# Understanding thresholds in first year engineering: digging beneath Mohr's Circle

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presented by Johnny Fill

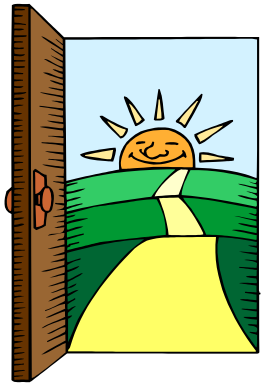
# Outline of talk

- Introduction to Threshold Concepts
- Outline of project
- Methods
- General thresholds
- “Mathematical description” as a threshold
- Mohr’s Circle as a threshold?
- Discussion
- Conclusions

# Threshold Concepts?

- “A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress.”

  Meyer & Land (2003)



# Threshold Concepts?

- Transformative
- Integrative
- Troublesome
- Traversal of “liminal space”
- Tools for curriculum design and development of teaching strategies

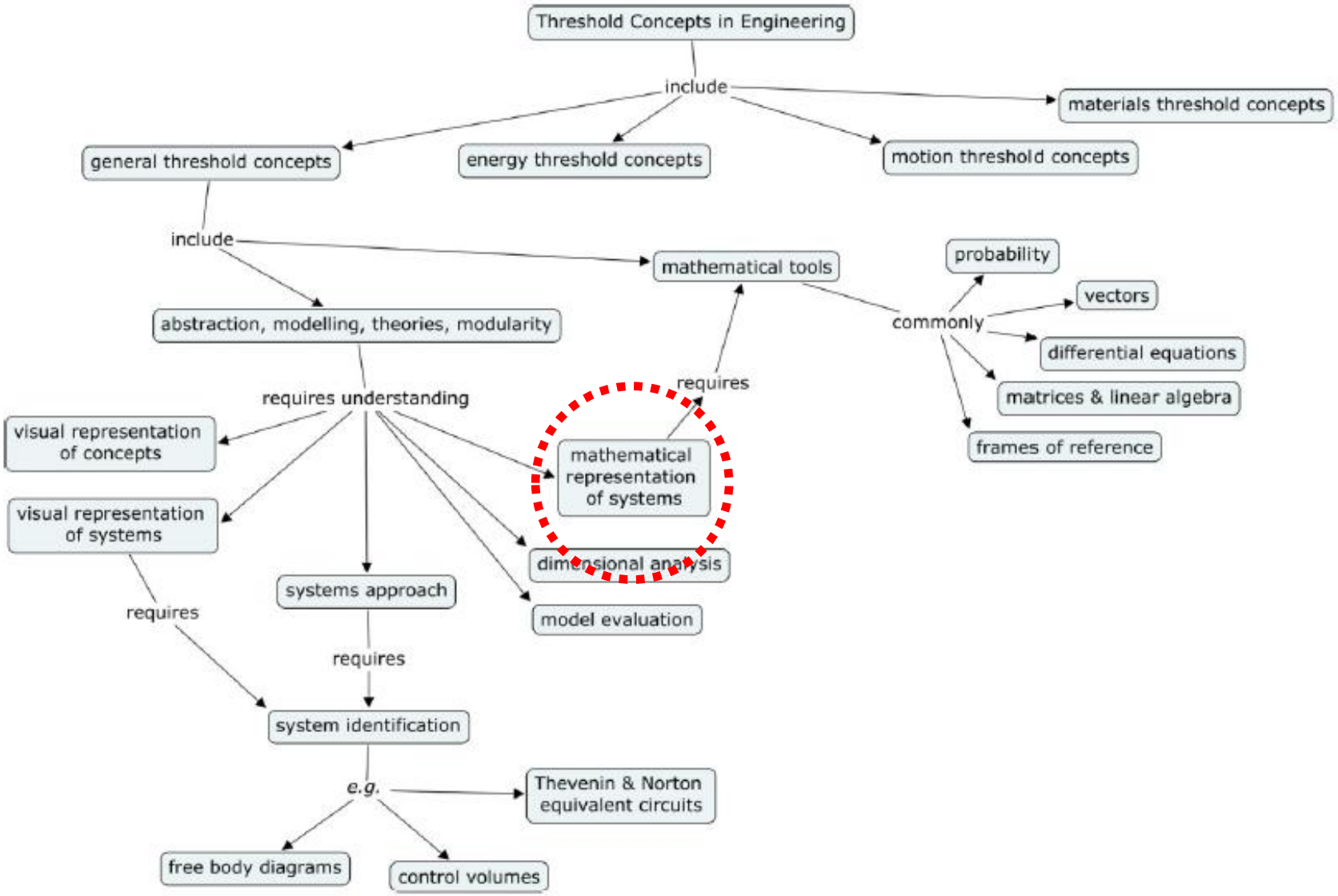
# Outline of project

- Aims: to identify and explore thresholds in first-year courses in Engineering and in Materials Science
- Three different universities:
  - University of Western Australia (UWA)
  - University of Birmingham (UB)
  - University of Oxford (OX)

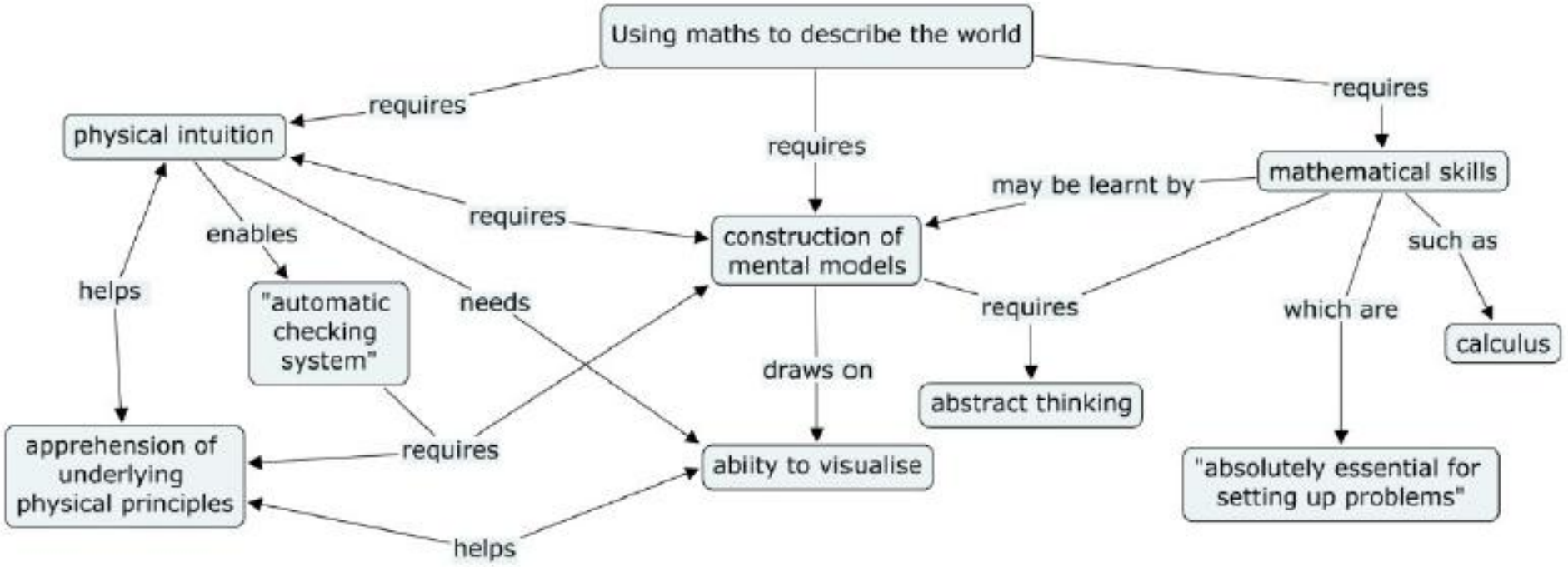
# Methods

- Semi-structured interviews with students and with tutors
- Graphical analysis (*e.g.* concept maps)
- Differences across sites
  - UWA: interviews built on previous conversations
  - OX: interviews were (mostly) separate conversations
  - UB: focus on specific modules within 1st year with analysis of textbook representations in relation to interviews

# General thresholds to understanding

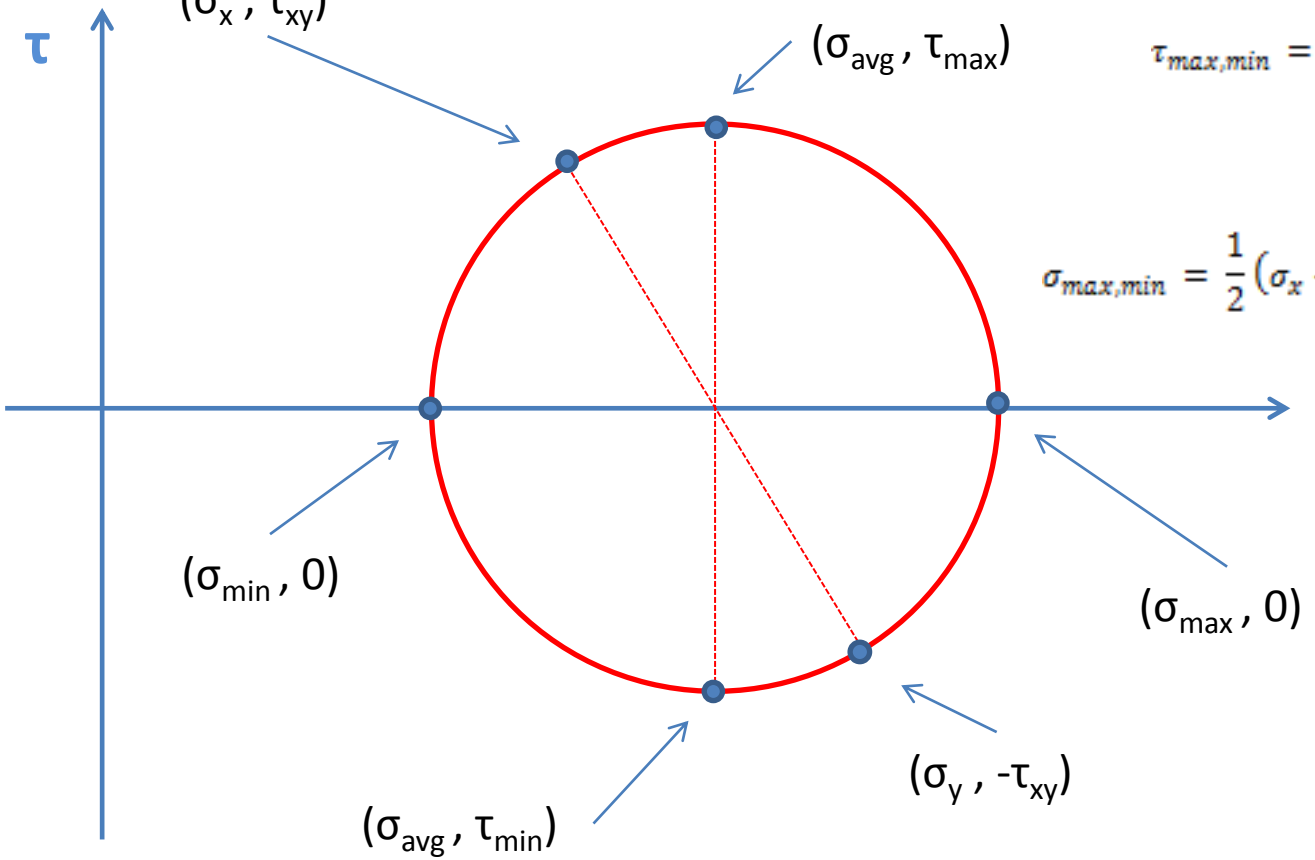


# “Thinking like an engineer”: mathematical description as a threshold




- Question: how are these “thinking processes” actually *taught* in universities?

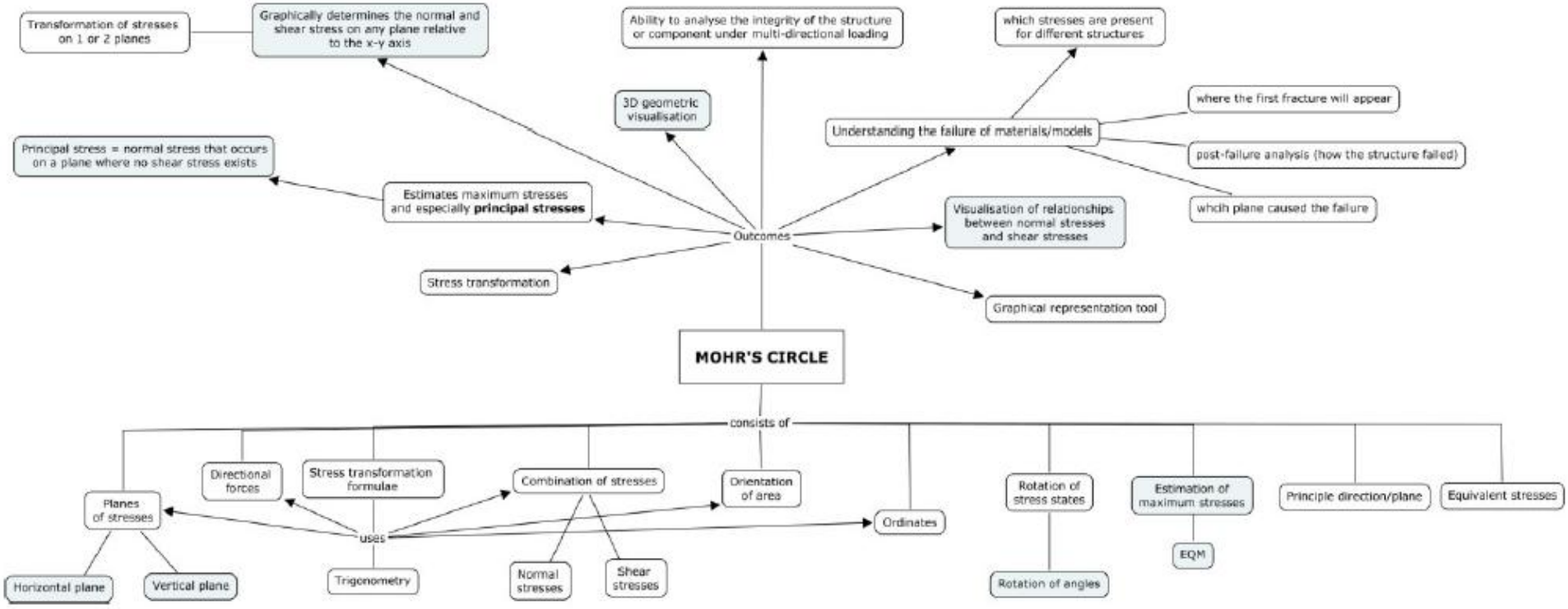
# Mohr's circle




$$\tau_{max,min} = \pm\sqrt{\left(\frac{1}{2}(\sigma_x - \sigma_y)\right)^2 + \tau_y^2}$$

$$\sigma_{max,min} = \frac{1}{2}(\sigma_x + \sigma_y) \pm \sqrt{\left(\frac{1}{2}(\sigma_x - \sigma_y)\right)^2 + \tau_y^2}$$

# Textbook representations of Mohr's Circle compared to interviewee's interpretations




- Concept map drawn from UB analyses of

(i) UWA & OX interviews

(ii) undergraduate textbooks

# Discussion: Is Mohr's circle a "concept"?

- **UWA mechanical engineering tutor:**

*"Mohr's circle is a **tool**, it's not a concept. I think the concept is what's called 'stress transformation'…"*

- **UWA civil engineering tutor:**

*"The stress is [the] fundamental concept. If a student does not understand stress, the Mohr's circle **technique** becomes empty, just something to memorise and to be confused."*

# Discussion: what is troublesome about Mohr's circle?

- Students are familiar with vector arithmetic and revert to using this for stress
- Stress can be referred to using the direction of a force vector when people are sloppy, although it actually involves two vectors
- As it involves two vectors and is a mathematical construct only, stress is difficult to visualise

# Discussion: what is troublesome about Mohr's circle?

- Unfamiliarity/lack of confidence with conceptual underpinning of stress tensors is compounded by unfamiliar graphical representation used in Mohr's circle
- Abstraction poses profound difficulties to many students

# Discussion: how can we help?

- Students respond positively to well-targeted pressure to “think for themselves”
- This process needs discussion with students in order to identify and effectively challenge their misconceptions
- “Thought processes” are important, as well as the content being taught
- “Tutorial environment” > “lecture hall” for this

# Conclusions

- Threshold concept theory is a valuable tool for researching university-level engineering & materials science
- “Thinking like an engineer”, using abstract mathematics to represent physical situations, is a set of skills that students must develop
- Analysis of specific examples such as Mohr’s circle can illuminate the obstacles students experience in developing these skills, as well as ways of overcoming these obstacles

# Selected bibliography and acknowledgements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