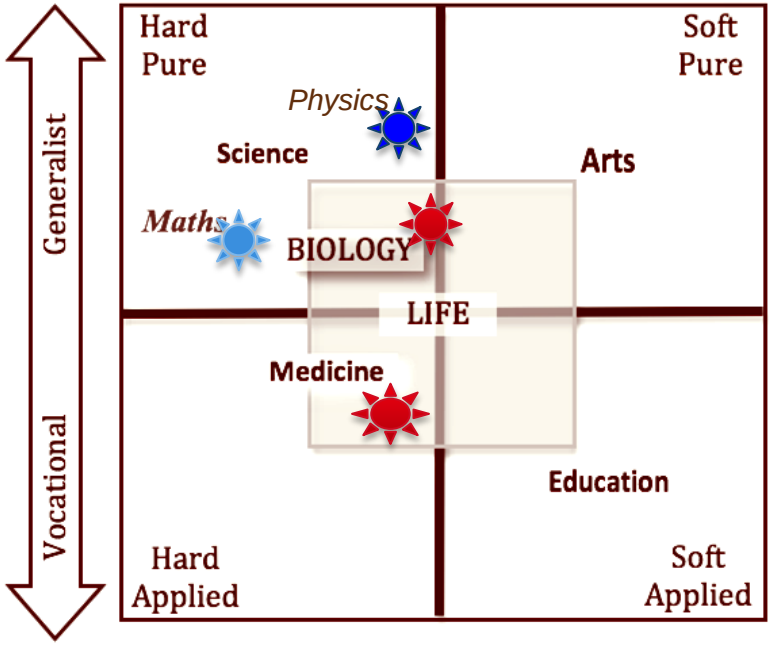
MINDLESSNESS	Triadic Dispositions	MINDFULNESS
Students with low confidence tend to be *reluctant to engage and to demonstrate their abilities* in data-handling exercises. We hear from them **"I can't do maths"** which a reflection of their self-doubt as to whether they can "do it".	***Abilities* are about being critical, strategising and demonstrating rigour; practicing like an expert.**	Able students are learning how to practice like an expert and are **confident** with **transferring** their numeracy skills across disciplines. These students pass easy across the liminal space.
Negative inclinations manifest as *amotiviation.* With respect to academic numeracy, we hear **"this isn't relevant"**. We assert that for some students, negative inclinations are tied up with poor numeric confidence.	***Inclinations* are about motivation, intrinsic and/or extrinsic.**	Positive inclinations align with attributes of students **who are "intrinsically" motivated and/or see relevance to their degree i.e. "extrinsic" motivation.** These students are inclined to enter the liminal space. **Different motivation in different disciplines.**
The sensitivities of a biologist are <u>not</u> the same as a mathematician when it come to numeracy; **student disengagement through misaligned sensitivities because they bring their <u>maths</u> sensitivities with them** e.g. there being a 'right' answer.	***Sensitivities* are about "alertness" to lack of rigour, adopting the thinking of a discipline expert.**	**Students here are learning to adopt the judgment of the discipline** expert and, perhaps, appreciate they have entered the liminal space. **It's not maths, it is science.**
PRE-LIMINAL		LIMINAL SPACE

ENGAGEMENT

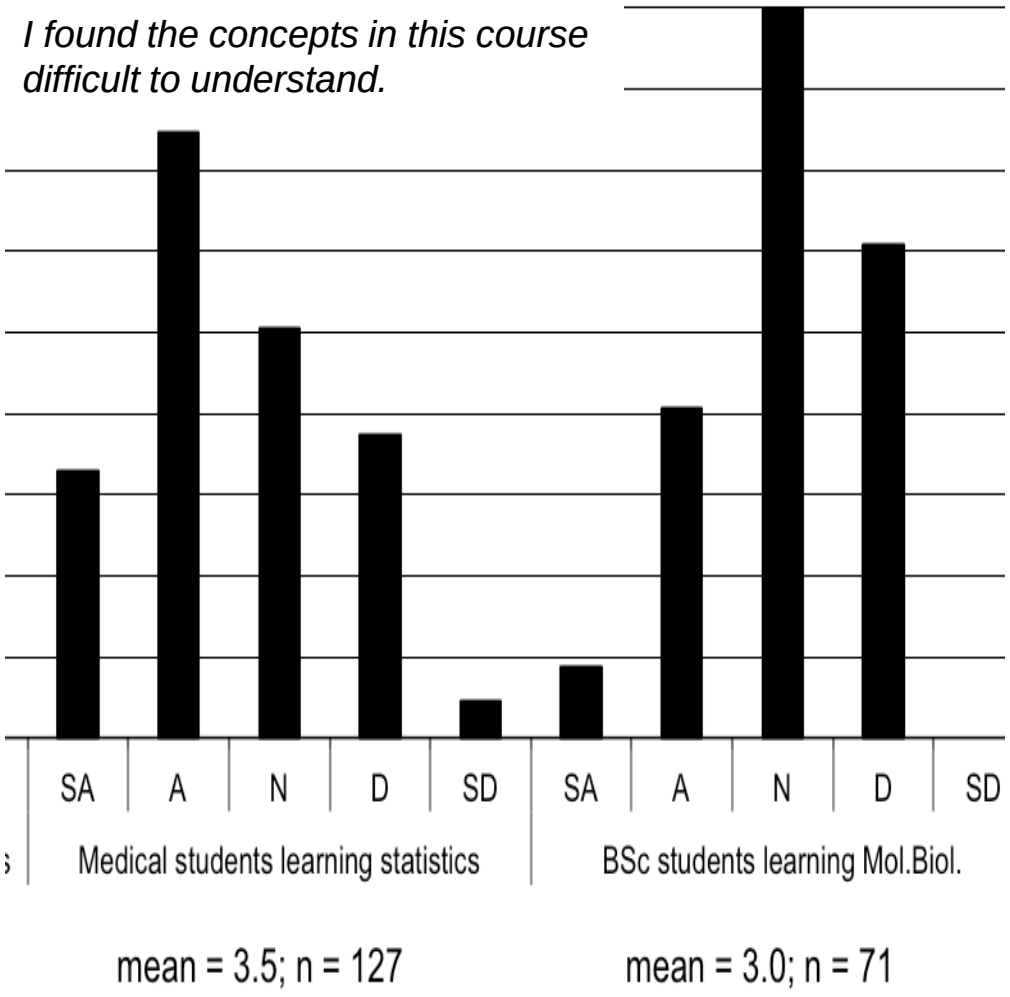
A continuation of our work into learning in the 'hard' disciplines

- Can student's perceptions of 'what was difficult about learning' and 'what did you like learning about the most' predict whether they are remaining preliminal or are demonstrating and developing *inclinations*, *sensitivities* and *abilities* required to practice the discipline?

- We asked the students in molecular biology, medicine (and physics)..



Inclinations, abilities, sensitivities



***from open responses: 'what was the most problematic aspect' and 'what did you like learning the most'.**

•Grappling with abstraction, visualisation, concept complexity, maths transference: **developing sensitivities.**

•**Inclination/motivation**

•Medical students: developing ability and sensitivity wrt topic for future and critical of teaching; don't like subject, tedious**: inclination to remain in preliminal space

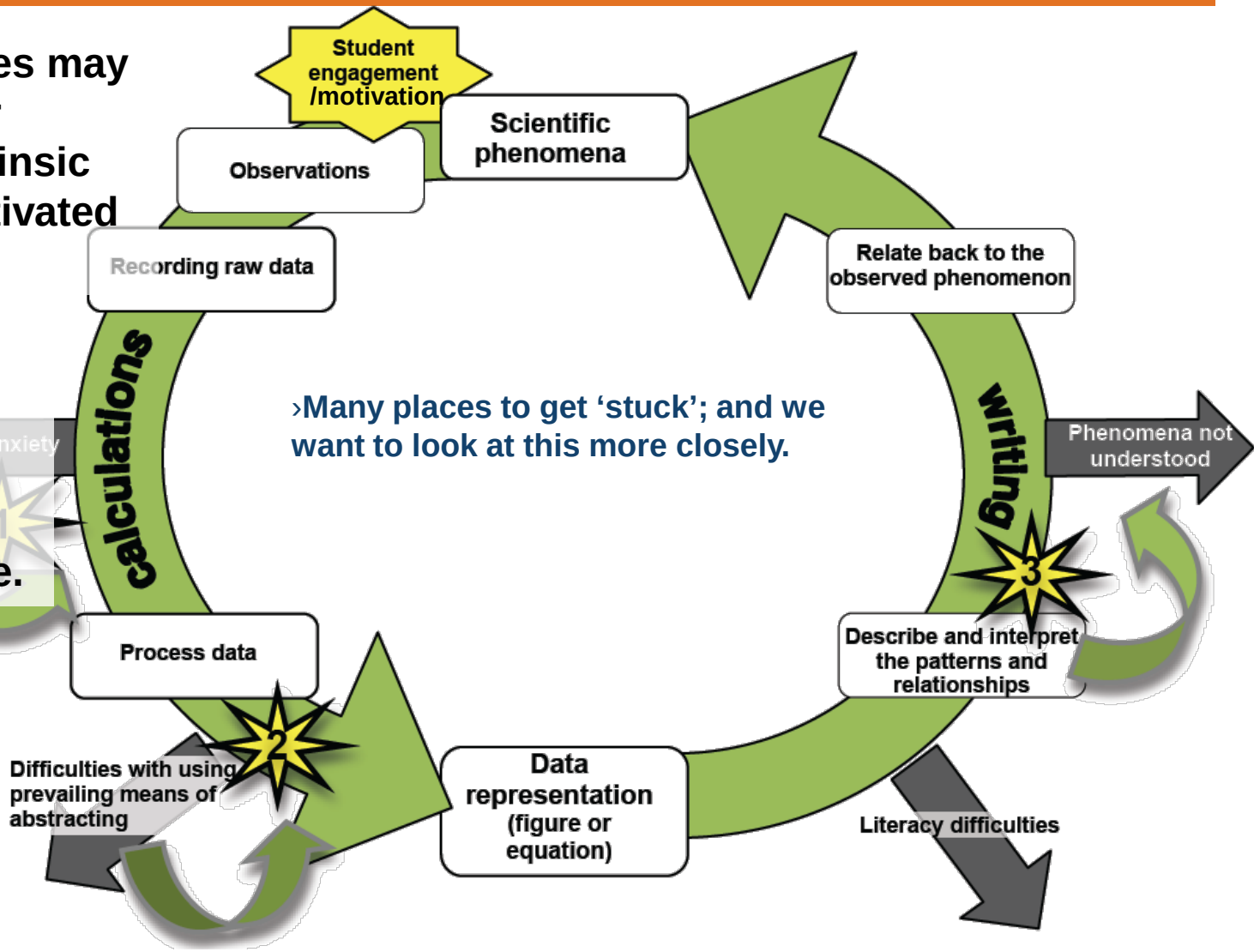
•Mol.Biol. "Interesting (to me)", intrinsic motivation.

**statistics in Medicine (Thompson, 2008).

Motivation strategies may depend on whether predominantly intrinsic or extrinsically motivated cohort.

Acknowledge that for some students this is "high road transfer" – need to improve confidence.

Abstracting and codifying data is troublesome.



Abstraction

- We expect students to be able to master *abstraction,* the highest cognitive level according to Biggs (2002), almost immediately and implicitly we expect students to engage in *mindfulness* (Langer, 1989) as they work through the experimentation process.
- There is still a lot to do with understanding ‘abstraction’ and with ‘sensitivities’ in science teaching and learning.
- To become expert and to develop a discipline appropriate thinking disposition requires a lot of exposure to the practices and process of that particular discipline (Perkins and Simmons 1988). E.g. Abstracting, codifying, adhering to conventions and appropriate symbols.

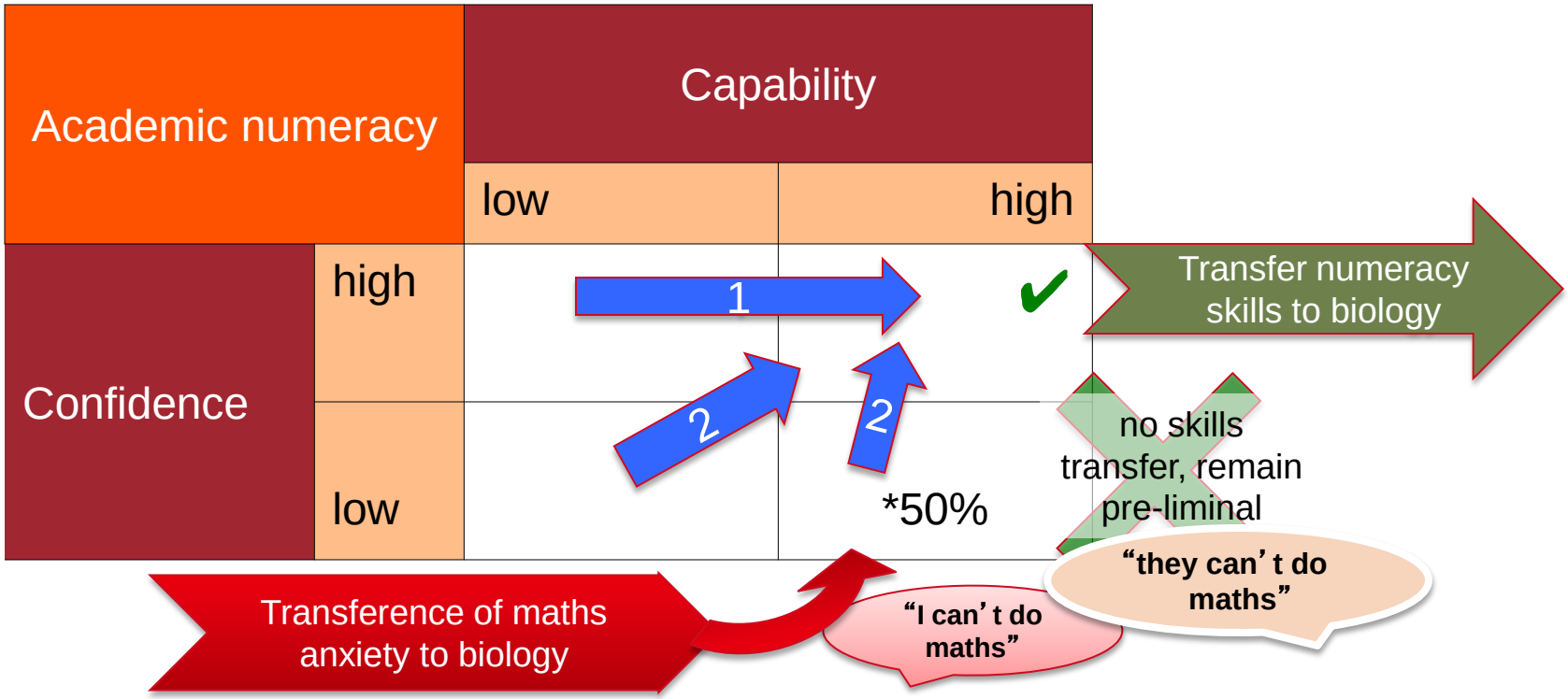
SUMMARY

- ‘I can’t do maths’, characterises rigidity of mind, which, because of its persistence, seems to be an artefact of the hidden curriculum and may be why the maths problem has been, and remains, so difficult to address directly.
- We are not just teaching the content, we are not just teaching the application of numeracy skills – we are helping students to develop their numeric *sensitivities* for biology.
- With respect to numeracy skills specifically, characterising discipline-specific sensitivities are where we expect to find some answers as to why the inter-disciplinary transfer of numeracy skills is so problematic.

Quinnell R., Thompson R. & LeBard R. (2013) *It's not maths; it's science: exploring thinking dispositions, learning thresholds and mindfulness in science learning.* International Journal of Mathematical Education in Science and Technology. 44(6): 808-816 http://www.tandfonline.com/doi/full/10.1080/0020739X.2013.800598#.UjLmRBZgNlI

Thank you.

Intervention matrix to improve students inclination in relation to academic numeracy



1. Remedial intervention to improve students numeracy skills incl. *relevant* examples of calculations to effect 'low road transfer'.
2. assistance to improve student confidence/reduce anxiety requires students to engage in reflection, more complex process: 'high road transfer'.

*Quinnell and Wong 2007, Quinnell et al, 2012