

**Panic spirals
and
deposits in the Bank of Previously Seen Problems**

**Epistemology, metacognition, emotion and community in
first-year Imperial Physics students' approaches to
problem-solving**

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MEd research project (2021-22)
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Motivation

- Problem-solving an integral physicist skill (e.g. IOP, IC programme specs)

'Physics trains numerate people who are experts at problem-solving.' (IOP)

- First year UG students often find problem-solving challenging
 - Indications from student surveys, anecdotal feedback from tutors
 - Low scores on January exam on questions requiring problem-solving
 - (Physics) literature: conceptual deficits
 - Conceptual understanding?... Or problem-solving skills?... Or...?

Methodology

- *Research question: “What are first-year undergraduate students’ approaches to problem-solving in physics and what influences how they apply these?”*
- Phenomenological approach; semi-structured interviews

“Do you have the skills you need for problem-solving?”

“How has your view of what problem-solving is changed over the past few years?”

“Describe a time when you tried to solve a challenging problem”

- One-on-one interviews via Teams during March 2022 (term 2)
- 6 first-year students volunteered
 - pseudonyms: Anna, Caroline, Claire, David, Elizabeth, Hugh
- Thematic analysis using open and axial coding

Transition from school to university

Ofqual FHEQ level descriptors:

Level 3 (A-level):

Identify, select and use appropriate cognitive and practical skills, methods and procedures to address **problems that while well-defined, may be complex and **non-routine**.**

Non-routine: solution method not immediately obvious to the solver

Level 4 (Year 1):

Identify, adapt and use appropriate cognitive and practical skills to inform actions and address **problems that are complex and non-routine while normally fairly well-defined.**

- ‘A-levels lacked any problem-solving’ (Elizabeth, David) → **problems were routine**
- Starting uni:
 - Greater amount of content
 - *‘I don’t even know how many equations you’ve got. It’s ridiculous... **it completely warps your way of studying physics**[...] school physics does not prepare you [for this] in any way and that’s really bad’* (Hugh)
 - Wider range of problems to solve for particular content:
 - *‘**you have to from one small example be able to apply this skill in a range of situations that you won’t have seen before.**’* (David)

Emotion - Words

satisfying

rewarding

intimidated

shock

terrified

panicked

struggle

daunted

jarring

panic spiral

stuck

unmanageable

overwhelmed

tend to shut down

Emotion - Imposter syndrome

- *'I'm like "Oh no, this isn't right 'cause it's taking me a lot of working out" or something, something **really silly for, like, a university student** [laughing, embarrassed], but even so...'* (Elizabeth)
 - Imposter syndrome triggering strong emotion
- *'everyone that's come here from A-level is used to understanding everything and kind of being able to do stuff quickly. And I think one of the biggest barriers is people going, "oh I can't do it, so **I'm a failure and therefore I'm awful at physics**" and they go down this awful little, like, **worry spiral**'* (Caroline)
 - Emotion impairing cognitive function
- *'one of the biggest things I see [when tutoring][...] is [they] see something they don't know and then **they panic, and then they can't function at all.** [...] they freeze up [...] and basically **anything that they might have had in their brain leaves.**'* (Caroline)
 - Emotion impairing cognitive function
- *'strong negative self-reactions can impair level of functioning by interfering with the intricate task of generating and testing alternative strategies of action'* (Bandura, 1991:p.263)

Community - interaction with peers in group work

- *'as I've done more practice and also kind of like **harshly, as I've seen other people do quite badly as well, [...]** you know, other people get things wrong and can't do things either[...] [P]art of me, I think, was **a bit worried that everybody else would be able to do things and I was just gonna sit there and not have a clue where to start, but, you know, I've realised that's actually not true and I can do things. I've definitely just got a lot of confidence out of doing group work and interacting with other people[...It's]** definitely given me confidence to then try problem sheets that I didn't think I would have been able to do [...] **It's like a positive feedback thing really.**' (Anna)*
 - From imposter syndrome to building self-efficacy

Epistemology

Schommer, Perry, Baxter Magolda

- Epistemology = beliefs about knowledge (what it is and how to gain it)

NAIVE	↔	EXPERT
<i>Knowledge is simple</i> A collection of isolated facts	↔	<i>Knowledge is complex</i> An interlinked network of concepts
<i>Knowledge is certain</i> everything is right or wrong; fixed, “set in stone” transmitted by authority figure who knows “the truth”	↔	<i>Knowledge is tentative; multiple ‘truths’</i> can be constructed;

‘[At school] it was always, kind of, “here's the problem. Here's how you do it.” [...] even with experiments[...]’ (Caroline)

Knowledge is “simple”, “certain”

*‘...whereas I think I have a much better understanding now [...] **that approaching it in different ways and via different methods can really help our understanding.***’ (Caroline)

Knowledge is “complex”, “tentative”

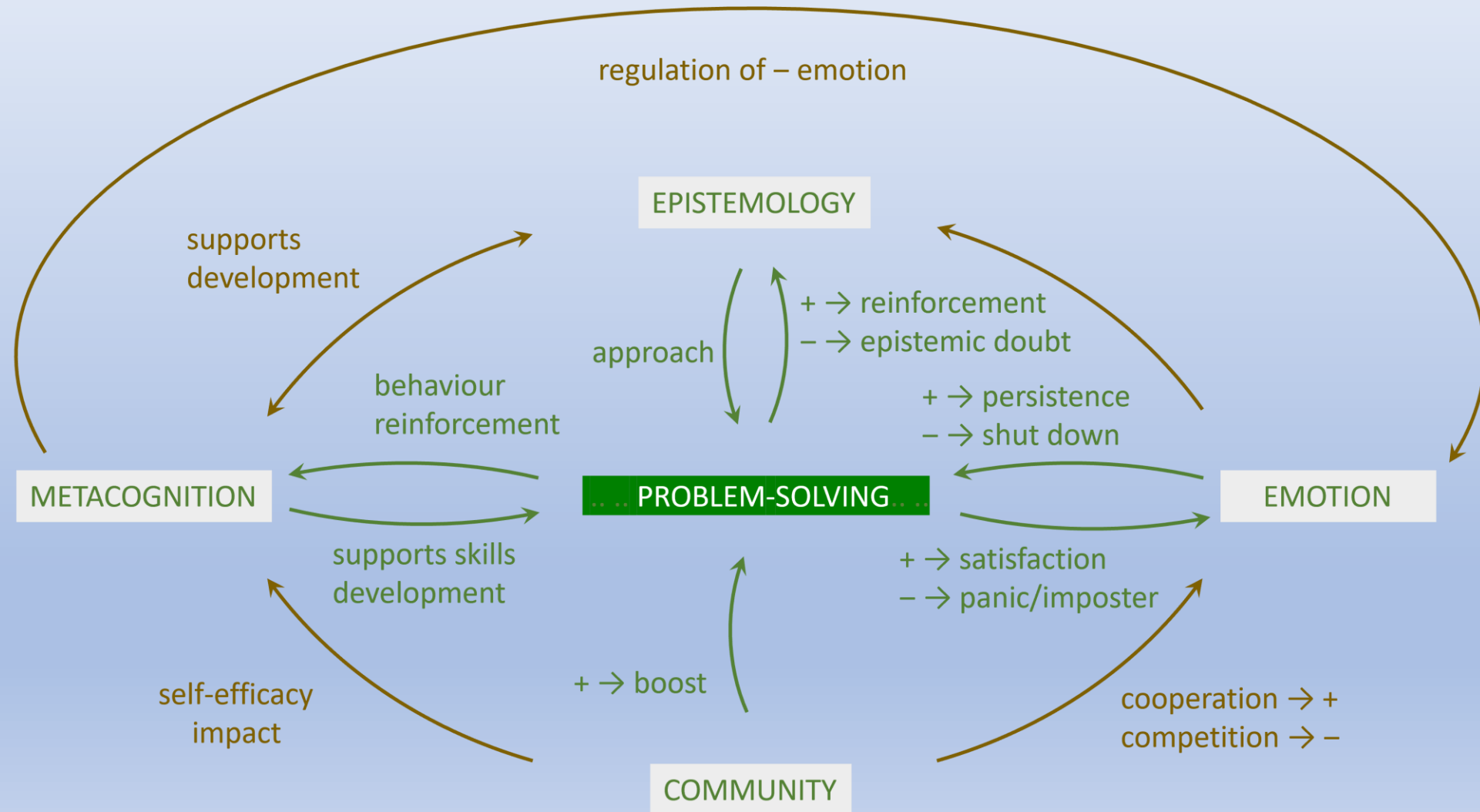
Epistemology - uncertainty

- *'I've struggled with anxiety for years. Um... And weirdly, **finding out that kind of nothing's certain and we don't really understand anything has helped.** [...] it means that me, like, getting stressed about stuff, it's like, "Cool. Well, I don't know this, but also we're still trying to work out how the universe works." So, you know, relatively, I'm doing pretty well here'* (Caroline)
 - Emotion-epistemology link
- *'they're not quite as fixed as... we sometimes imagine and they can be applied in different ways to do different things'* (Caroline)
 - Believing "knowledge is simple" leads to simple problem-solving
 - Believing "knowledge is complex" facilitates complex problem-solving

Influences on problem-solving

- Literature: focus on the cognitive
- Curriculum design: focus on the cognitive
- Problem-solving is not just about cognition!
- Influences:
 - Epistemology
 - Emotion
 - emotion mitigated by developing self-regulation and self-efficacy
 - Metacognition
 - benefits from interactions with peers
 - Community
 - benefits from interactions with peers
- Development in these four areas should also aid *cognitive* performance
- These influences are interlinked...

Influences on problem-solving are *interlinked*



Metacognition: Self-regulation

- *‘when I solve the question and I realise it doesn't work, I do tend to shut down a lot just like “oh, why doesn't that work?” I just keep thinking “oh, why doesn't it work?” [...] I think the shutting down is probably because of the difference in difficulty from high school to university.’ (Claire)*
 - Lack of preparation for difficulties
 - Strategic planning during forethought and reflection (Zimmerman)

Possible interventions

- Epistemology
 - Instructors should recognise additional cognitive load in problem-solving for students with novice beliefs about knowledge
 - Challenge: scaffold helping students realise the need for change and to help bring that about
- Cognitive
 - Building skills in “putting it all together”, “finding a route through” problems
- Emotion:
 - Expectation-setting - pre-arrival resources
- Social
 - Encourage group work, particularly the peer-to-peer interactions
- Metacognition:
 - More!; Integrate with content (not just peripheral/one-off events)