

Present-day Practicals webinar series '25/'26



Welcome to webinar 1:

“How do students truly learn in the lab?”

Dr Hendra Y. Agustian
University of Copenhagen




We're all familiar with the phrase that “hands-on” lab work is a great way to learn. This hands-on aspect is often assumed to be the key pedagogical value of laboratory education. But have you ever stopped to think about why?

We encourage you to **turn on your camera** to help create a more personal and interactive atmosphere.

This webinar will **not be recorded** to help create an open, interactive atmosphere where everyone feels comfortable to share ideas and ask questions. Instead, we'll share a **recap** afterwards

Who are we?



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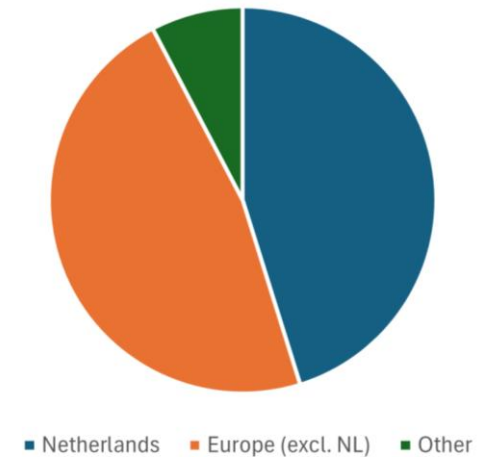
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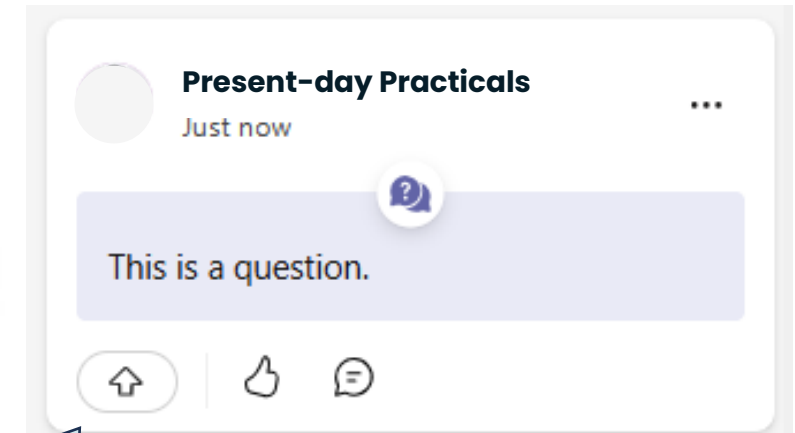
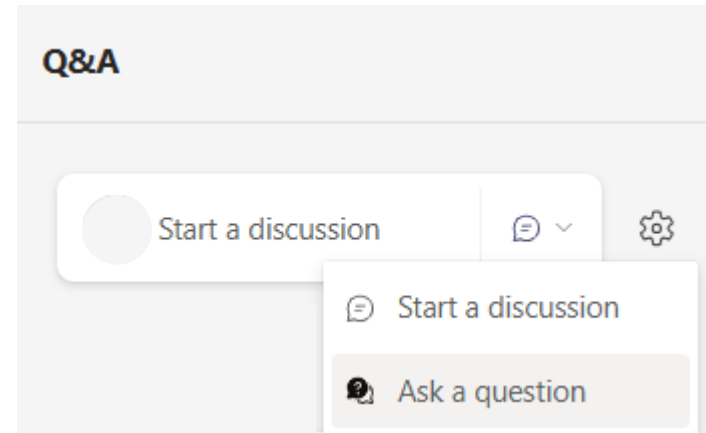
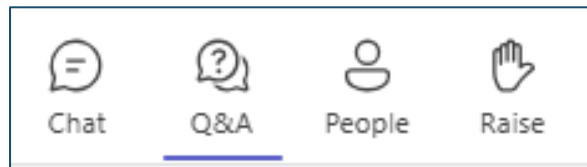
21 different countries:

- Aruba
- Australia
- Austria
- Belgium
- Czech Republic
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- Ethiopia
- Germany
- Greece
- Hungary
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- Jordan
- Latvia
- Norway
- Slovakia
- Spain
- Switzerland
- The Netherlands
- United Kingdom
- United States of America

Regional distribution



Use the **Q&A** to post
your questions and
share your ideas



After the webinar, we'll share a **recap** containing slides,
lessons learned, and additional information and resources

Webinar 1:



“How do students truly learn in the lab?”

Dr Hendra Y. Agustian
University of Copenhagen



We're all familiar with the phrase that “hands-on” lab work is a great way to learn. This hands-on aspect is often assumed to be the key pedagogical value of laboratory education. But have you ever stopped to think about why?

How do students truly learn in the lab?

Hendra Agustian

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Why focus on lab learning?

- Substantial part of higher science education **curriculum**
- A part of an **identity** as a scientist: *doing* science, working with *physical materials*, (wearing a lab coat?), and *talking* about *ideas* in science with each other
- Expensive! Gotta make that investment worthwhile
- So that we can actually provide some **evidence** for whether, if, what, and how students truly learn and develop their lab-related competencies



Question for you

What makes lab learning special in your experience?

Share a quick response in the chat.



Using our body in learning science

- Physical
- Phenomenological (experiential)
- Ecological
- Interactional

Embodied cognition

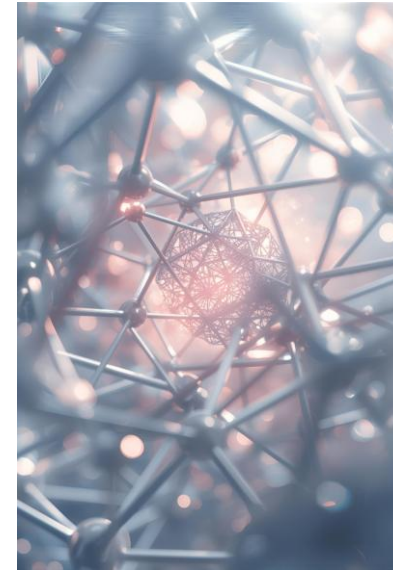


Knowledge and knowing in science

- When learning science, we think about knowledge (concepts, procedures)
- Also, we judge a lot
 - Is this good?
 - How do I know it's good?
 - How do I know that I know?

Epistemic cognition

Greene et al. (2016) Handbook on epistemic cognition. Routledge.



Question for you

How do students use their bodies while learning in your lab?

- Share one surprising example from your own teaching experience.
- Discuss in the breakout rooms (ca. 5 mins).
- Share out in the plenum.

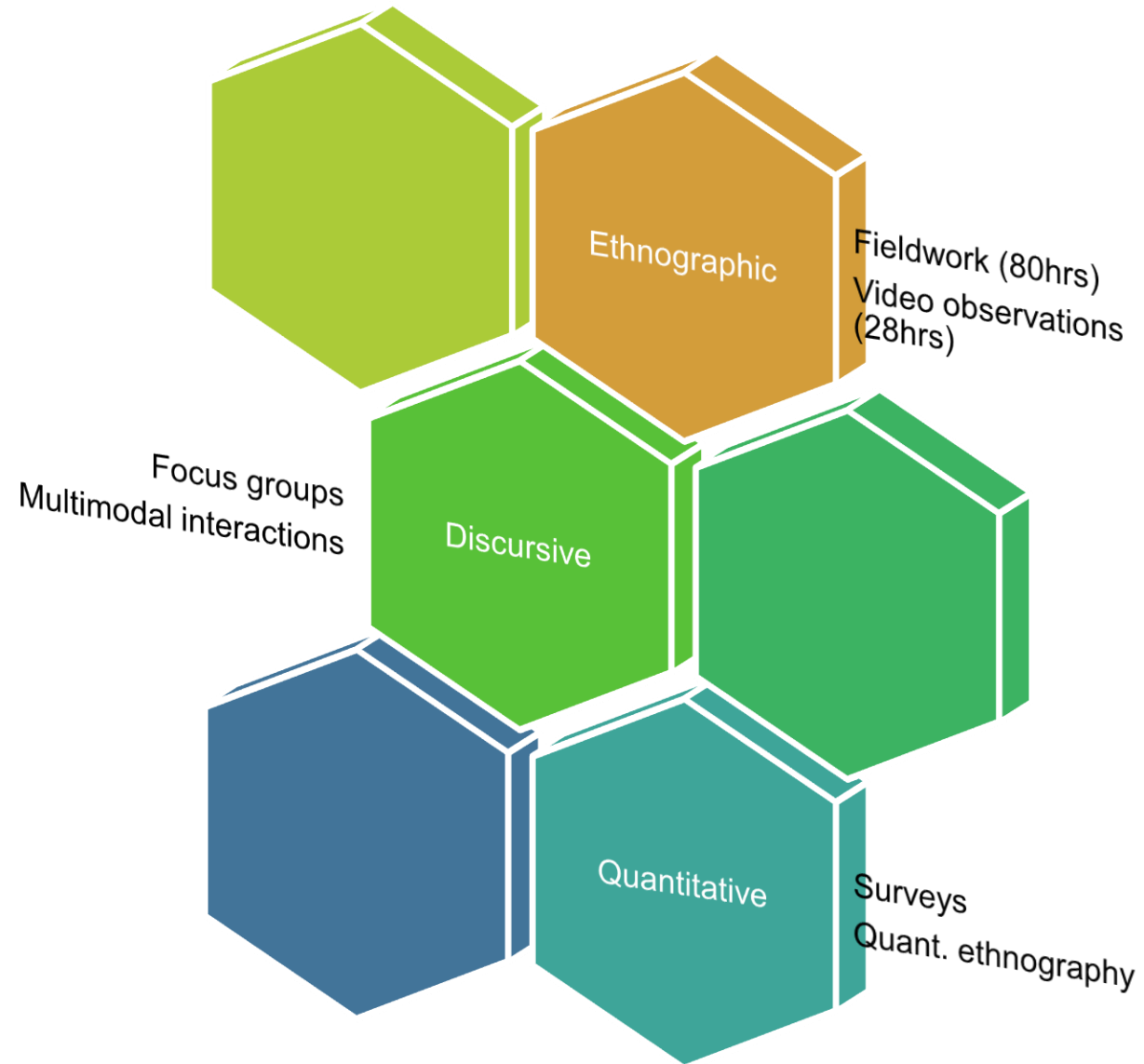


Key question for today

How do actions and thinking link together when students learn in the lab?

Today, we'll explore how the mind and body combine to build understanding, what we call "**embodied epistemic cognition**"



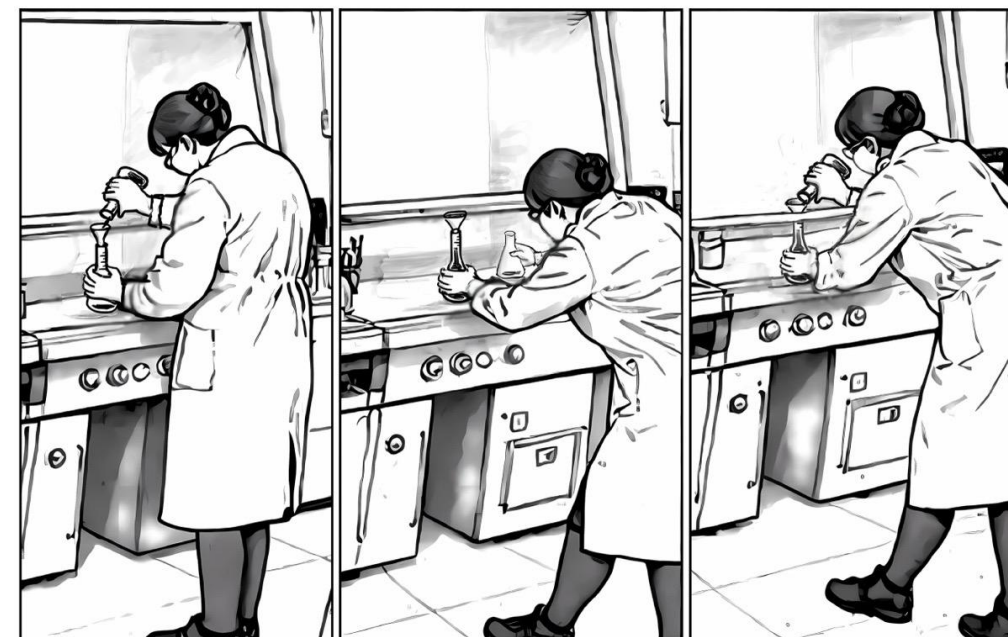
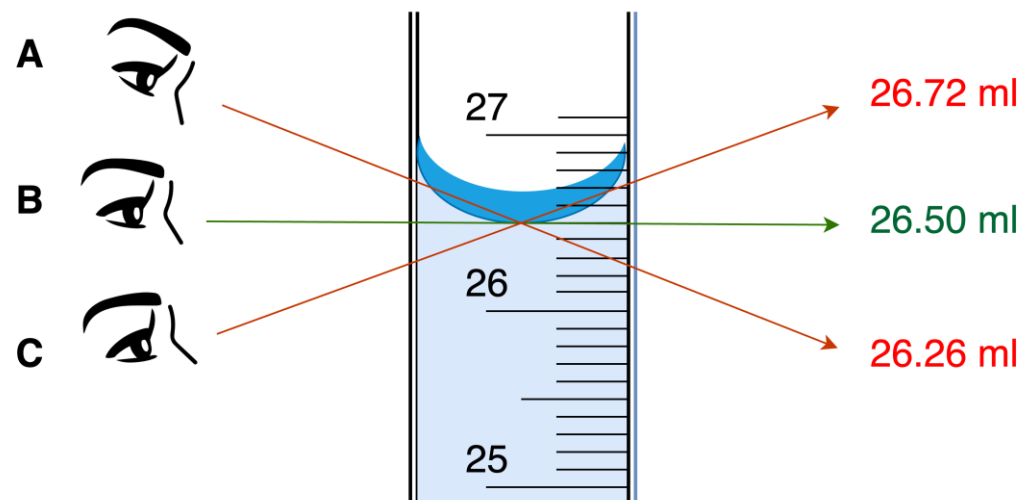


Methods

- Laboratories of pharmaceutical physical and analytical chemistry, 2nd year BSc
- Focus: Experiment on quantitative determination of acetaminophen and caffeine in commercial tablets using HPLC

Data corpus	n	Note
Focus group transcripts	30	Based on excerpts of video recording or laboratory report
Laboratory discourse	47	Focus on 4 pairs of students
Video recordings	47	Multimodal observations
Survey responses	912 +	Across 4 universities in DK, CZ, US, and ID

Real-life lab examples



Real-life lab examples

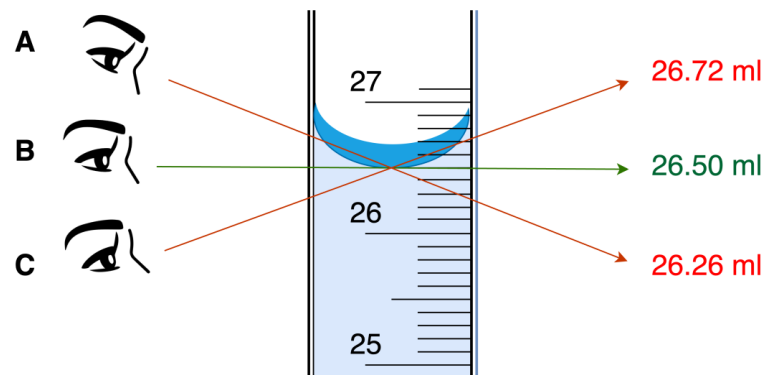


TABLE 6 A stanza on body awareness and spatial navigation (Day 1, EF, line 5012-5021)

Interlocutor	Utterance	Non-verbal cue and action
Felix	I think it's..., it's one of the short ones.	Kneeling, Felix looks at the scale on the cylinder closely.
Eliana	1... Isn't that long, you think?	Eliana looks at the scale on the cylinder closely.
Felix	Uh..., no, it's the short.	Kneeling, Felix looks at the scale on the cylinder closely.
Eliana	Or that... The middle there?	Eliana looks at the scale on the cylinder closely.
Eliana	Or that... The middle there?	Eliana looks at the scale on the cylinder closely.
Felix	The long lines digits are 10' interval, the short digits are 5'.	Kneeling, Felix looks at the scale on the cylinder closely.
Eliana	1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Yes, OK.	Eliana dispenses the solutions, Felix immediately stands up.
Felix	It was up to 3, you should have the next.	Felix stands up.
Eliana	No, I'm going to have the next little.	Eliana proceeds with another.
Felix	Uh... Stop, I think you're there. ... Yes...	Felix watches as Eliana works.
Eliana	Yes, it is now a very nice drink. I don't think methanol smells as much...	Felix quickly fetches the methanol from Eliana, covers it with his hand.

Real-life lab examples

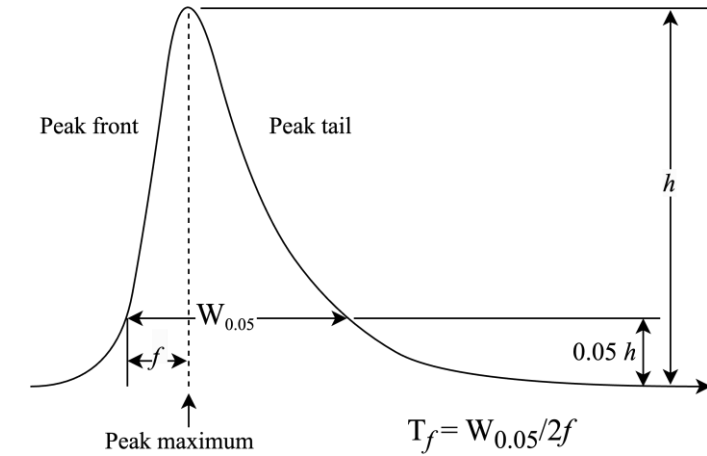
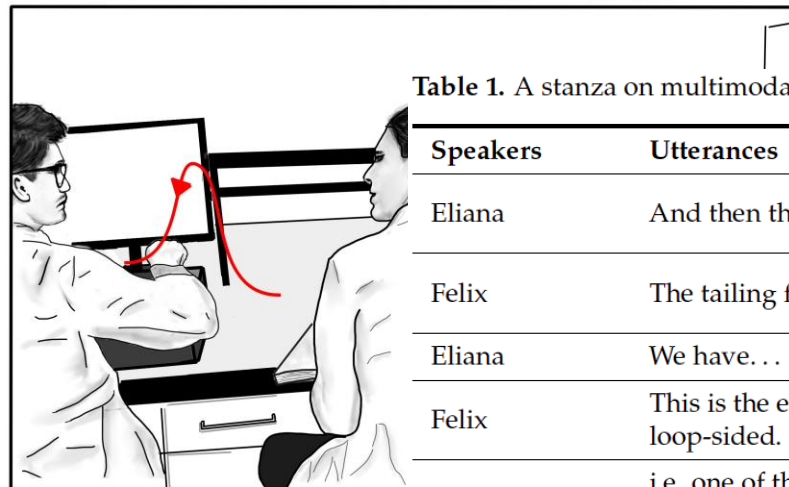
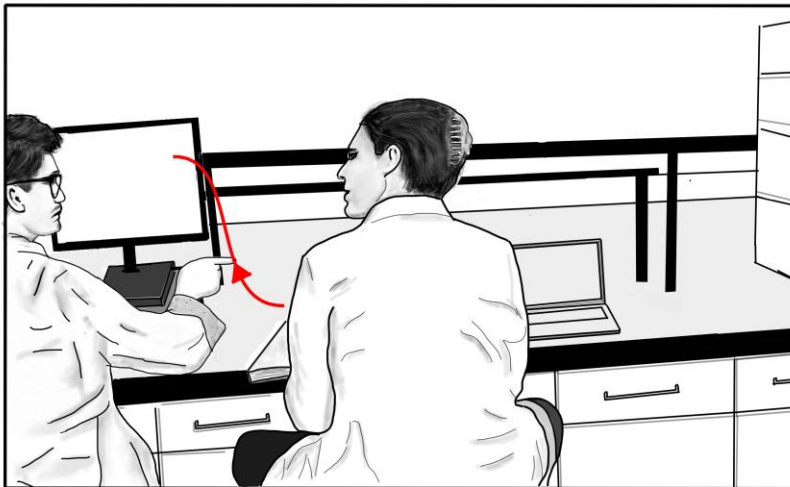
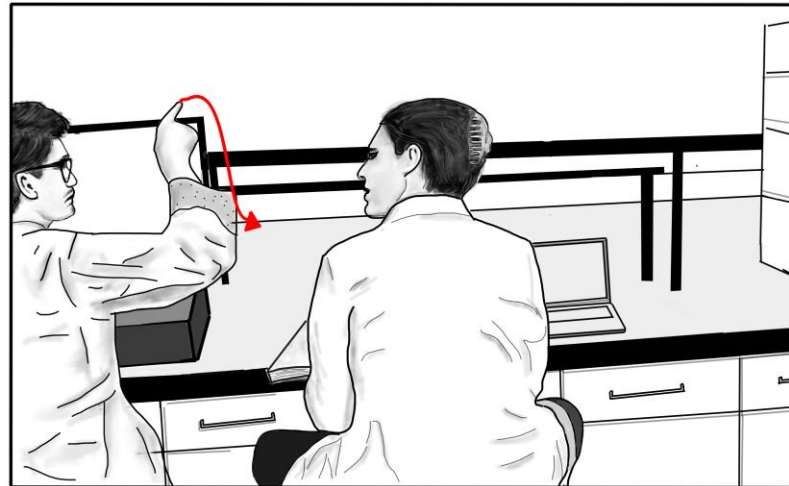
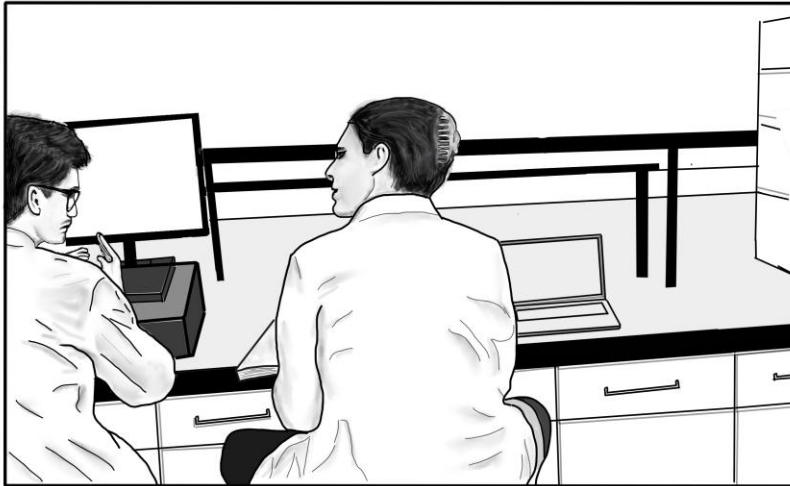


Table 1. A stanza on multimodal conceptual discourse.

Speakers	Utterances	Non-Verbal Cues and Action
Eliana	And then there is the tailing factor?	Eliana invokes a concept specific to chromatography.
Felix	The tailing factor. . .	Felix intends to type, but discusses the concept instead.
Eliana	We have. . .	Eliana looks at Felix.
Felix	This is the extent to which it is loop-sided.	Felix looks at Eliana, explains the concept using hand gestures.
Felix	i.e. one of them runs down, and the other it is like that where there is a tail, is it not like that?	Felix looks at Eliana, explains the concept using hand gestures.

More examples

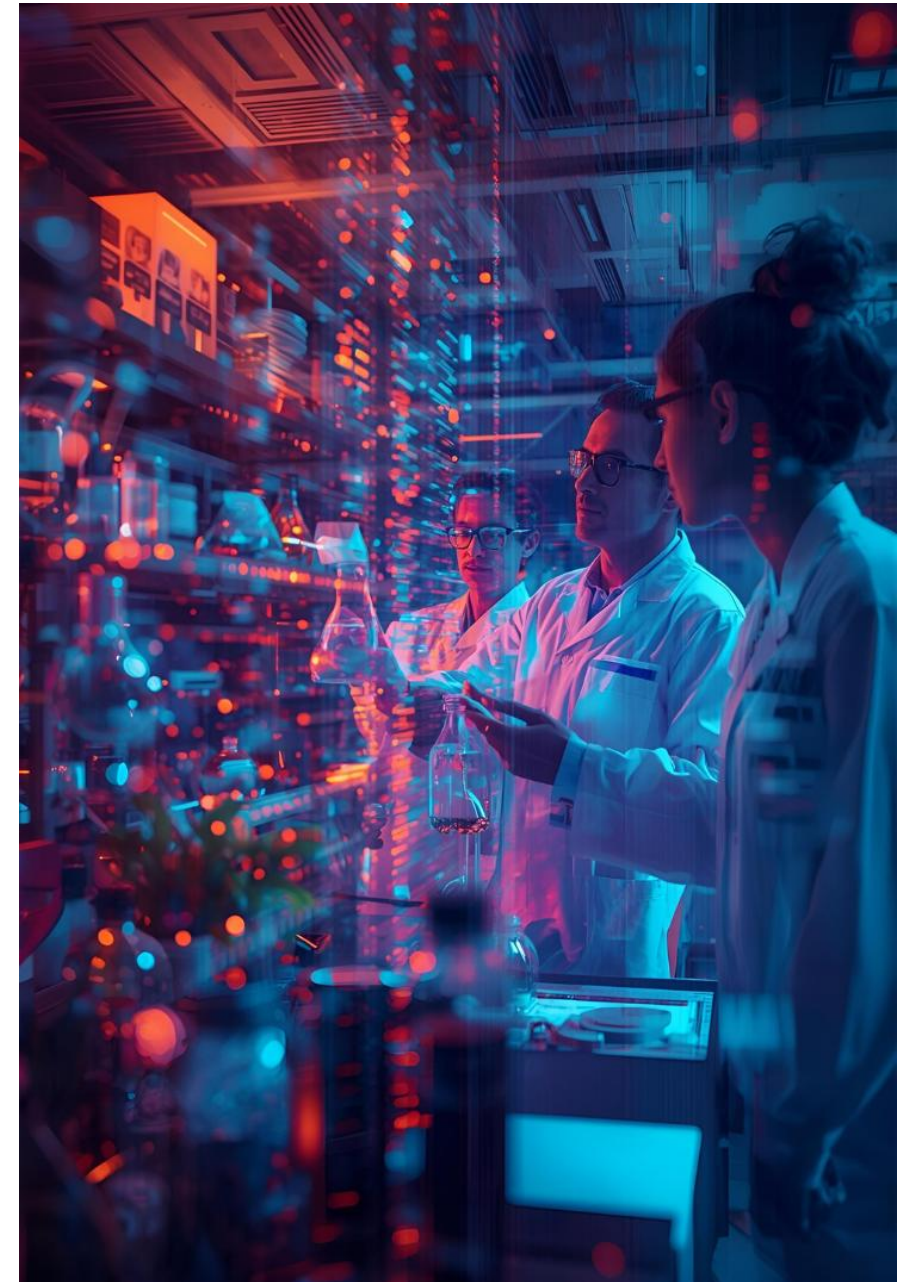
TABLE 8 A stanza on interbody cognitive load distribution (Day 3, GH, line 11218-11228)

Interlocutor	Utterance	Non-verbal cue and action
Theo	This now contains all the data you have been running, also from Module 2.	Theo points to the screen.
Grace	And this is the one we have used this time.	Grace works on the HPLC computer while Hayley stands by, working on her laptop.
Theo	Yes, so you click on that one, and double-click over in it.	Theo looks at the screen..
Grace	Here.	Grace works on the HPLC computer.
Theo	Actually, there is. I think you can do it in both places.	Theo points to the screen.
Grace	For all of it, or just on one of them.	Grace works on the HPLC computer
Theo	Just click the 1 and it does it to load data, you could also have click load data. Then all your runs in the sequence are loaded.	Theo points to the screen.
Grace	Yes, what should I press here?	Grace works on the HPLC computer.
Theo	It then all depends on what you are interested in doing with your data processing.	Theo points to the screen.
Grace	Ok.	Grace responds.
Theo	So what it is on now, it is that you can only just make identification, and some area. If you choose that 3D UV concept, there will be additional options. Then we can do everything with data.	Theo points to the screen.



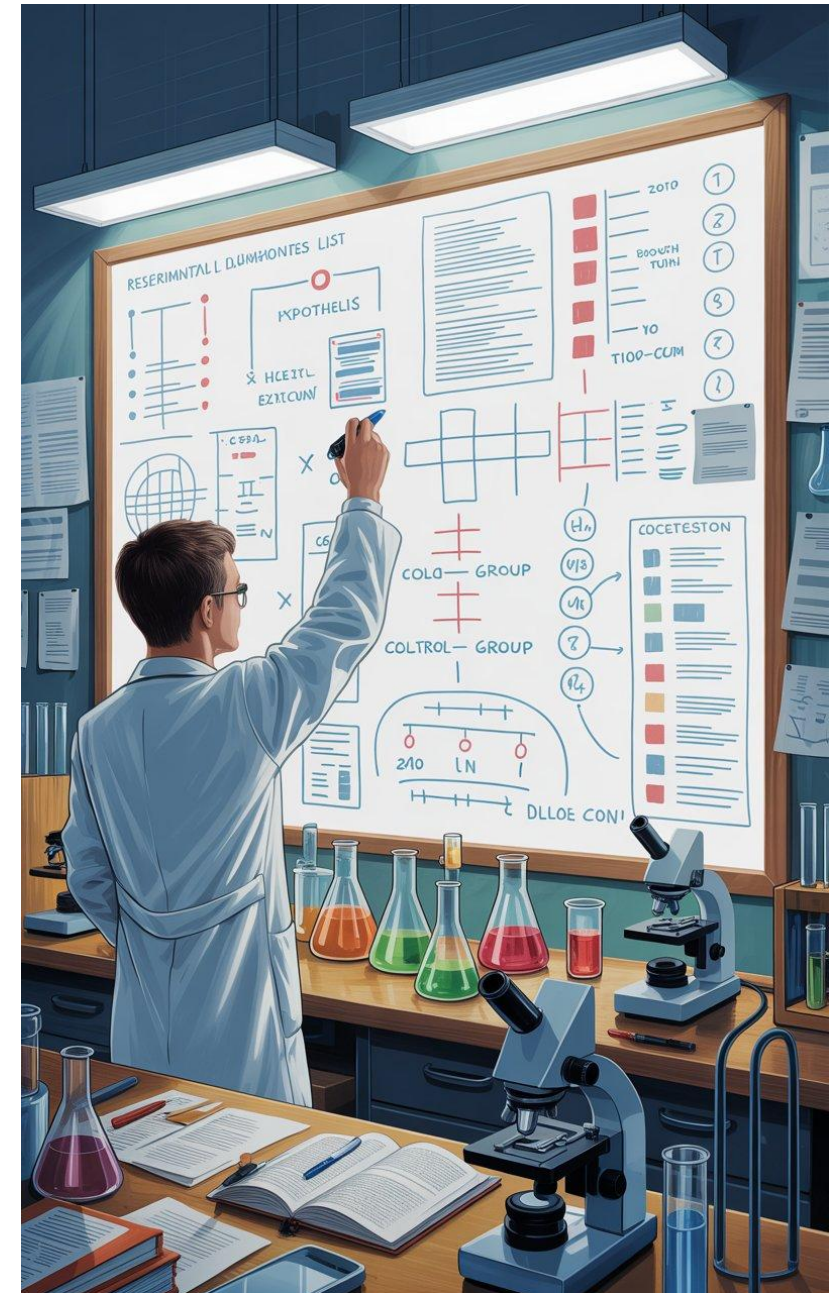
7 ways bodies play a role in lab learning

- Practice technical skills
- Use senses to guide actions (seeing, smelling, touching)
- Be aware of their positioning and space
- Use instruments to assist thinking
- Gesture to explain or solve tasks
- Divide tasks and thinking together
- Support each other through hands-on help



8 ways students think about knowledge and knowing in science

- Frame concepts and theories
- Generate hypotheses/questions
- Design experiments
- Evaluate data
- Explain results and build arguments
- Validate findings
- Acknowledge uncertainties
- Collaborate and communicate



When hands and minds intertwine

Hendra: [Pointing to a page in the lab report] If you get this as a result of your SST, what can you tell me about this chromatogram? (See Figure) Is it a good one? Why?

Alexis: It's good because the peaks are well separated. Um, so...

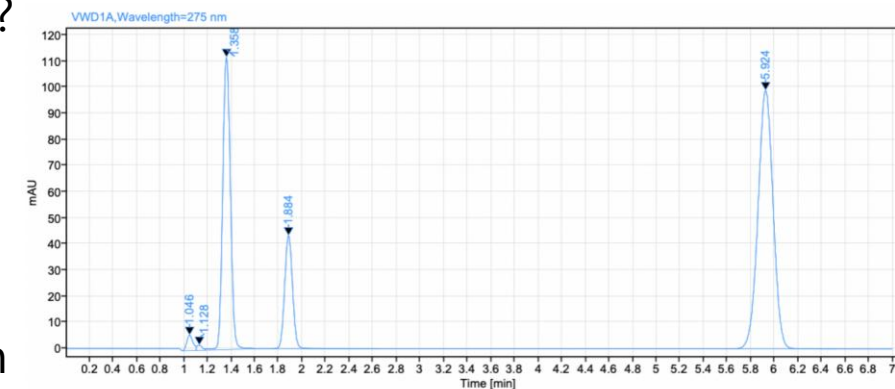
Brooks: Yea, ... so you get a pretty clear separation of the different compounds within the tablet. Which one to do, which one you would like to analyse. If the peaks weren't separated from each other, it would be impossible to analyse the areas. So that's also why we test the resolution, to see...

Alexis: How separated they are.

Brooks: And they are sufficient to do some analysis on.

Alexis: And you can also look at the chemical structure of the compound, to see, and then tell which will be held in the column the longest.

Brooks: Mmm. Tendencies.

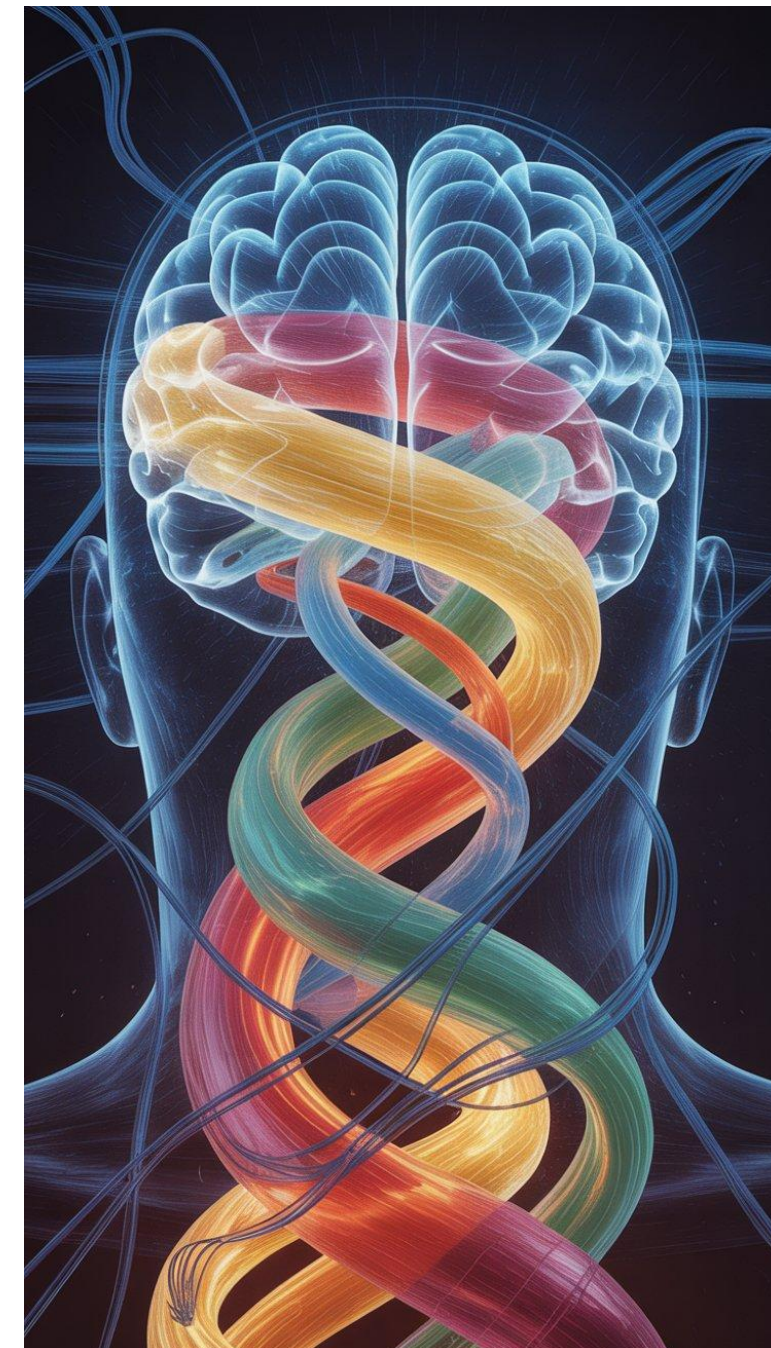


When cognition and emotion intertwine

Hendra: How do you feel about having to use this, another set of data?

Hayley: Well usually I don't mind, but I was a bit *embarrassed*, I could say. Usually, it's very common, that things go wrong in the laboratory. And also when I have to speak with my friends, and they are all, oh yes, mistakes, mistakes, mistakes. And I would say the *[procedural] mistake* we made, I'm sort of *happy for it*, because we didn't really do anything wrong with the calculations or anything. We have understood the entire process, so I was alright with it, other than of course, [alas]! I made a mistake, ha ha ha ha ha.

Grace: I think *we learn a lot from making mistakes* because once you make a mistake, it sticks. *That's how you remember*. So it's a learning experience where you really get stuck, don't do this now. Now you have tried it and learned it, and now you know what to do, and is actually really beneficial sometimes, because if you do everything correctly all the time, then there isn't really any learning experience.



Question for you

Think about a recent lab. Which of these ways of engaging the body in knowledge co-construction did your students use?

- Discuss in the breakout rooms (ca. 5 mins).
- Share out in the plenum.



Link to padlet: tiny.cc/pdp25



Take home messages

- Consider designing laboratory experiences that explicitly engage both epistemic and embodied dimensions of learning.
- Provide opportunities for students to engage in scientific practices, eg. **experimental design** and **critical data evaluation**.
- Facilitate this **reflective practice** through **dialogic prompts** that specifically address how embodied experiences are relevant to understanding scientific concepts and procedures.



Further reading

Chemistry Education Research and Practice



PERSPECTIVE

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Cite this: Chem. Educ. Res. Pract.,
2022, 23, 538

Considering the hexad of learning domains in the laboratory to address the overlooked aspects of chemistry education and fragmentary approach to assessment of student learning

Hendra Y. Agustian

This article seeks to provide researchers and practitioners in laboratory education, particularly those involved in the curriculum design and implementation of teaching laboratories at university level, with a conceptual framework and a working model for an integrated assessment of learning domains, by attending to a more holistic approach to learning in the laboratory. Prevailing learning theories suggest that the triad of cognitive, psychomotor, and affective domains should be addressed in order to warrant meaningful learning. In the research tradition of psychology and philosophy of mind, this triad also manifests as a concert of cognitive, conative, and affective domains. The paper argues that at least in the context of chemistry laboratory education, this is insufficient. The social and epistemic domains are often overlooked or dismissed altogether. Research in science studies may provide insight into the urgency and usefulness of integrating these domains into chemistry teaching and learning. Firstly, laboratory work is conceptualised here as an epistemic practice, in which students generate data, propose knowledge derived from the data, evaluate, and legitimise it. Secondly, the operationalisation of the hexad of learning domains is proposed, in terms of curriculum design, instruction, and assessment.

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Introduction

Ever since Justus von Liebig introduced individual laboratory work in the chemistry laboratory during his professorship at the University of Gießen in Germany back in the 19th century, the laboratory has been developed and viewed as an essential part of chemistry education at university level as we know today. Teaching laboratories are also common in health and medical sciences. They comprise various practical activities involving teaching staff and laboratory technicians, requiring materials and equipment which often amount to substantial educational expenses. Notwithstanding the perpetual presence and seemingly self-evident importance of laboratory work, scholars have been critical of its justification in chemistry education, especially considering the high cost to run a teaching laboratory (*cf.* Hofstein and Lunetta, 1982, 2003; Kirschner, 1992; Hodson, 1990; Reid and Shah, 2007; Bretz, 2019). Chiefly for this reason, chemistry educators need to provide more evidence of student learning in the laboratory, which goes beyond uni-dimensional marking of laboratory reports. In her editorial piece on the importance of laboratory courses, Bretz (2019) succinctly reasserts the need for substantiating learning in the

undergraduate laboratory. She contends that evidence of student learning in the teaching laboratory is paramount because higher education is influenced by diverse stakeholders who do not necessarily share the same value proposition.

In an attempt to substantiate the effect of laboratory instructions on student learning process and outcomes, chemistry education researchers have conducted empirical studies focused on various elements of learning in the laboratory at tertiary level (Agustian *et al.*, unpublished work). To date, some of these studies have been situated within particular theoretical frameworks, in terms of how learning is conceptualised and how the concept is operationalised into research instruments. For instance, student learning in the laboratory has been conceptualised in terms of cognitive load theory (*e.g.*, Winberg and Berg, 2007; Limniou *et al.*, 2009; Agustian, 2020a). Other researchers refer to the theory of meaningful learning, in which not only is the cognitive domain of learning investigated, but also in relation to the affective and psychomotor domains (*e.g.*, Rubin and Tamir, 1988; Bledsoe and Flick, 2012; Galloway and Bretz, 2015a, 2015b, 2015c).

Although research endeavours in this field have, to some extent, demonstrated the pedagogical value of teaching laboratories, I argue that the manner in which various aspects of learning have been conceptualised, operationalised, and substantiated is somewhat fragmentary or treated in isolation, with

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ARTICLE



A Growing Body of Knowledge

On Four Different Senses of Embodiment in Science Education

Magdalena Kersting · Jesper Haglund · Rolf Steier

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Abstract

Science deals with the world around us, and we understand, experience, and study this world through and with our bodies. While science educators have started to acknowledge the critical role of the body in science learning, approaches to conceptualising the body in science education vary greatly. Embodiment and embodied cognition serve as umbrella terms for different approaches to bodily learning processes. Unfortunately, researchers and educators often blur these different approaches and use various claims of embodiment interchangeably. Understanding and acknowledging the diversity of embodied perspectives strengthen arguments in science education research and allows realising the potential of embodied cognition in science education practice. We need a comprehensive overview of the various ways the body bears on science learning. With this paper, we wish to present such an overview by disentangling key ideas of embodiment and embodied cognition with a view towards science education. Drawing on the historical traditions of phenomenology and ecological psychology, we propose four senses of embodiment that conceptualise the body in *physical, phenomenological, ecological, and interactionist* terms. By illustrating the multiple senses of embodiment through examples from the recent science education literature, we show that embodied cognition bears on practical educational problems and has a variety of theoretical implications for science education. We hope that future work can recognise such different senses of embodiment and show how they might work together to strengthen the many roles of the body in science education research and practice.

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RESEARCH ARTICLE

“I Feel Like a Real Chemist Right Now”: Epistemic Affect as a Fundamental Driver of Inquiry in the Chemistry Laboratory

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Keywords: affect and emotion | chemistry laboratory | epistemic affect | experimental work | higher science education

ABSTRACT

Affect and emotions matter to science learning. They also matter because they are integral to science identity formation and sense of belonging. This study aims to foreground the epistemic and affective character of laboratory work in higher science education by conceptualizing it as epistemic practice, in which students activate their body and mind in discursive processes of proposing, communicating, and evaluating knowledge. On this conceptualization is an emerging construct, “epistemic affect,” which refers to how one feels when engaging with epistemic practices. Several methods were used to provide triangulated evidence for student learning processes and lived experiences in the chemistry laboratory. Students were observed and interviewed using custom protocols based on previously validated work. The empirical materials consist of audio recordings and transcripts of focus group interviews, audio and video recordings of students doing an experiment in analytical chemistry, verbatim transcripts of utterances and non-verbal cues, as well as instructional artifacts (laboratory manuals, textbooks, and reports). Key findings from the study reveal a range of epistemic emotions experienced by students, including curiosity, frustration, and joy, which are intertwined with their engagement in experimental work and exploration of scientific principles. The study also identifies affective constructs such as confidence, pride, and humility, which contribute to students’ identity development within the context of laboratory-related epistemic practices. These affective experiences are situated in the embodied nature of laboratory work, where failures and mistakes are common, but also serve as opportunities for learning. The research underscores the importance of recognizing and addressing the affective dimensions of learning in the chemistry laboratory. It suggests that fostering positive epistemic emotions and resolving negative ones can enhance students’ learning experiences and engagement with science. The study calls for a more holistic approach to chemistry education that acknowledges the role of emotion in laboratory-related epistemic practices.

1 | Introduction

Student learning in the chemistry laboratory can be conceptualized as a multidimensional construct, encompassing psychomotor, cognitive, affective, conative, social, and epistemic

domains (Agustian 2022; Nasir *et al.* 2021). The many dimensions of learning in this context lend themselves to a rich account of student experiences, but they are not equally represented in educational research and practice. A multitude of works in the field of laboratory education tend to put much

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Chemistry Education Research and Practice



PAPER

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Striving to learn to do chemistry in the laboratory: epistemic conation as a fundamental driver of inquiry

Hendra Y. Agustian, ·¹ Bente Gammelgaard, ·² Muhammad Aswin Rangkuti ·³ Marie Larsen Ryberg

Learning to do chemistry in the laboratory involves dispositional, motivational, and volitional factors that sustain and direct inquiry. These aspects have been theorised as constituting an incentive dimension that serves as a fundamental driver of inquiry, and they are often conceptualised as grit, perseverance, motivation, and similar notions emphasising individual characteristics or personality traits in students’ striving to learn. While concepts like grit and perseverance treat learning motivation as stable individual traits, epistemic conation captures the dynamic, knowledge-specific intentions that emerge when learners actively seek, evaluate, and apply scientific understanding—shifting focus from who the students are to how they intentionally engage with epistemic practice. Based on a series of studies within the context of laboratory education in pharmaceutical analytical chemistry, which is also a part of a large, recently concluded project, the paper unfolds how epistemic conation manifests in students’ collaborative and individual practices during laboratory experiments, highlighting how it encompasses conative dispositions, motivational factors, goal orientations, and volitional strategies. Through a mixed-method approach involving 30 students in the focus groups’ data and 43 students in the laboratory discourse data, we show that the social aspects of key constructs, such as perseverance, epistemic motivation, experimental goal orientation, and active help-seeking, are crucial in student learning and competence development in the laboratory. These findings suggest that effective laboratory instruction requires assessing how perseverance and motivation emerge through group dynamics, rather than evaluating students’ perseverance or motivation as a personal trait, and instructors would need to assess how these qualities emerge and function within group dynamics and peer interactions. Implications for research and practice are presented.

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1. Introduction

Rosalind Franklin’s iconic accomplishment as an English chemist and a trailblazer in molecular biochemistry demonstrates how perseverance emerges through and creates supportive environments across time and space (Latawa, 2021). She resisted gender discrimination in science during a pivotal moment when higher education finally, gradually admitted women (Shah, 2018). Through her persistence in doing research that led to the discovery of the DNA structure, albeit not credited initially (Julian, 1980), Franklin not only navigated hostile institutional contexts but also cultivated a legacy that now provides an inspirational environment for underrepresented scientists and students in

STEM (Latawa, 2021; Sunaser, 2023), showing how perseverance is as much an individual resource as a collective state of affairs.

Franklin’s experience encapsulates a key question about what makes human beings strive to pursue knowledge and persist in their striving. Historically, this question has given rise to a range of theories about what constitutes such striving and how it can be promoted. This has recently been addressed through the idea of “grit”, which has been used as a predictor of success and integrated into educational and training programmes (Sisk, 2011; Duckworth and Gross, 2014; Audley and Donaldson, 2022). However, the notion of grit has been criticised for overemphasising individual perseverance while overshadowing systemic barriers to success (Kirchgasler, 2018). An important critique (Credé, 2018) concerns the way the focus on grit tends to disregard social conditions, particularly those of marginalised, underrepresented students. In general chemistry, the deficit narrative of grit has been studied among Black and Latinx student populations, reasserting that grit is not an

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Upcoming webinars

Present-day Practicals webinar series '25/'26

1. How do students truly learn in the lab?
2. Extended reality in lab education
3. Refocusing labs: from cookbook to open inquiry
4. Fostering sustainability in lab education
5. Artificial intelligence in lab education
6. TBA

Thu 06/11/'25

Thu 20/11/'25

Tue 02/12/'25

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Thu 29/01/'26

Tue 17/02/'26

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March 2026



Link to evaluation



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