LESGEVEN IN DE CHEMIE INNOVEREN MET SYSTEEMDENKEN

CHEMICAL SCIENCE & ENGINEERING (SCHEIKUNDIGE TECHNOLOGIE) AAN DE UT

WAAROM ZOUDEN JOUW LEERLINGEN DAAR VOOR KIEZEN?
HOE SPREKEN WE ZE AAN?

Leonie Krab, opleidingsdirecteur en docent
Albert Wong, onderzoeker en docent
Arnoud Onnink, projectcoördinator en docent

Conferentie scheikundeleraren
Woudschoten
3 november 2023

UNIVERSITY
OF TWENTE.

6 VWO → UNIVERSITEIT

- We hebben meer scheikundig ingenieurs nodig voor de uitdagingen van deze tijd
- We hebben ruimte op de UT voor meer studenten in de science-opleidingen
- We staan als internationale opleiding onder druk vanwege politieke initiatieven
- Waar blijven de meiden?!

Timetable Online Bachelor Open Day

- 14:00 - 16:30 | Live chat beschikbaar
- 14:00 - 14:30 | Waarom UT?
- 14:30 - 15:05 | Studiepresentatie 1
- 15:05 - 15:30 | Kies een sessie
- 15:30 - 16:05 | Studiepresentatie 2
- 16:05 - 16:30 | Live Q&A

Wo 15 nov: Online Open Day
Vr 22/za 23 maart: on campus

HOE ENTHOUSIASMEREN WE LEERLINGEN?

BSc Chemical Science & Engineering (CSE) aan de UT:

We doceren over relevante chemie en vaardigheden voor de toekomst:

- de energietransitie,
- alternatieve, duurzame processen,
- LCA,
- duurzame materialen
- essentiële vaardigheden, etc.

Jullie begrijpen hoe boeiend én belangrijk dat is!

➢ Kunnen we samen bereiken dat meer leerlingen kiezen voor een studie als deze?

CSE CURRICULUM 2023-2024

YEAR 1

1 Chemistry	EC	2 Process Engineering	EC	3 Materials Science	EC	4 Equilibria & Electrochemistry	EC
Introduction to Mathematics & Calculus 1A	4	Mathematics: Calculus 1B	3	Mathematics: Linear Algebra	3	Mathematics: Calculus 2	3
Fundamentals of chemistry - (in)organ. structures - reaction categories - reaction mechanisms - polymers (synthesis) - project	8.5	**Thermodynamics**	4.5	**Materials Science** - quantum phenomena - inorg. mat. Science - polymers (physical prop.) - project	9.5	**Equilibria** - chemical equilibria - phase equilibria	5
		Process engineering - written test - distillation practicum - project	5			**Think like a researcher (Electrochemistry)** - electrochemistry (theory) - lab course & project	7
Lab course 1: Basic skills & Synthesis	2.5	Lab course 2: Energy & Process engineering	2.5	Lab course 3: Materials	2.5		

math
chemistry/ physics/ skills
lab

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CURRICULUM SCHEIKUNDIGE TECHNOLOGIE

YEAR 2

5 Industrial processes	EC	6 Transport Phenomena	EC	7 Molecules & Materials	EC	8A Process design	EC	8B Materials Science & Technology	EC
						Elective module: choose 8A or 8B			
Vector calculus	2	Numerical Methods	3.5	Organic and Bio-organic Chemistry incl. Lab course	8	Introduction Chemical Reaction Engineering (incl. process control)	4	Chemistry & Techn. of Inorganic Materials	4
Kinetics & Catalysis	4.5	Physical Transport Phenomena - fluid dynamics - heat transfer - mass transfer	7.5			Introduction Separation Methods	4	Chemistry & Techn. of Organic Materials	4
Industrial Chemistry & Processes	4.0			Interface Science incl.project	3	Project process design	7	Advanced Materials Science - materials S&T - project	7
Project Sustainable Industrial Chemistry and Essential Skills	4.5	Project Transport Phenomena	4	Characterization of Molecules & Materials Chemistry incl. Lab course	4				

www.utwente.nl/onderwijs/bachelor/opleidingen/chemical-science-engineering/

→ doorklikken naar "Studieprogramma"

Of stel een vraag: bachelor-cse@utwente.nl

Curriculum B-CSE 2023-2024

YEAR 3

9 Minor 1	EC	10 Minor 2	EC	11 Intro Bachelor assignment	EC	12 Bachelor assignment	EC
Minor module - at the UT, or - exchange semester, or - getting teacher qualification	15	Minor module - at the UT, or - exchange semester, or - getting teacher qualification	15	Research	2.5	Bachelor assignment - lab work / simulations - interpreting results - report writing - final presentation	15
				Statistics	3		
				Ethics	2.5		
				Preparation Bachelor Assignment	2		
				Elective: Biochemistry / Bionanotechnol. / Process Equipment Design / Study Tour prep. / some Applied Physics courses / Other (Board of Examiners)	5		

Essential skills education in the bachelor's:

a. **Intellectual and practical skills**
1. Inquiry and analysis
2. Critical thinking
3. Creative thinking
4. Written communication
5. Oral communication
6. Reading
7. Quantitative literacy
8. Information literacy
9. Teamwork
10. Problem solving
    - For CSE, this includes Design, and Modelling

b. **Personal and social responsibility**
11. Civic engagement – local and global
    - For CSE, this includes Sustainability awareness
12. Intercultural knowledge and competence
13. Ethical reasoning
14. Foundations and skills for lifelong learning
15. Global learning

c. **Integrative and applied learning**
16. Integrative learning

Ook veel aandacht voor essentiële vaardigheden!

- math
- chemistry/ physics/ skills
- lab
- large projects
- minor

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LEERLINGEN ENTHOUSIASMEREN MET CREATIVITEIT!

- Creativiteit als motivator
- Hoe zetten we creativiteit door, als een leerlijn van basisschool via de middelbare school naar het hoger onderwijs?
- Hoe zetten we creativiteit slim in, zodat het bijdraagt aan oplossingen?

- ➢ Conceptueel modelleren en systeemdenken in ons onderwijs
- ➢ Masterclass: “Lesgeven in de chemie innoveren met systeemdenken”

Workshop **Conceptual Modeling**

Albert Wong & Arnoud Onnink

M1 Fundamentals of Chemistry

3 November 2023

Masterpiece Gallery

The Masterpiece Gallery showcases the mindboggling creativity of the LEGO® community. Here, we pay tribute to great talents that have chosen the LEGO brick as their creative medium and spent countless hours conceptualising, designing, building and perfecting their artistic visions.

The Masterpiece Gallery is a celebration of the human imagination and the audacity of creation. It is a gallery dedicated to the LEGO builders of the world, featuring original works by multiple talents. The exhibited pieces have been handpicked by the gallery's curators and change on a regular basis, so most likely there will be something new on display for your next visit.

This is our tribute to our loyal fans around the world. and hopefully a great source of inspiration to everybody. Go create.

Overview workshop Conceptual Modeling (CM)

Learning Objectives

Part I. Context: Why do I need CM?
- Understand the context of CM
- Acquaint with typical problems in chemistry

Part II. Theory: What is a CM?
- Theoretical foundation of CM

Part III. Applicability: How do I develop a CM?
- Practice developing a CM

Lecture Format

- Lecture/Slides
- Poll questions (4)
- Group assignment (1)

Post-Lecture

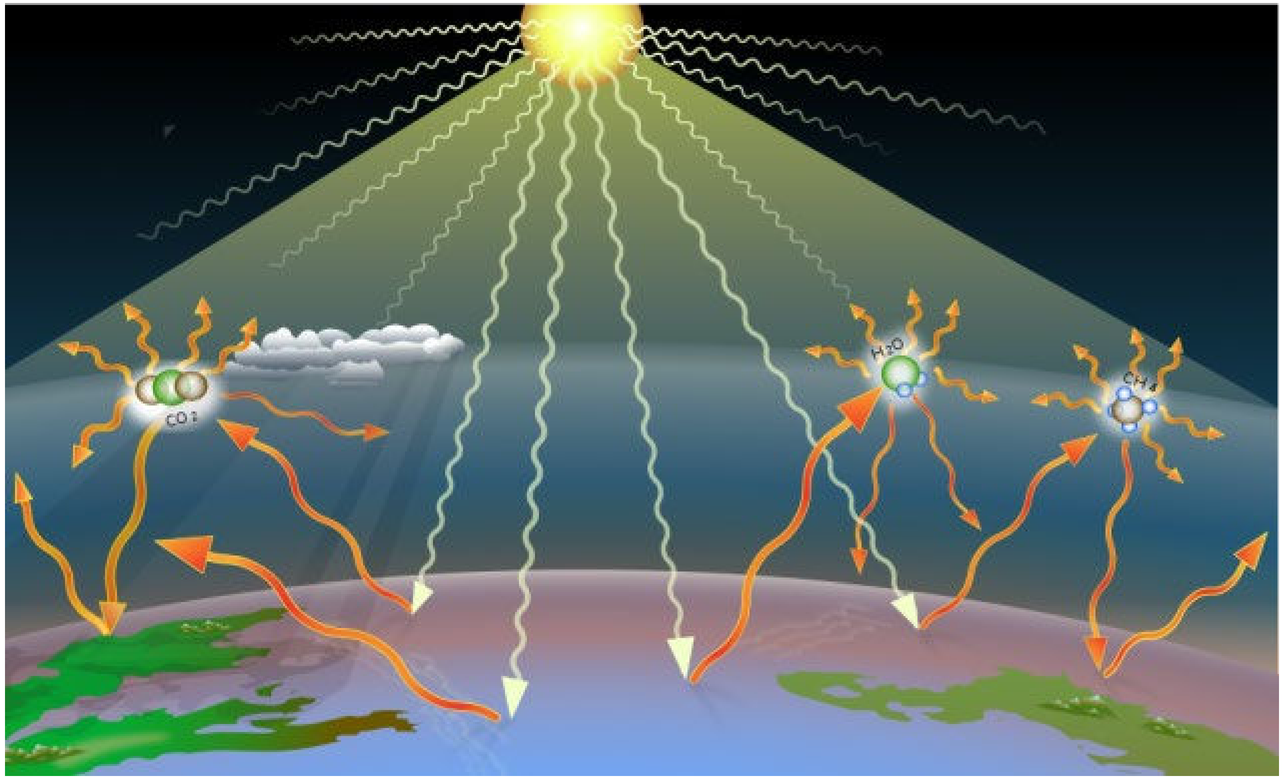
- Read suggestions literature (optional)
- Start your project; chose topic, contact tutor, and initiate literature search

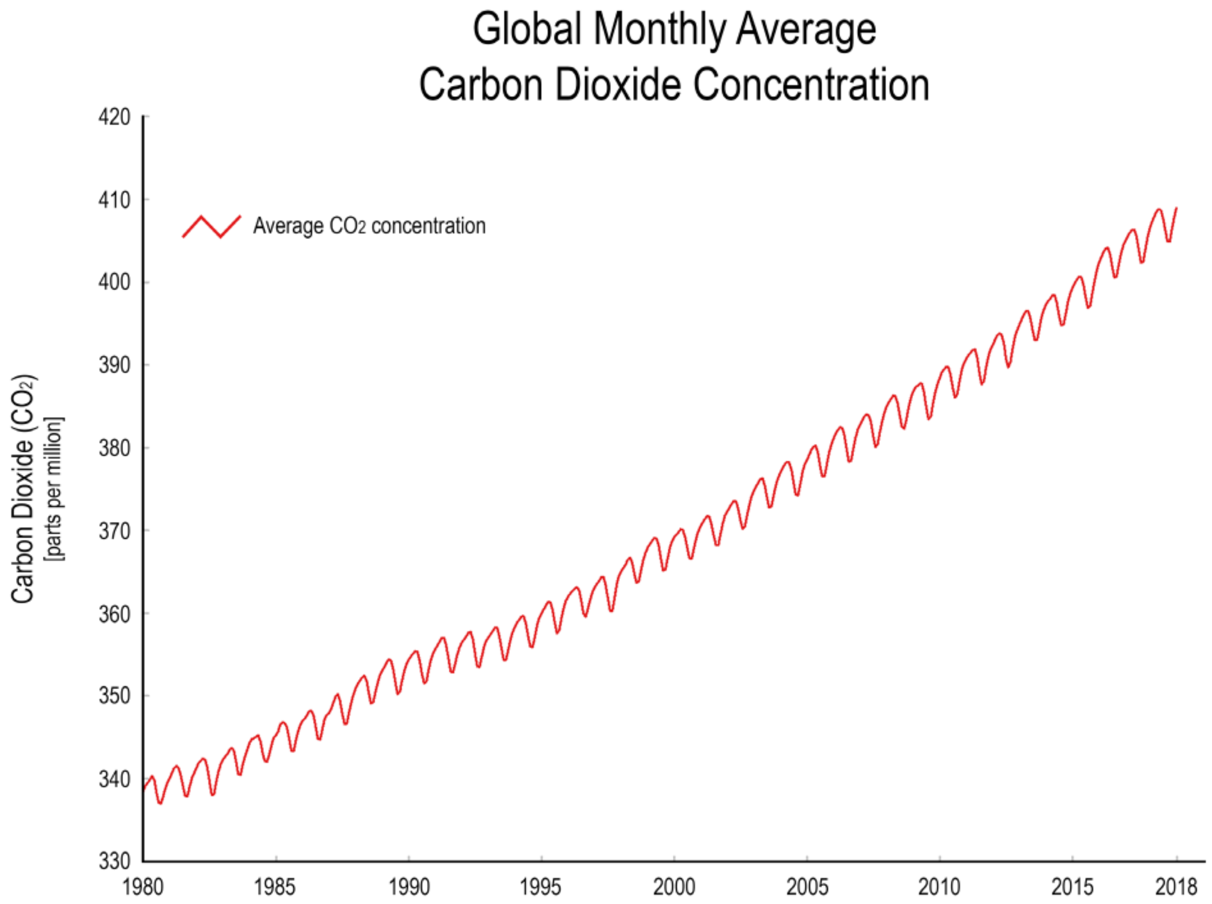
References

1. York *et al.*, *J. Chem. Educ.* **2019**, 96, 2742−2751
2. M. Orozco, M. Boon & A. S. Arce, *Eur. J. of Eng. Edu.* **2022**
3. M. Boon & T. Knuuttila, *Philos. Sci.* **2009**

Part I. Context: Why do I need CM?

You probably will need to think of solutions related to sustainability!





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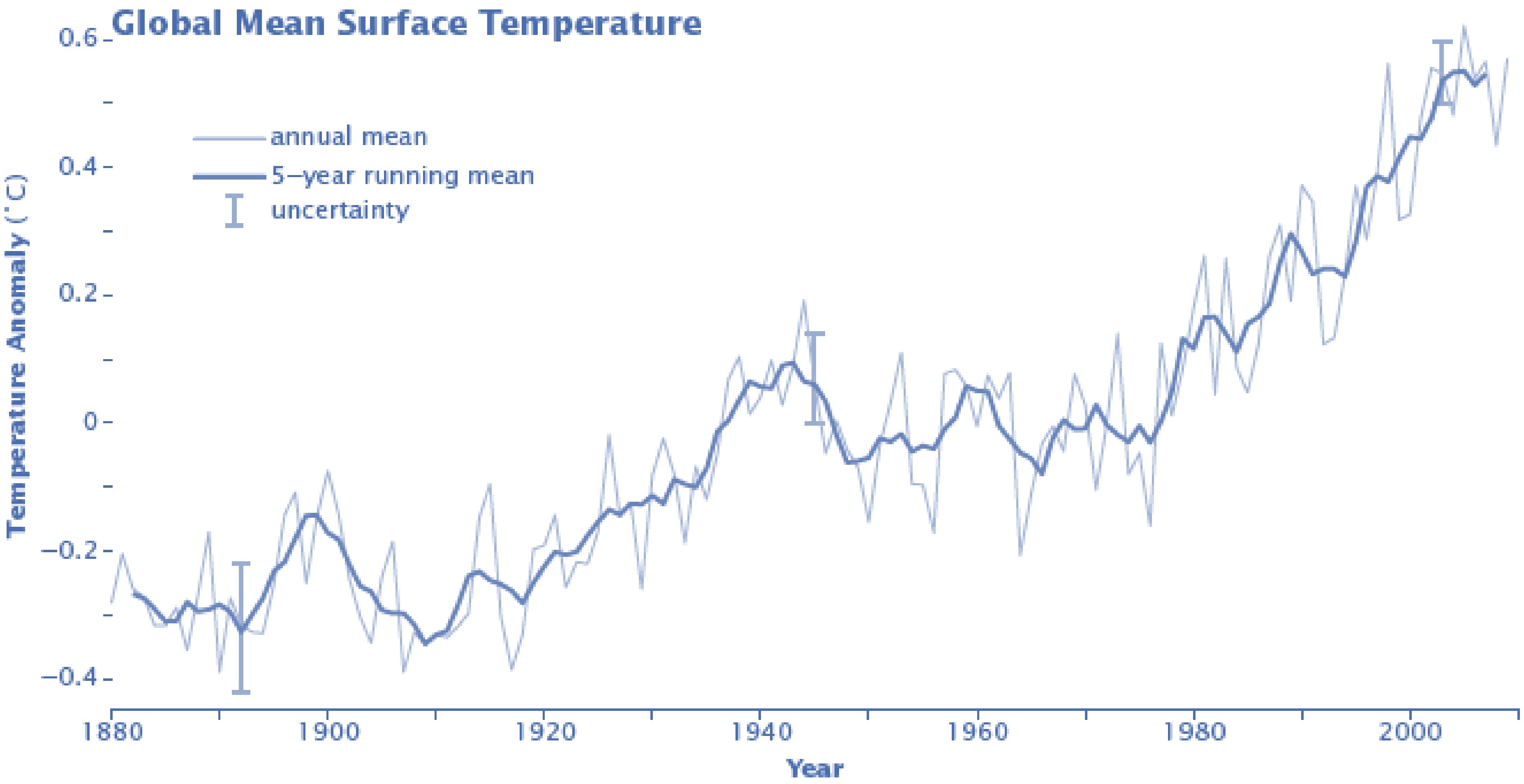

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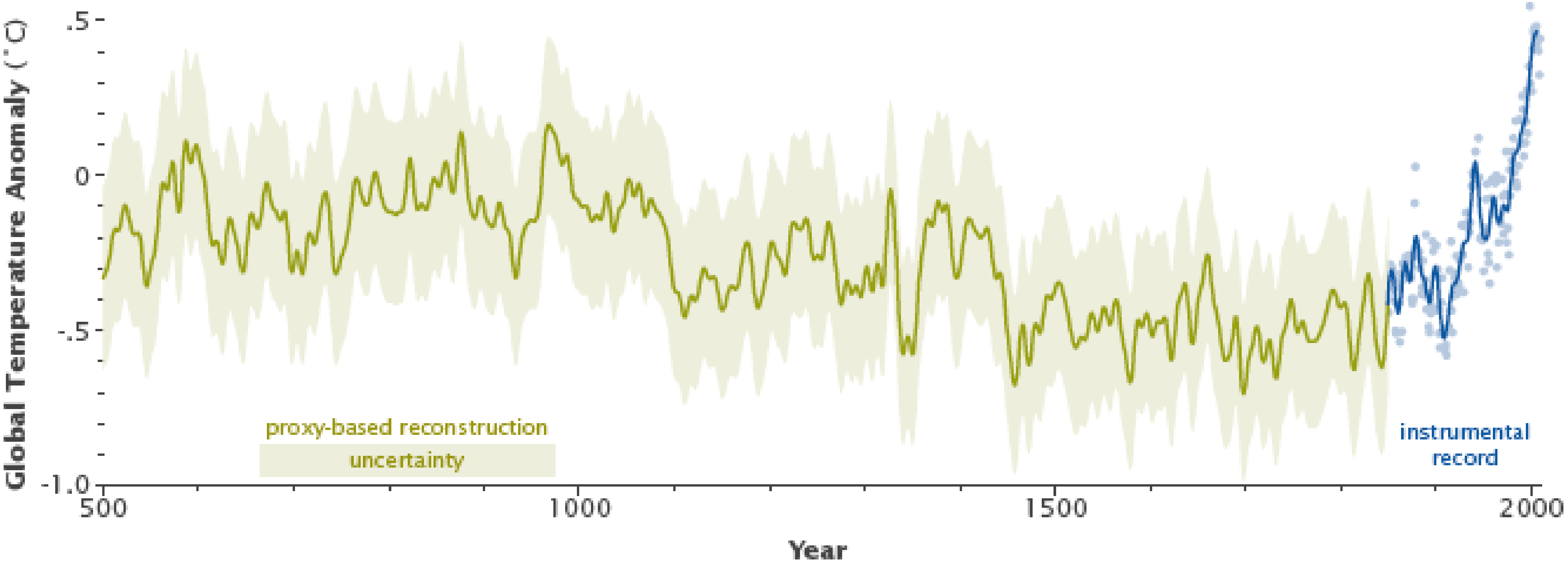
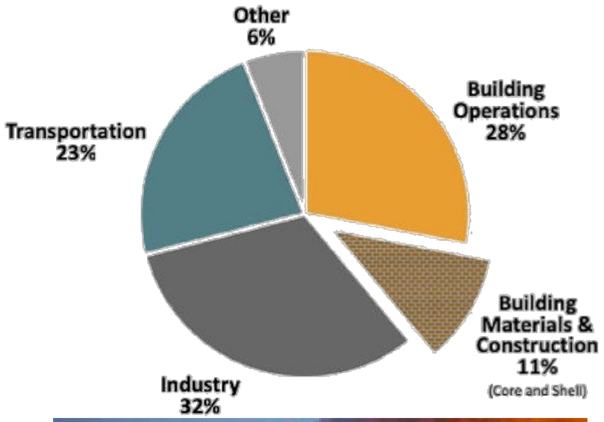
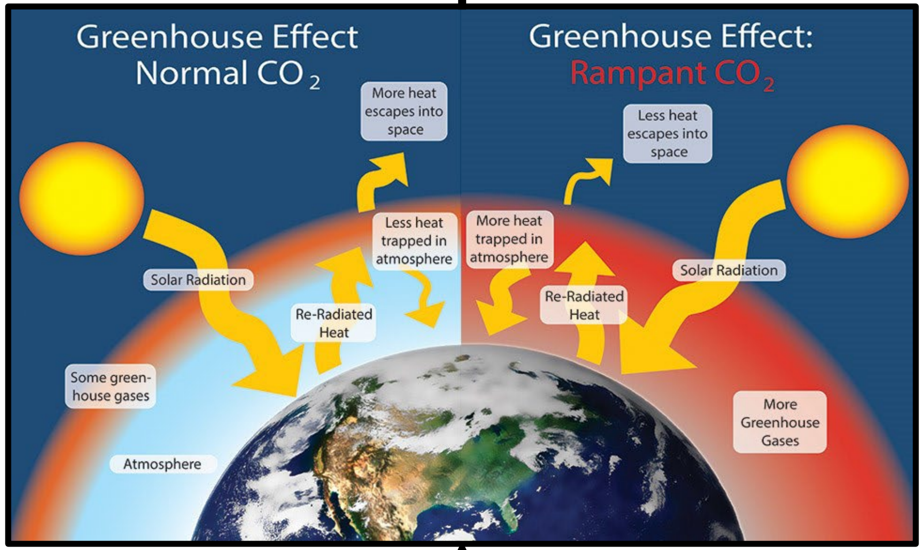
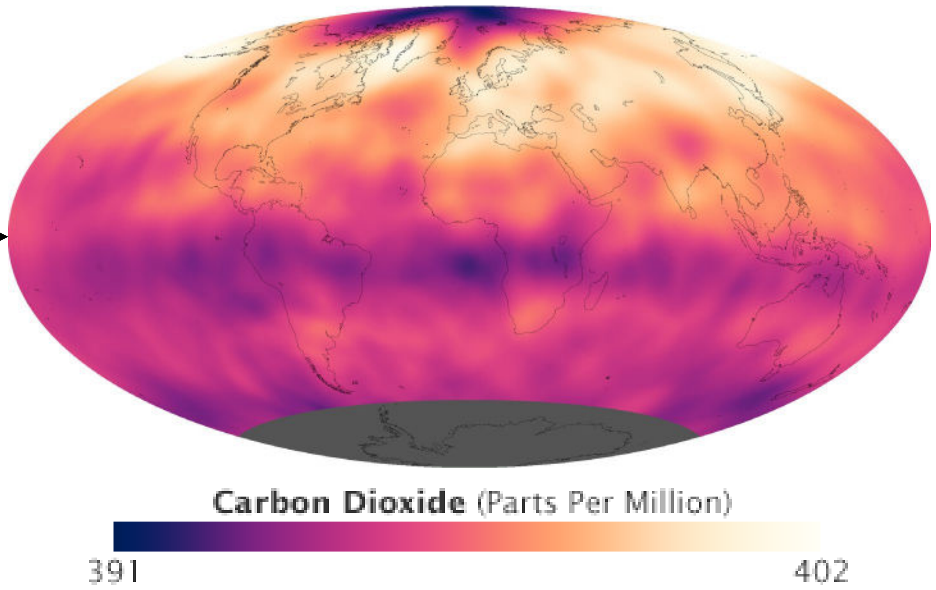


Solutions are difficult to 'find' because …







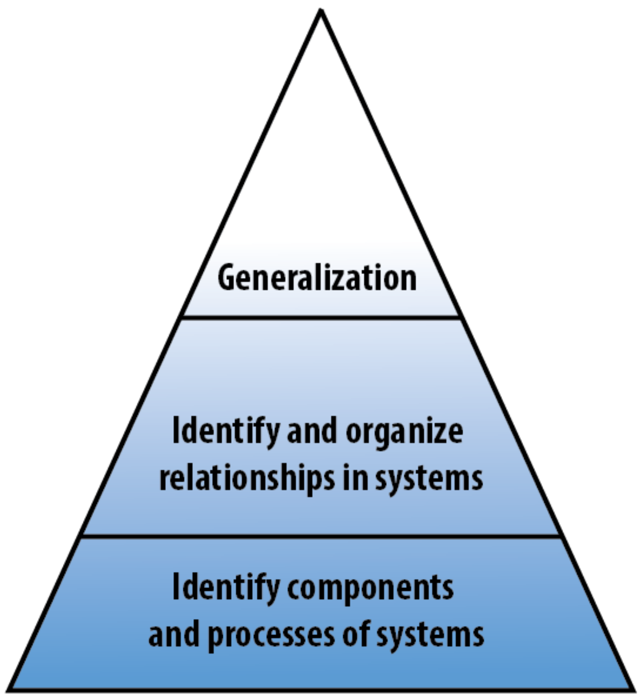
Solutions are difficult to 'find' because …

Grand challenges of the 21st Century require skills in **investigating and understanding interactions between a system and its environment, including the human components therein.**

Solutions require systems thinking!

Grand challenges of the 21st Century require skills in investigating and understanding **interactions between a system and its environment**, including the human components therein.

Characteristics of Systems Thinking

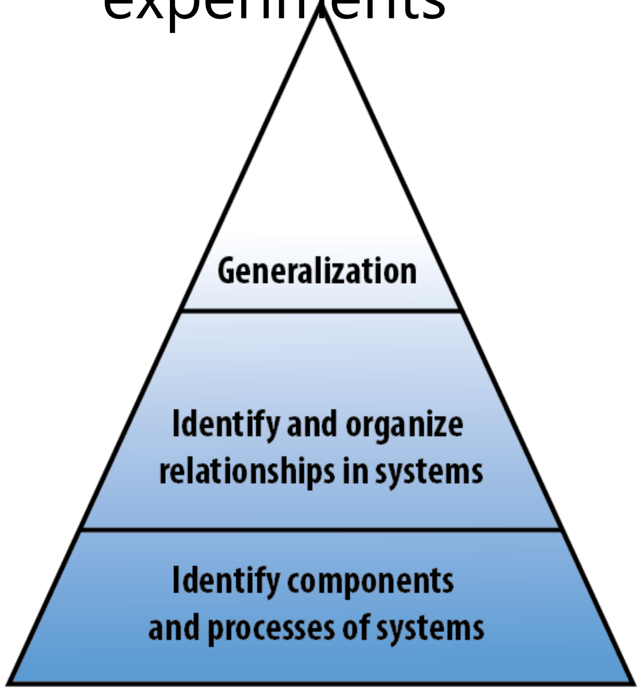


- **Recognizing that a sum is greater than its parts**
  All pieces are interconnected and contribute to the outcomes of the system.
- **Considering closed loops**
  There are many ways in which two system-relevant variables affect each other, as opposed to how one variable affects the other (as in linear chains).
- **Prioritizing candidate solutions**
  Tries to expand the range of options available for solving a problem.

Systems thinkers are curious, have open minds, and seek out root causes

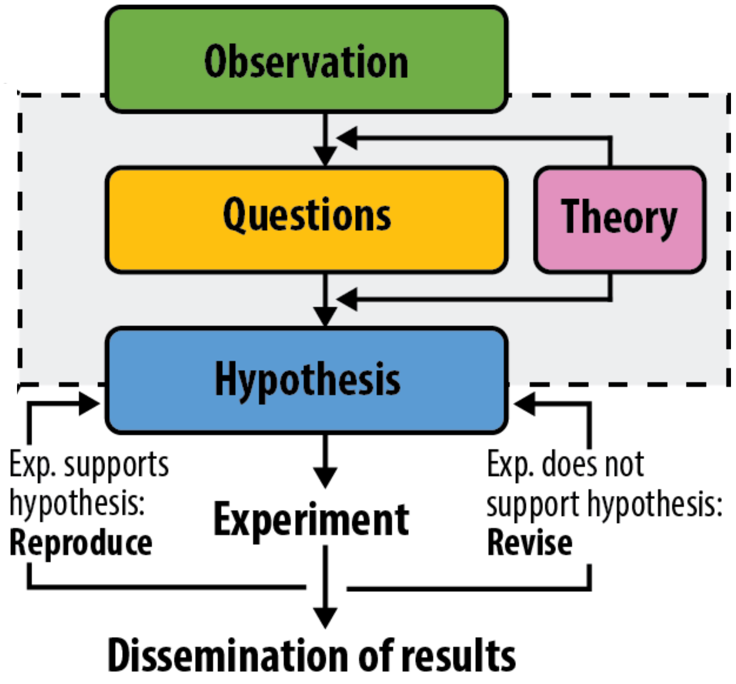
But how do we go from Systems Thinking (ST) to the classical hypothesis-deductive model?

Think in systems experiments



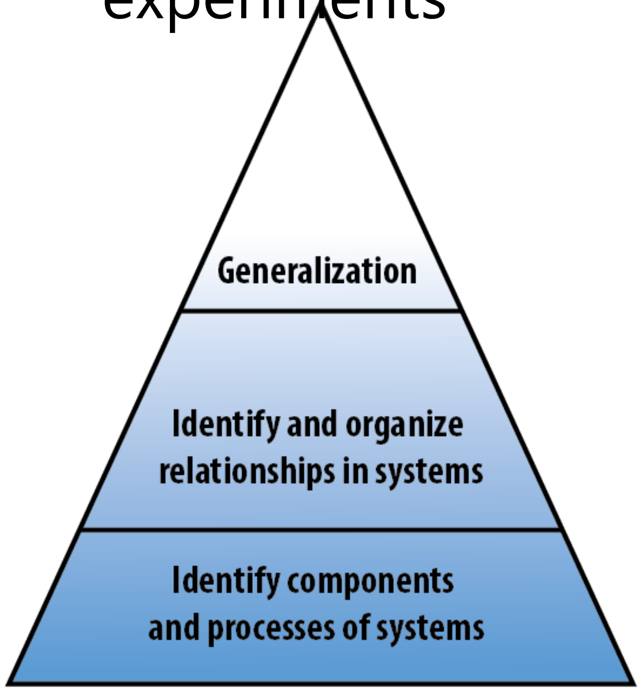
? →

Design chemistry

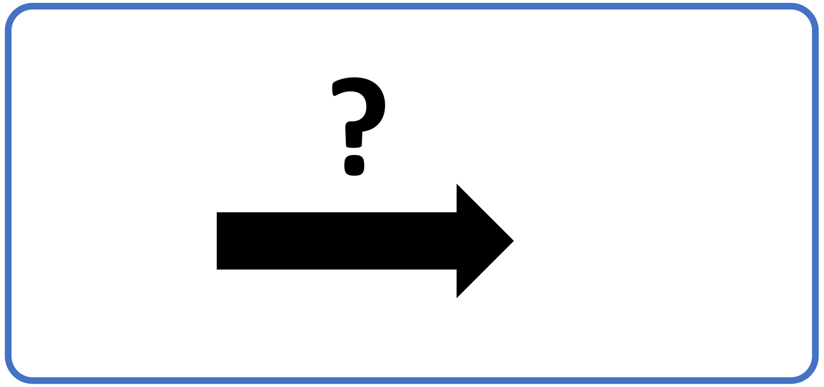


Summary Part I: **We need methods for Systems Thinking in Sustainable Chemistry**

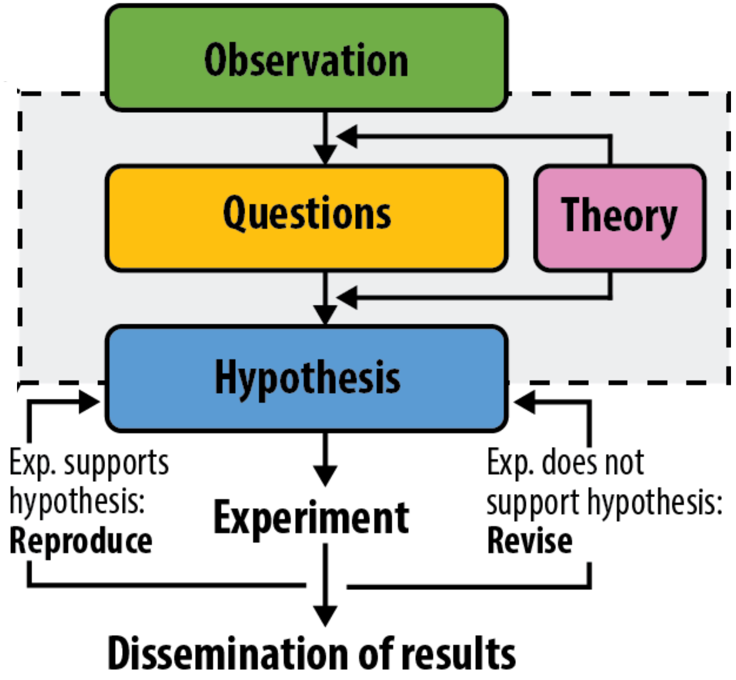
Think in systems experiments



Conceptual model

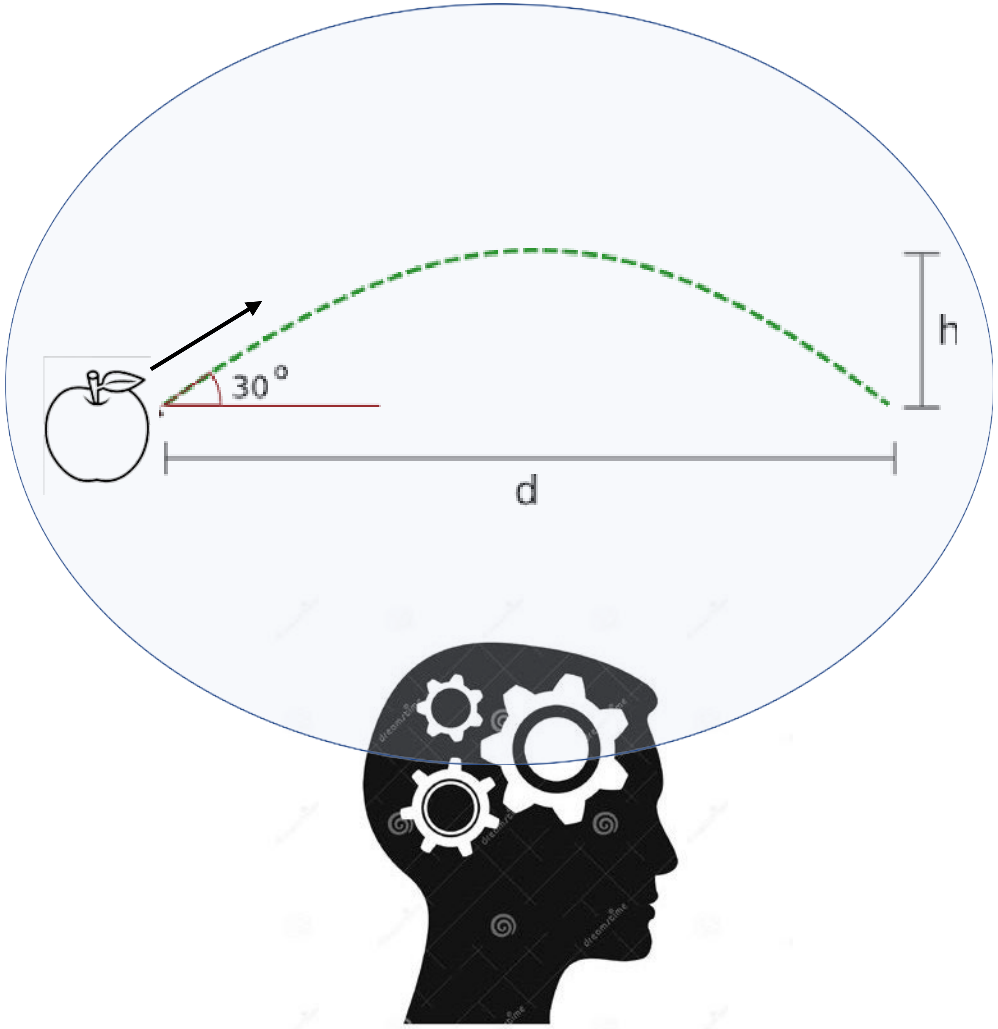


Design chemistry



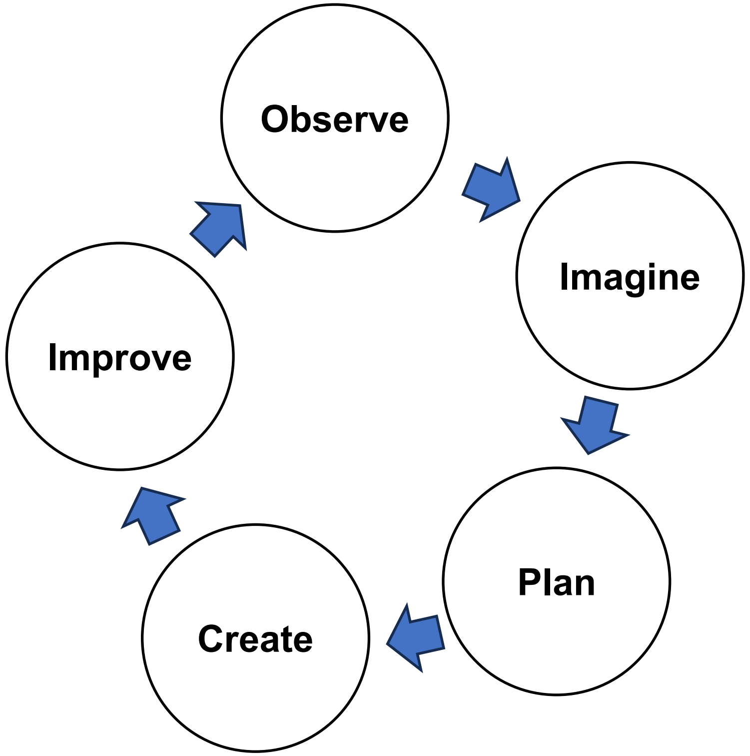
Part II. Theory: What is a CM?

What happened?



Based on this **conceptual model**, a **mathematical model** can be constructed using Newton's laws.

So, how do you develop a conceptual model?



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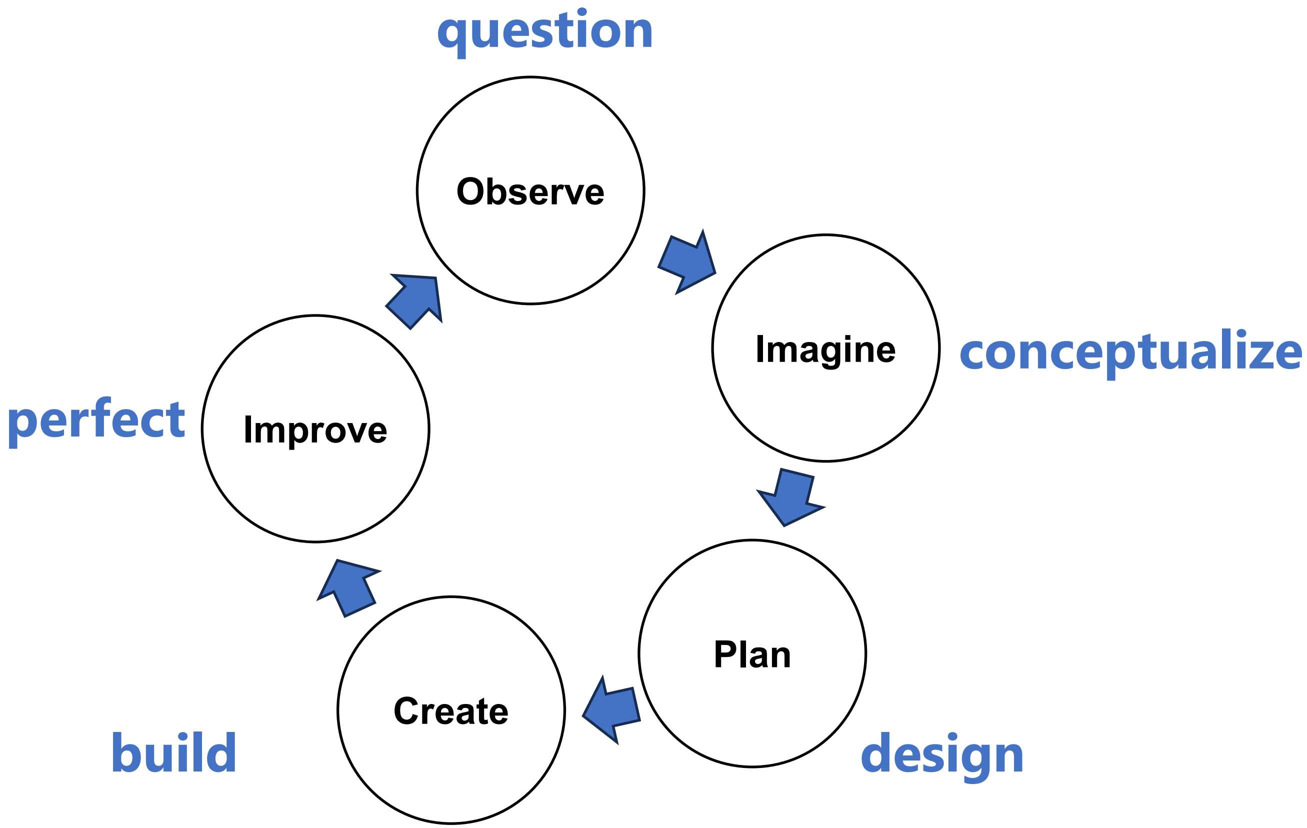
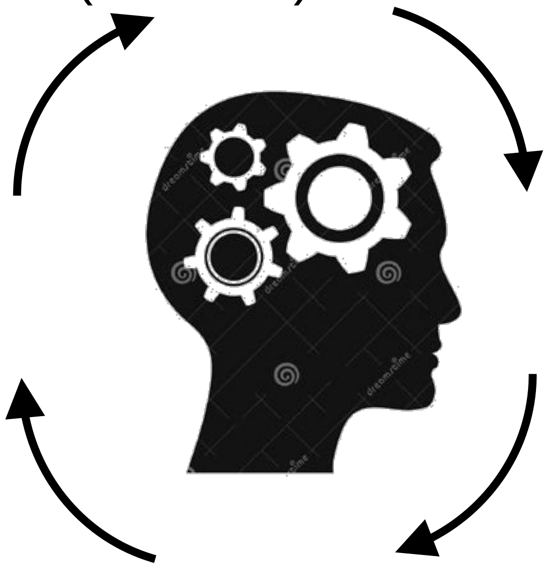


So, **how** do you develop a conceptual model?

The **problem** = a 'story' of your understanding of the problem (Phase I).



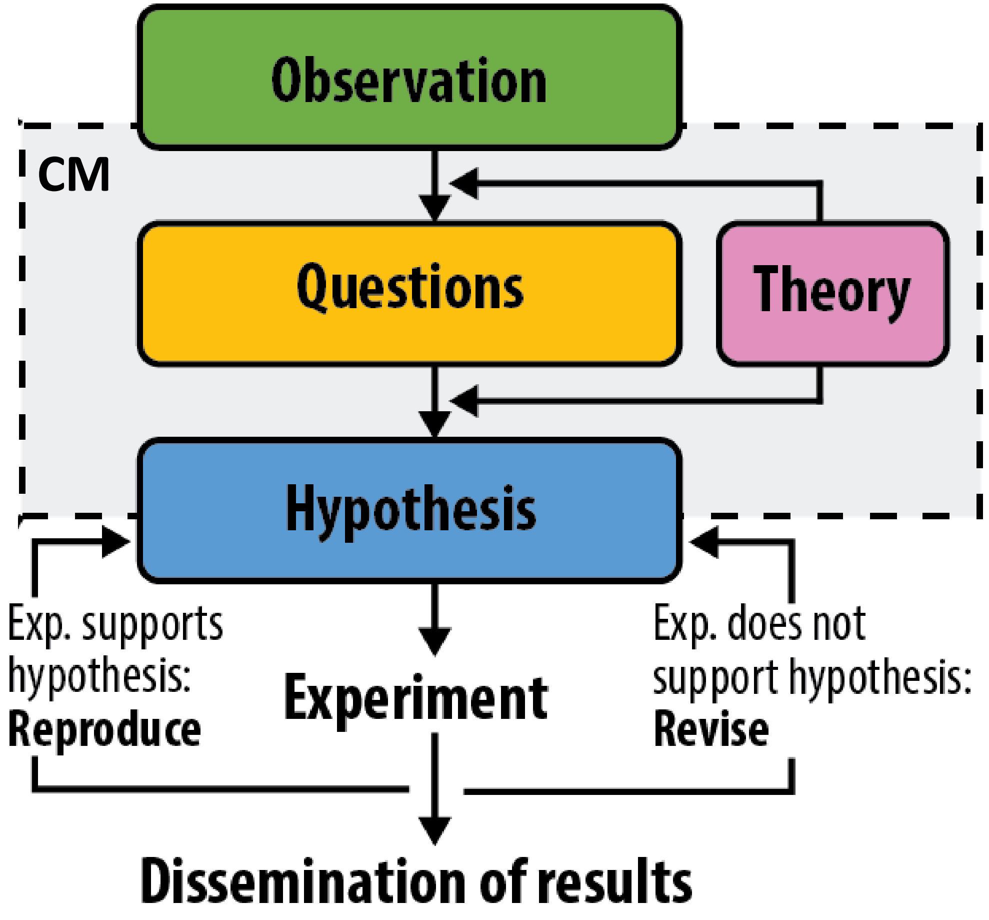
- **Ask questions** to broaden and deepen your understanding
- **Search answers** in your textbooks and scientific literature
- Integrate information into a **coherent** 'story'
- How can you address a **scientific gap**?

The **solution** = your design idea for solving that problem (Phase II).

Why could CM help?

- You should come up a **hypothesis**,
- Which forces you to enter an empirical cycle (i.e., a **deductive method**).
- Trouble is getting lost:

On what grounds can we build a hypothesis?



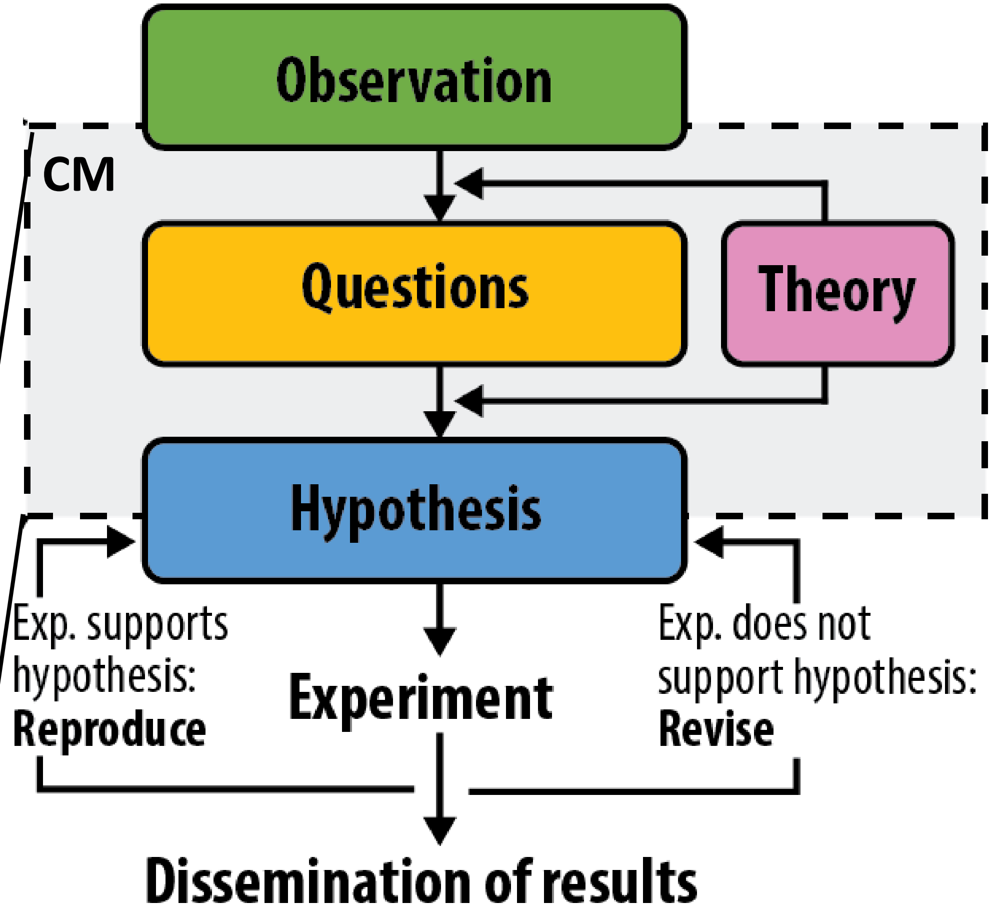
CM is a tool for developing hypothesis

- You should come up a **hypothesis**,
- Which forces you to enter an empirical cycle (i.e., a **hypothetical-deductive method**).
- Trouble is getting lost:

On what grounds can we build a hypothesis?

A Conceptual Model:

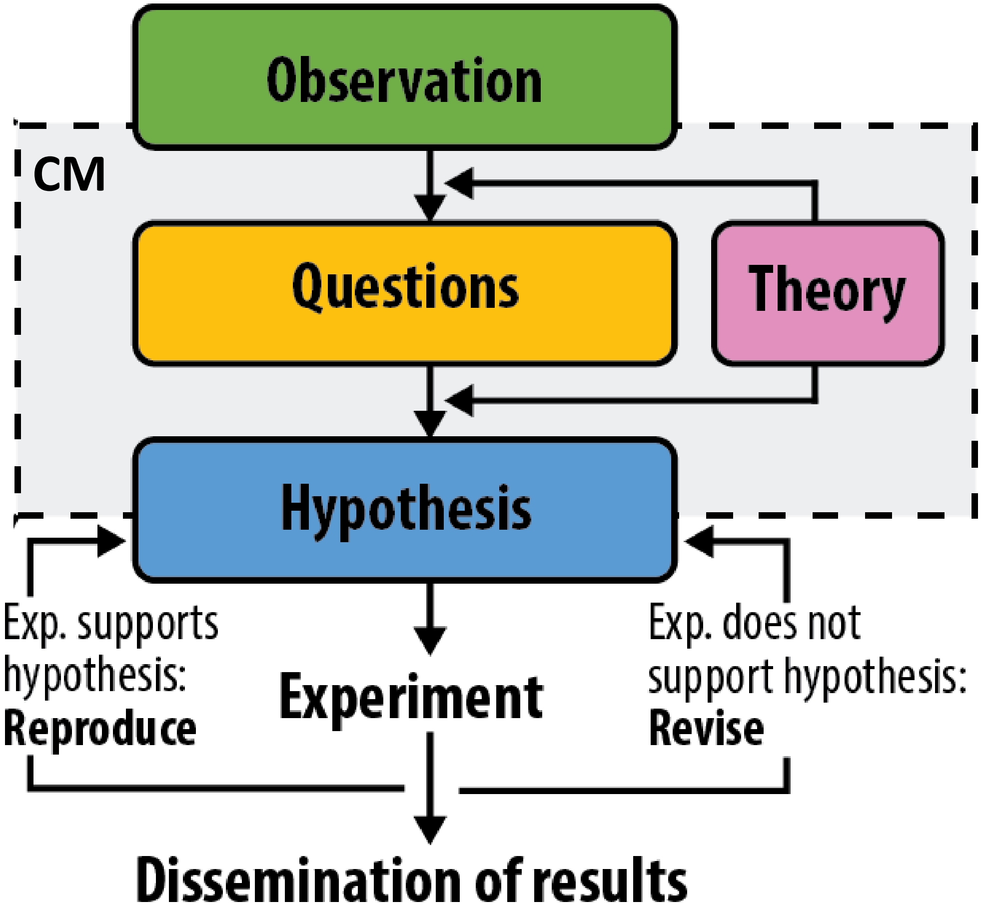
1. A **tool** for getting to **a hypothesis**
2. Entails **simplifications**; is **never complete**



Requirements: CM must conform method of deduction

Logical reasoning comprises:

1. **A demonstration that you asked questions** to broaden and deepen your understanding
2. **A demonstration that you searched answers** in your textbooks and scientific literature
3. **An integration** of information into a **coherent 'story'.** *(i.e., information becomes knowledge)*
4. **A scientific gap**. *(otherwise, your experiment was not needed to create knowledge)*



Summary Part II:

CM **is** a method that promotes **concept-related thinking**

CM **focuses** on the **reasoning ability** of scientists

CM **can** enable the development of **systems thinking abilities**

From Part II to Part III:

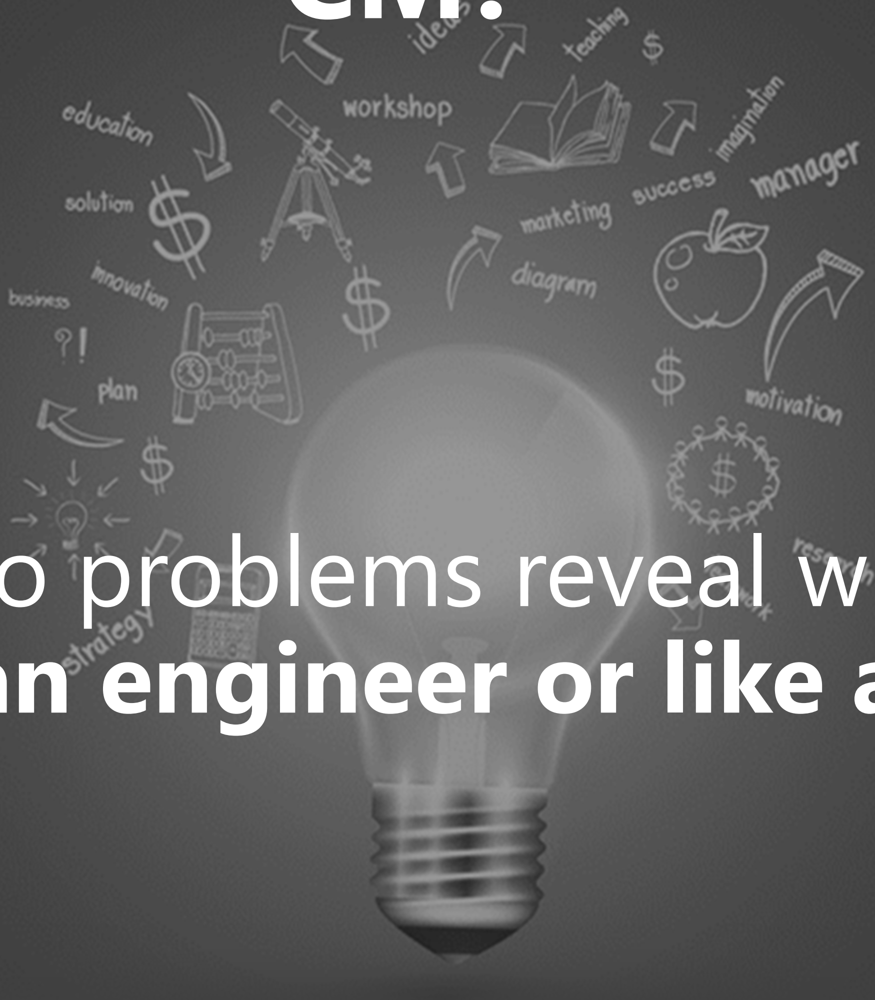
CM **is** a method that promote **concept-related thinking**

CM **focuses** on the **reasoning ability** of scientists

CM **can** enable the development of **systems thinking abilities**

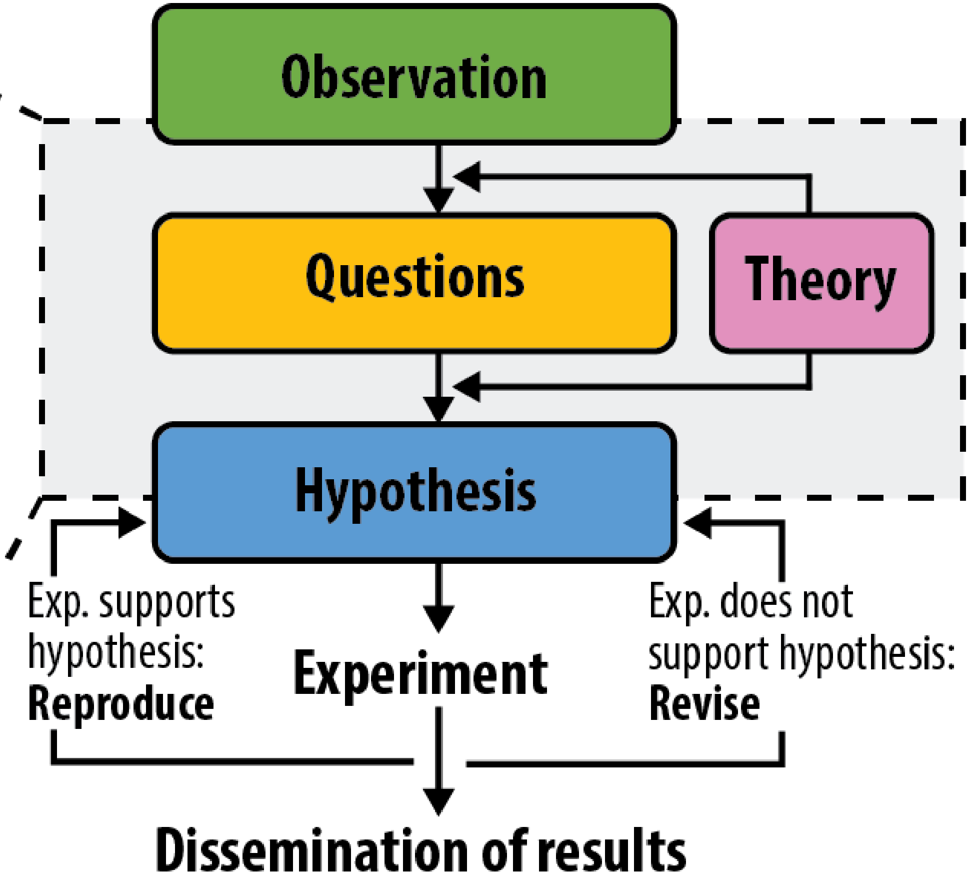
Part III. CM in **this project** should allow you to familiarize with the academic way of thinking and **apply critical thinking skills as a team**

Part III. Applicability: How do I develop a CM?



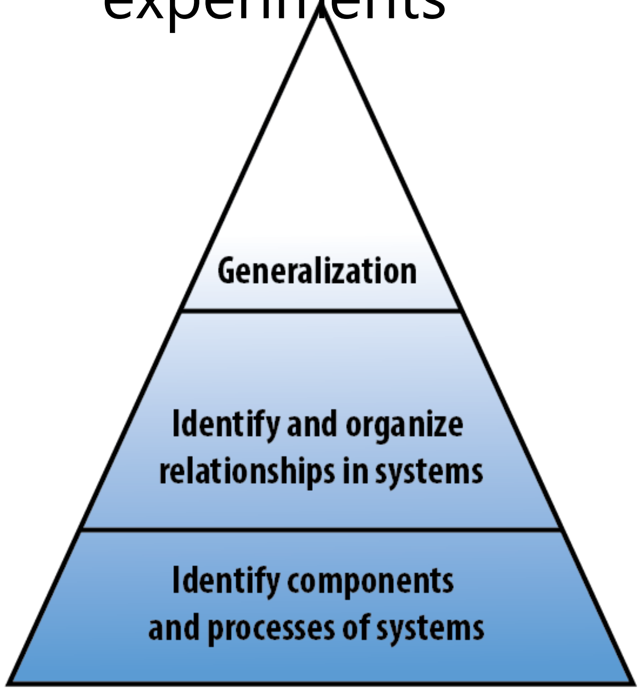
Solutions to problems reveal whether one **thinks like an engineer or like a researcher**

Assignment: Let us brainstorm

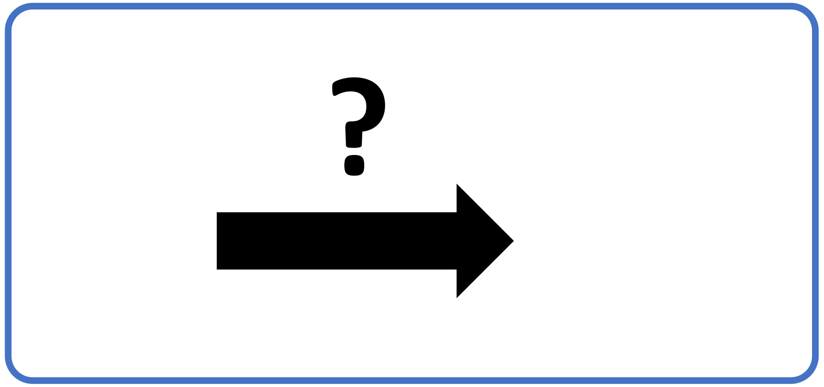


Recap Part I: **We need methods for Systems Thinking in Sustainable Chemistry**

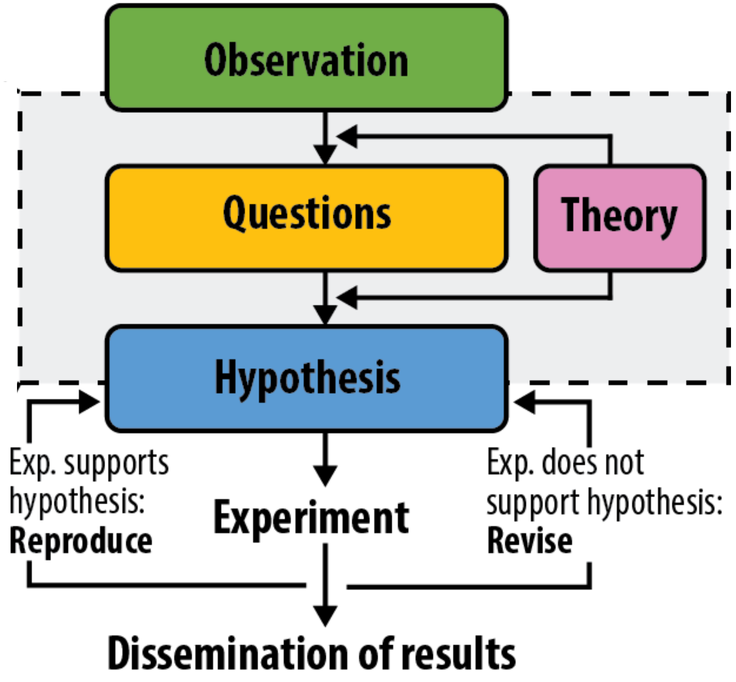
Think in systems experiments



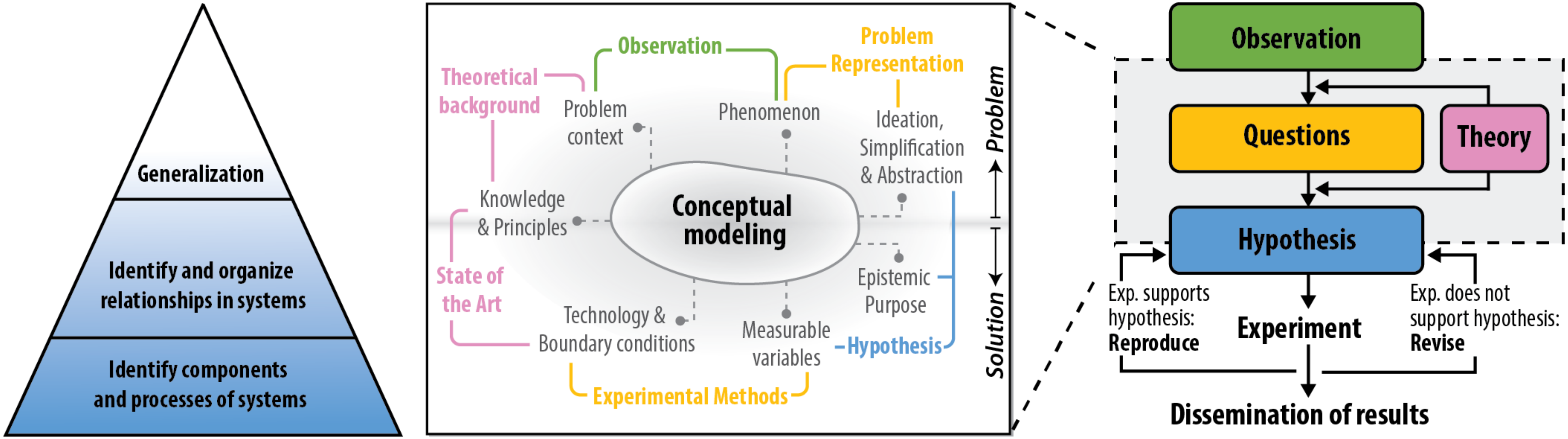
Conceptual model



Design chemistry



Combining all parts

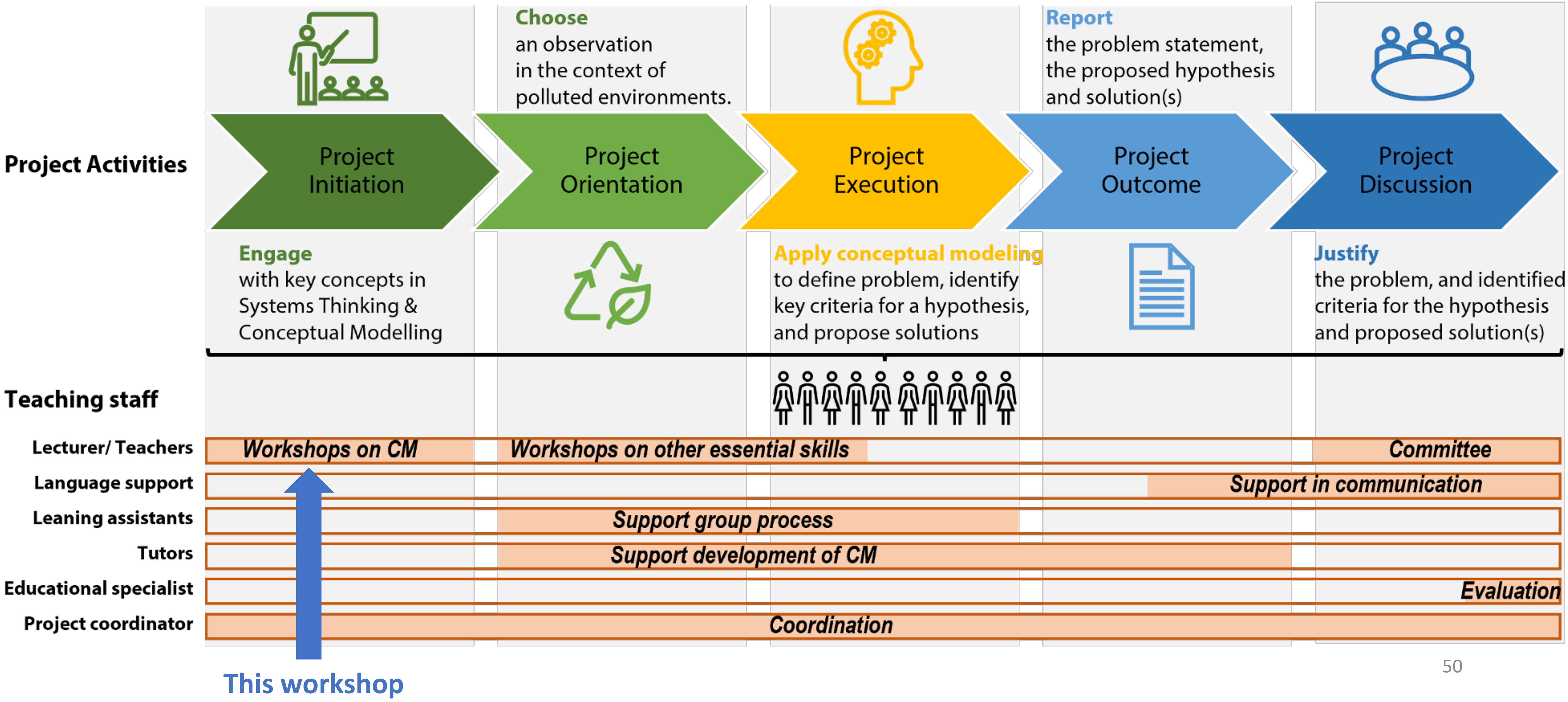


Conceptual Modeling Enables Systems Thinking in Sustainable Chemistry and Chemical Engineering

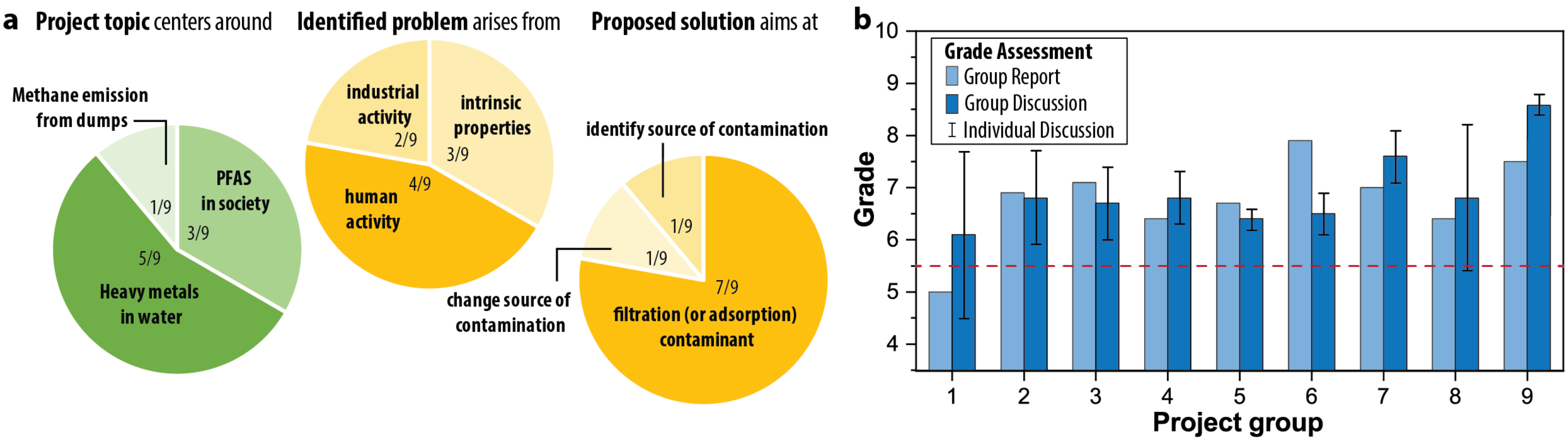
Leonie E. Krab-Hüsken, Linlin Pei, Pepijn G. de Vries, Saskia Lindhoud, Jos M. J. Paulusse, Pascal Jonkheijm, and Albert S. Y. Wong*

We published this in November 2023: https://pubs.acs.org/doi/10.1021/acs.jchemed.3c00337

General activities and objectives in the project



Examples from previous year



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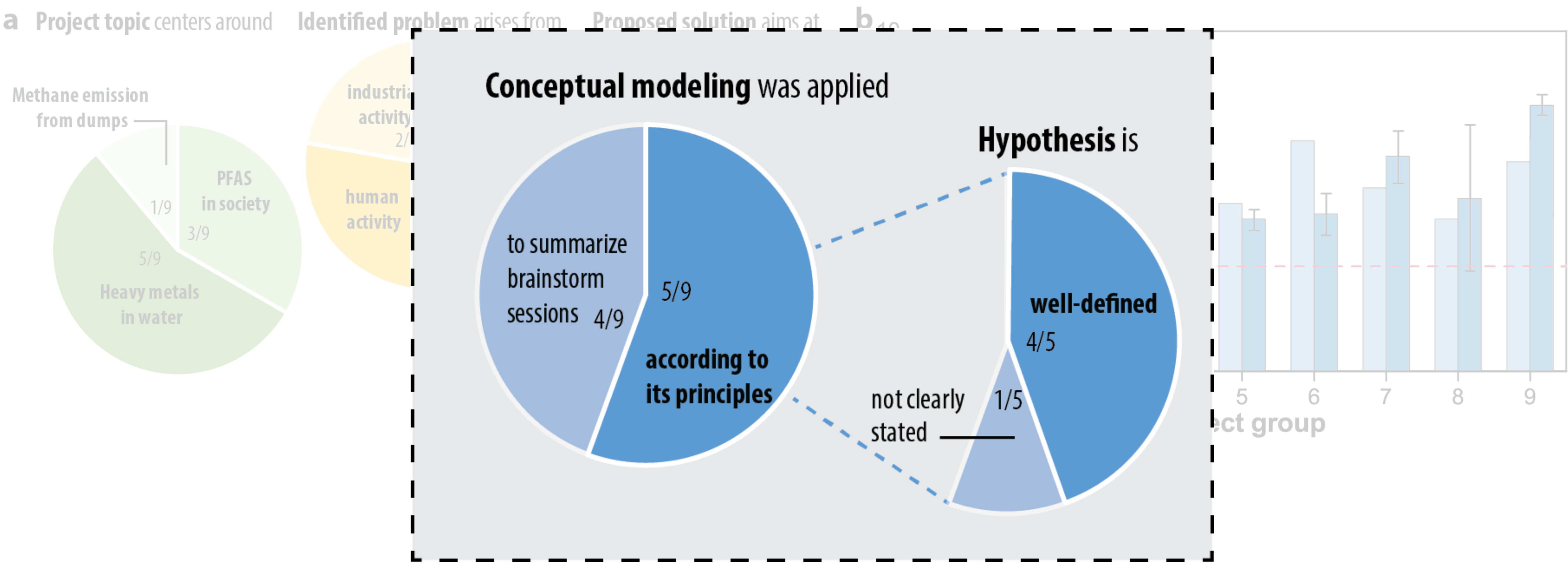


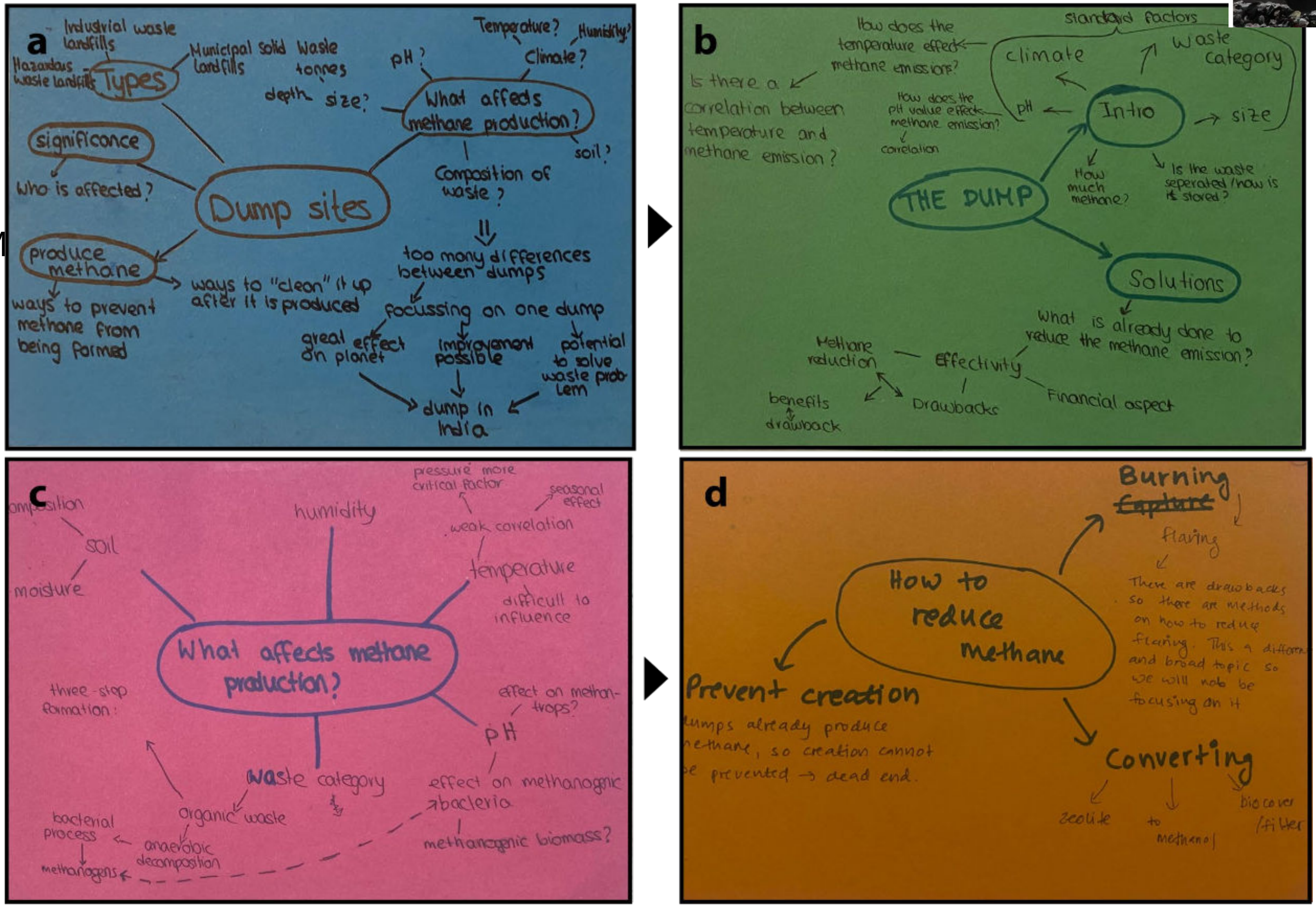
Lessons learned: A collective student's perspective

Procedure to organize their final CM.

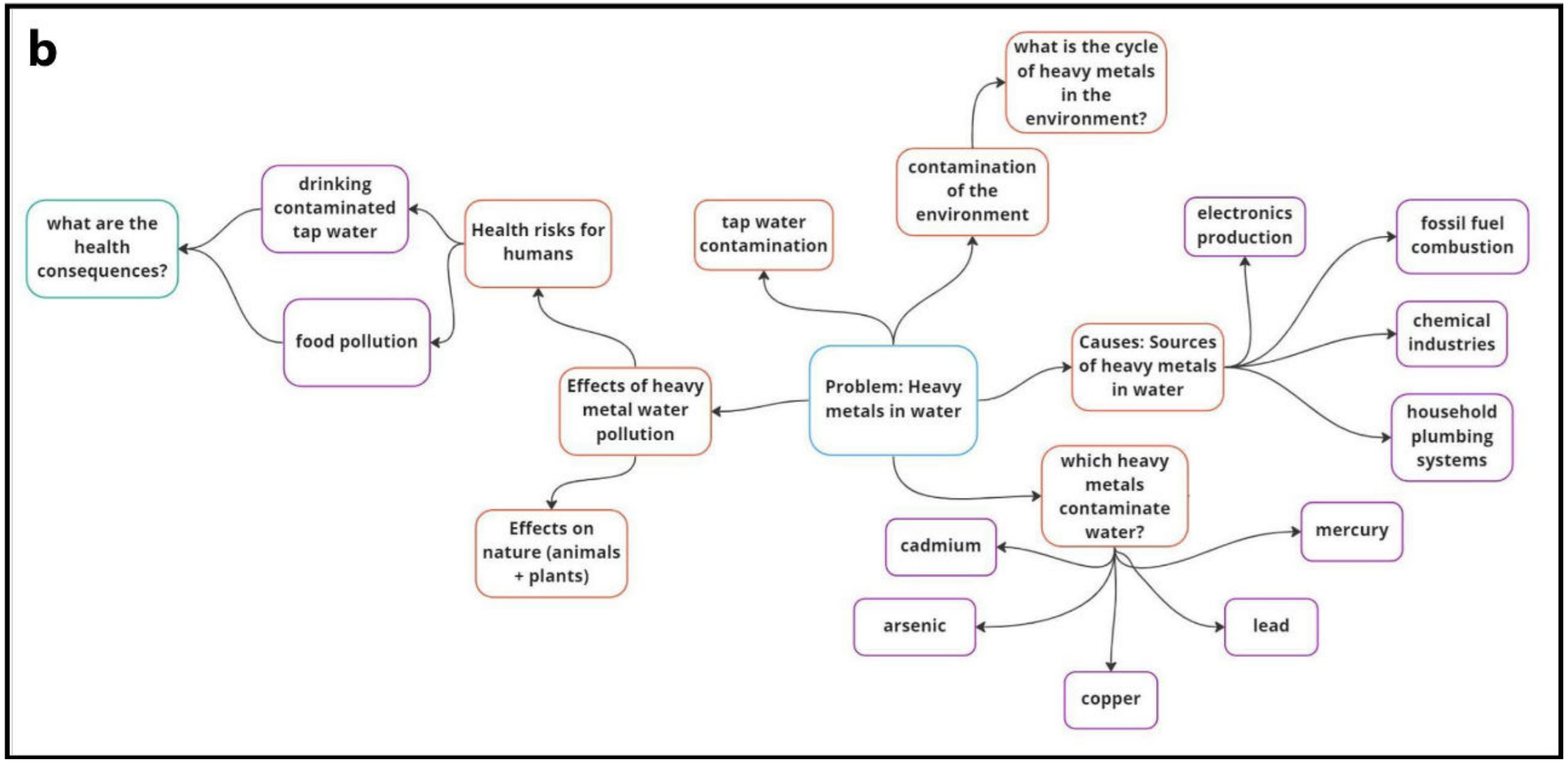
1. **Find background information** to understand the relevance of the topic
2. **Specify search** to find correlations between the phenomenon and different variables. Furthermore, look into existing methods that one could use.
3. **Narrow down the approach**, based on correlations found in step 2.
4. **Discussed and compared various methods**, as a group. The discussion includes materials and operating costs, which are an essential factor in large scale application.

Example of **successful** applications of CM

Procedure to organize CM



Example of **unsuccessful** applications of CM

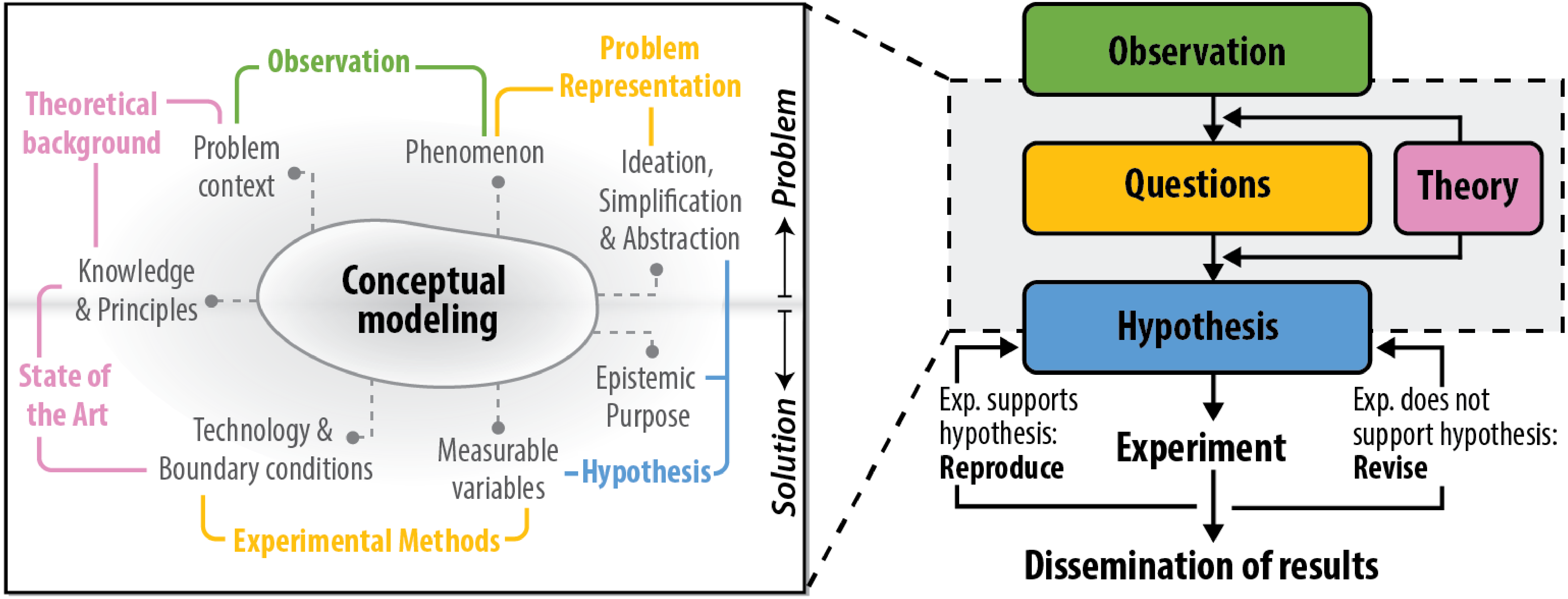


A CM depicted as a mind map for **unstructured connections**

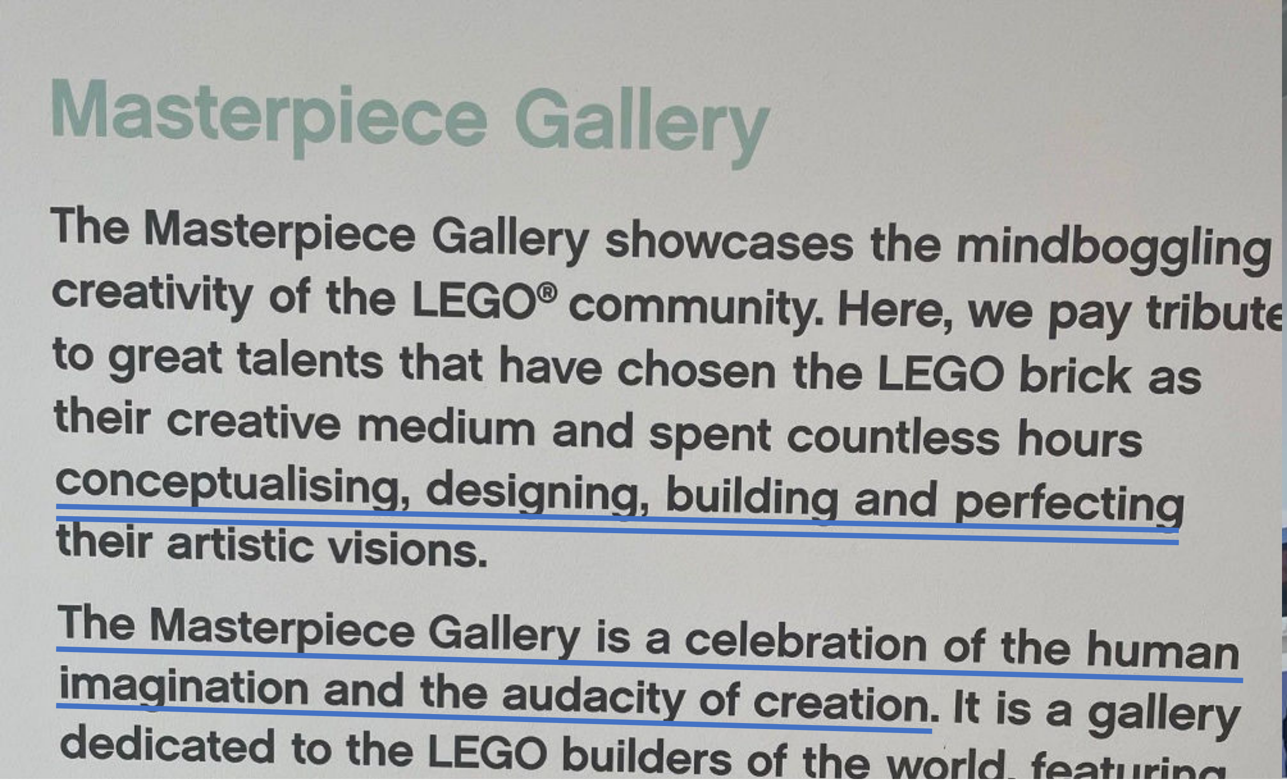
Roles of tutors and learning assistants in guiding

Teaching staff	Role in project	Possible actions wherein help could be provided
Tutor (experienced researcher with a PhD degree in chemistry and a permanent position at our university)	**Guidance of the development of CM**	Create an accurate representation of a relevant societal problem.
		Assess if scientific literature is relevant.
		Identify criteria for narrowing down the problem.
		Asking the right questions to formulate a research question.
		Getting to a meaningful hypothesis.
		Designing a plausible solution.
Learning assistant (senior student with extensive didactical training and experience in CSE projects)	**Guidance of the group process**	Organize agenda, communication, and division of team roles.
		Monitor and stimulate group dynamics.
		Establish and maintain a friendly and open atmosphere.
		Level with students (being approachable).

Summary : CM scaffolds the transition from an observation to developing a hypothesis.



We published this in November 2023: https://pubs.acs.org/doi/10.1021/acs.jchemed.3c00337



“Be curious, have open mind, and seek out root causes”

—> CM provides you the framework