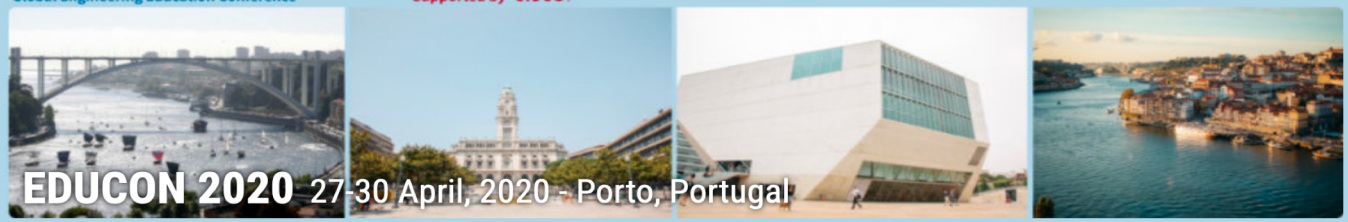
IEEE EDUCON Global Engineering Education Conference ONLINE Supported by CISCO



Complex problem solving and PBL in engineering education

Anette Kolmos

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http://www.ucpbl.net

United Nations Educational, Scientific and Cultural Organization

AALBORG UNIVERSITY

Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the auspices of UNESCO

Take away messages

- Bring in more **variation in learning methodologies**
- Apply **variation in PBL**
  - Problems
  - Projects
  - Degree of interdisciplinarity and complexity

- **Reflection on variation** and ways to create personal learning tracks
- Develop at a **system level** – or at least across courses

https://greenlogic.com.au/blog/what-is-transfer-learning/

Introduction

Challenges are lining up….

- Corona – and the overnight implementation of digital learning and digital conferences….. Maybe we need some reconstructions…

- Climate change, sustainability and all the SDGs
- Fourth industrial revolution with an integrated AI and IoT approach

What EE ought to discuss:

- What are the future competences?
- Ways to integrate and address system thinking?
- How do engineers interact with AI, larger systems?
- How do we educate for lifelong personal learning tracks?

https://www.it2trust.com/en/events/march-webinar-multi-cloud-challenges-ahead-what-to-do/

Is the answer student centred Problem and Project Based Learning?

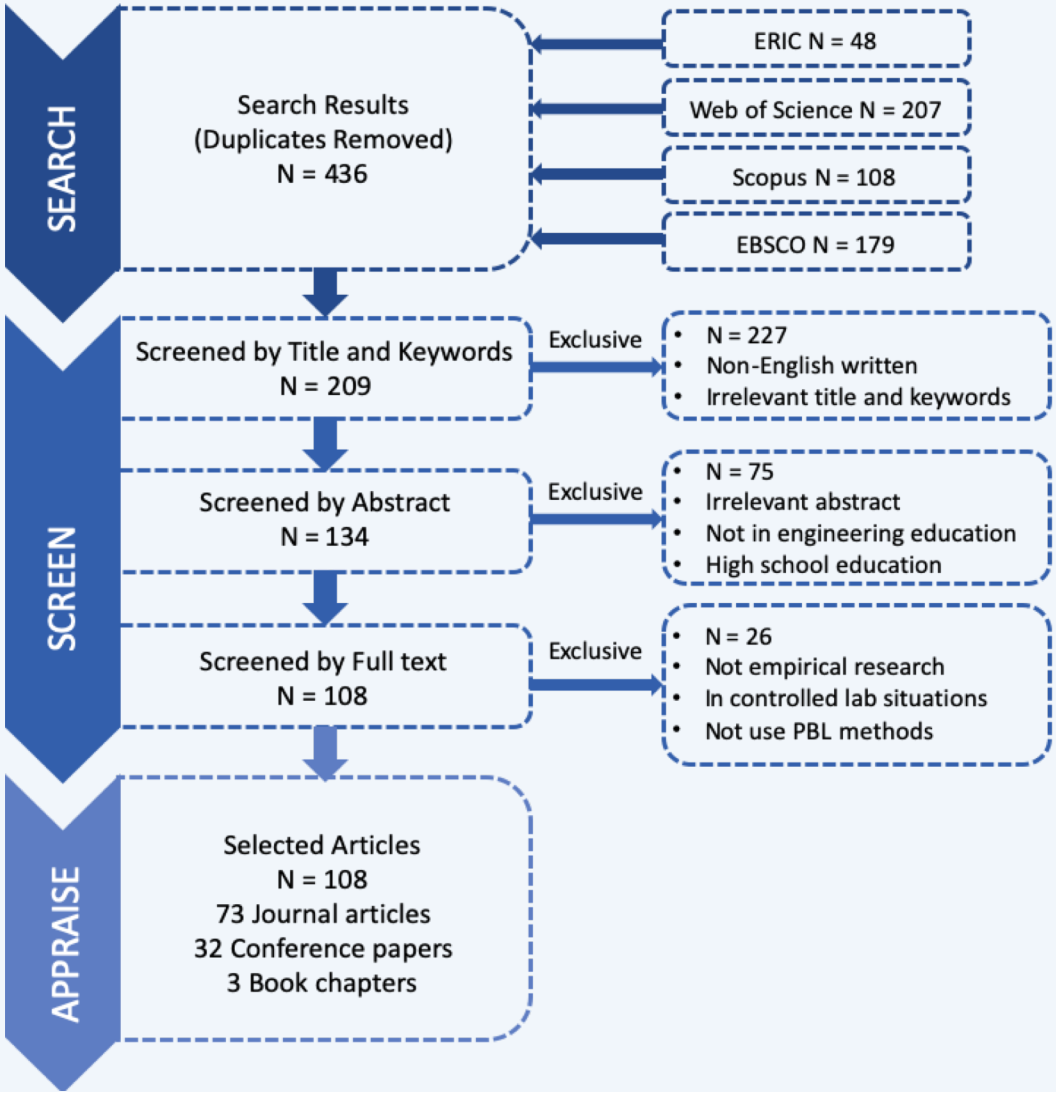
Learning content as well as process competences (collaboration, project management …)

- **No if it is:**
  - the same type of problems students deal with … and no link to SDGs
  - If it the same type of projects students deal with … same group size, credits
  - If there is no clear progression in the curriculum
  - If the students are not reflecting the project process
  - If there is no integration of AI and IoT – no anticipation and future orientation

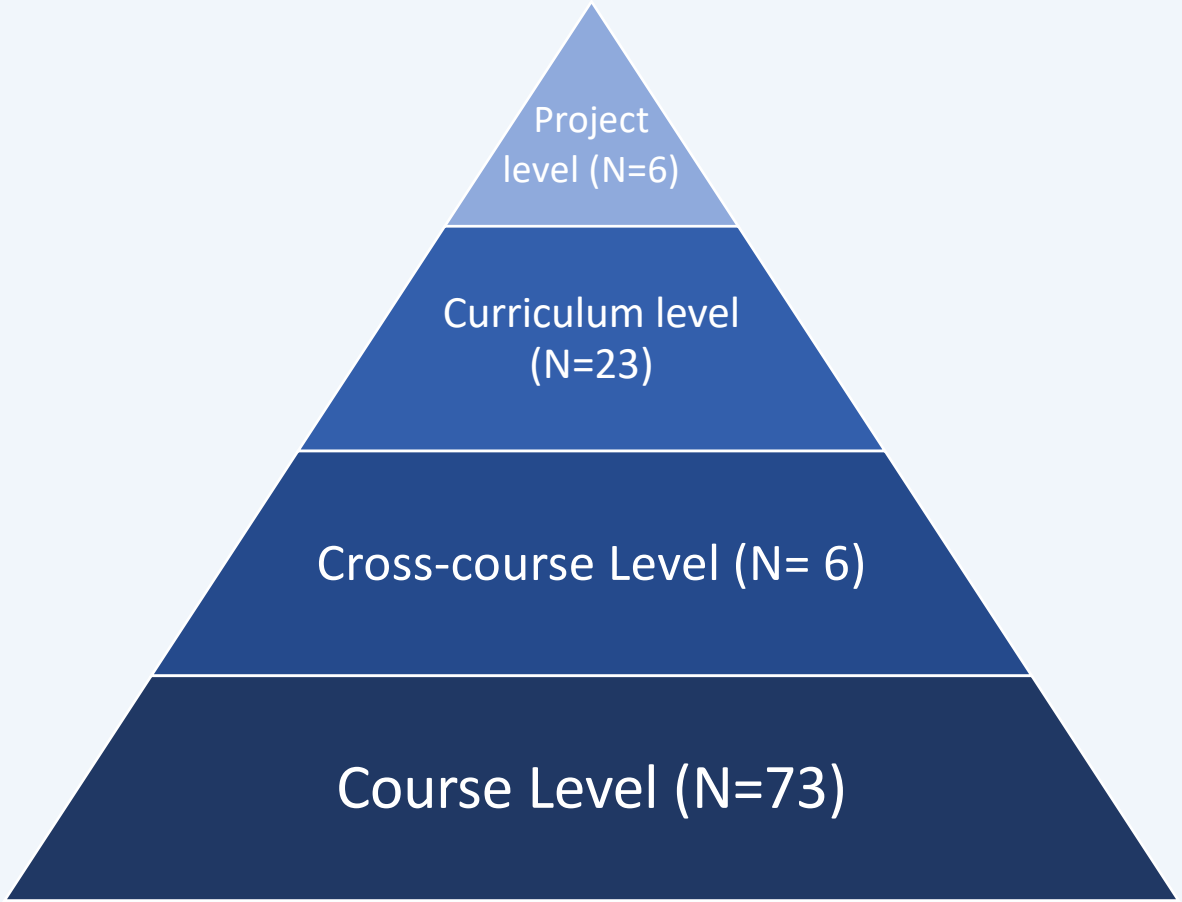
Review on PBL – Keywords – Chen et al. 2020

Block 1	"PBL" or "problem-based" or "projected-based" or "problem solv*" or "problem-orient*" or "project-orient*"
AND	
Block 2	"engineering education" or "manufacturing"
AND	
Block 3	"implement*" or "practice*" or "practise*"
AND	
Block 4	"challenge*" or "issue*" or "difficult*"

Searching Processes



Findings – Implementation of PBL in EE



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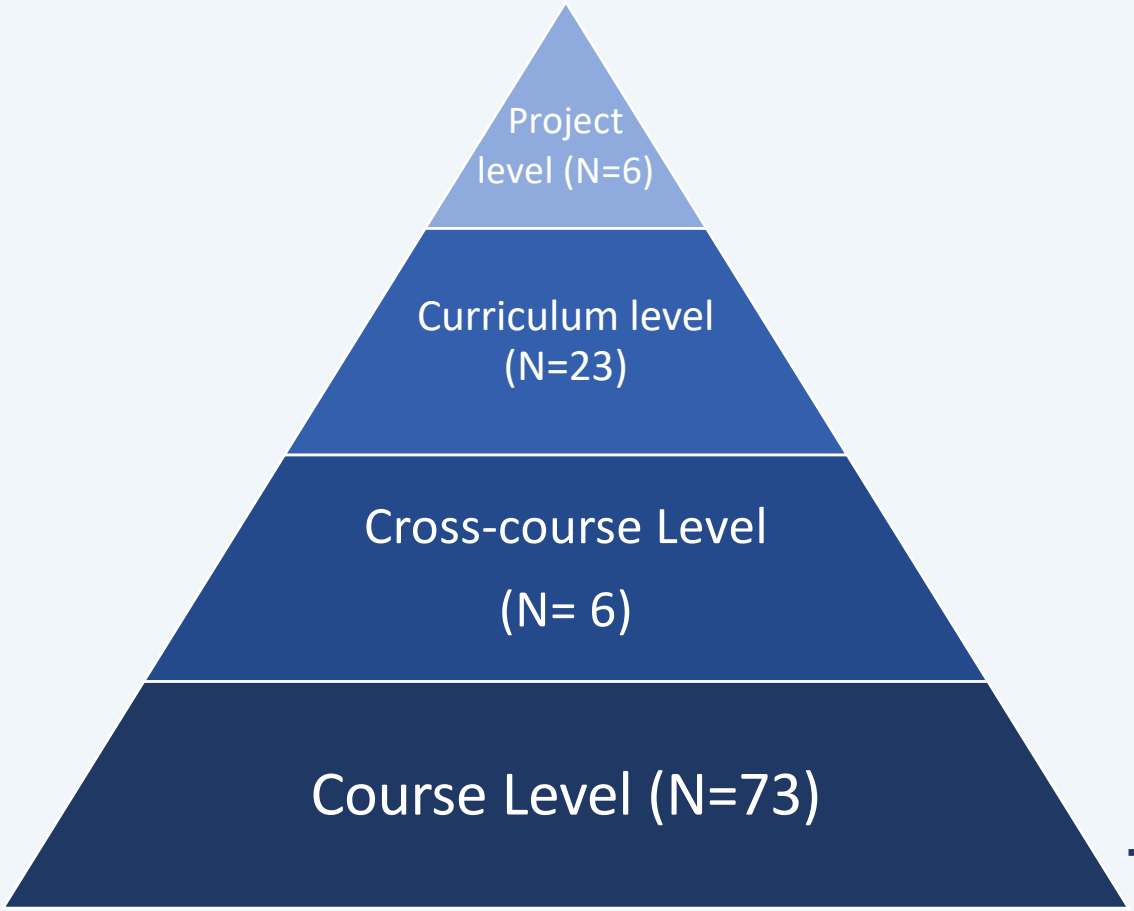


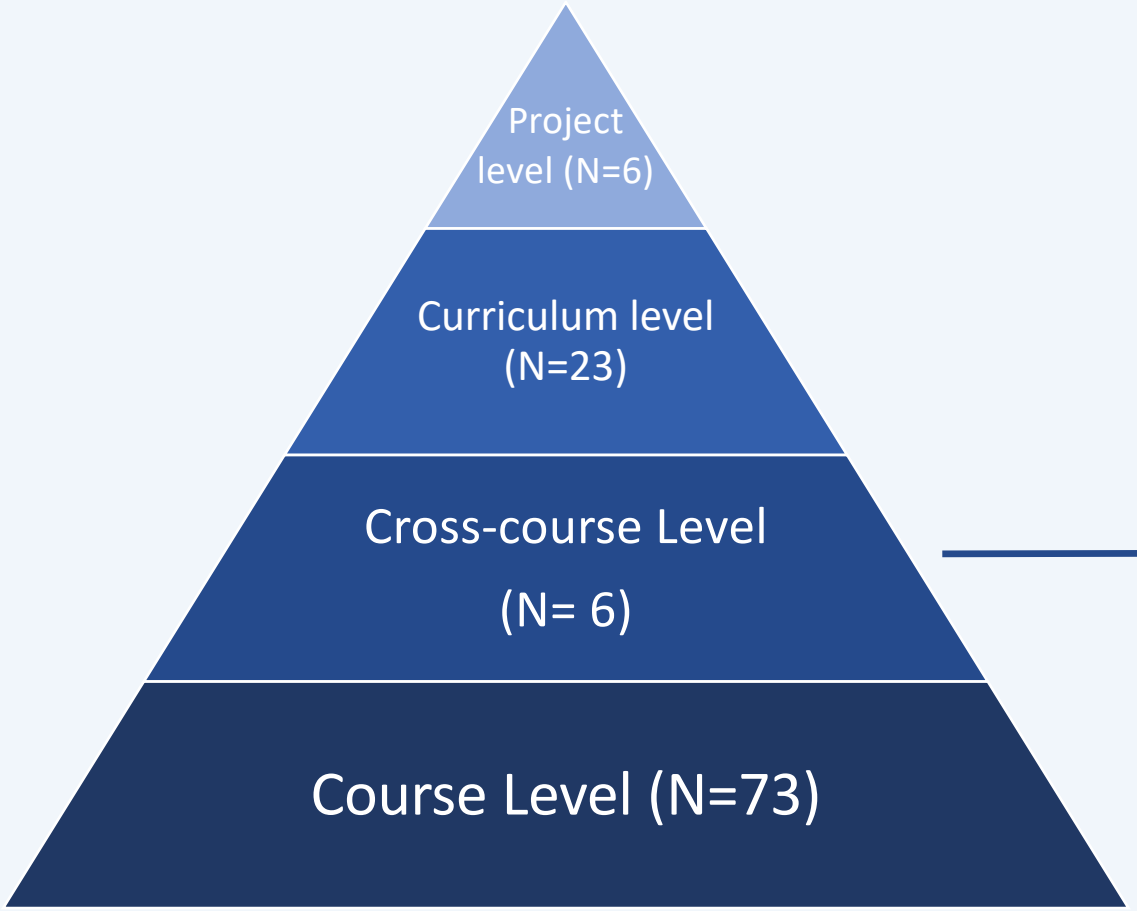
Problems for students to solve

- Well-defined problems given by instructors
- Open-ended or real-life problem given by instructors
- Few open-ended or real-life problem proposed by students

Duration of the courses

- One semester
- One month
- Two weeks

Findings – Implementation of PBL in EE



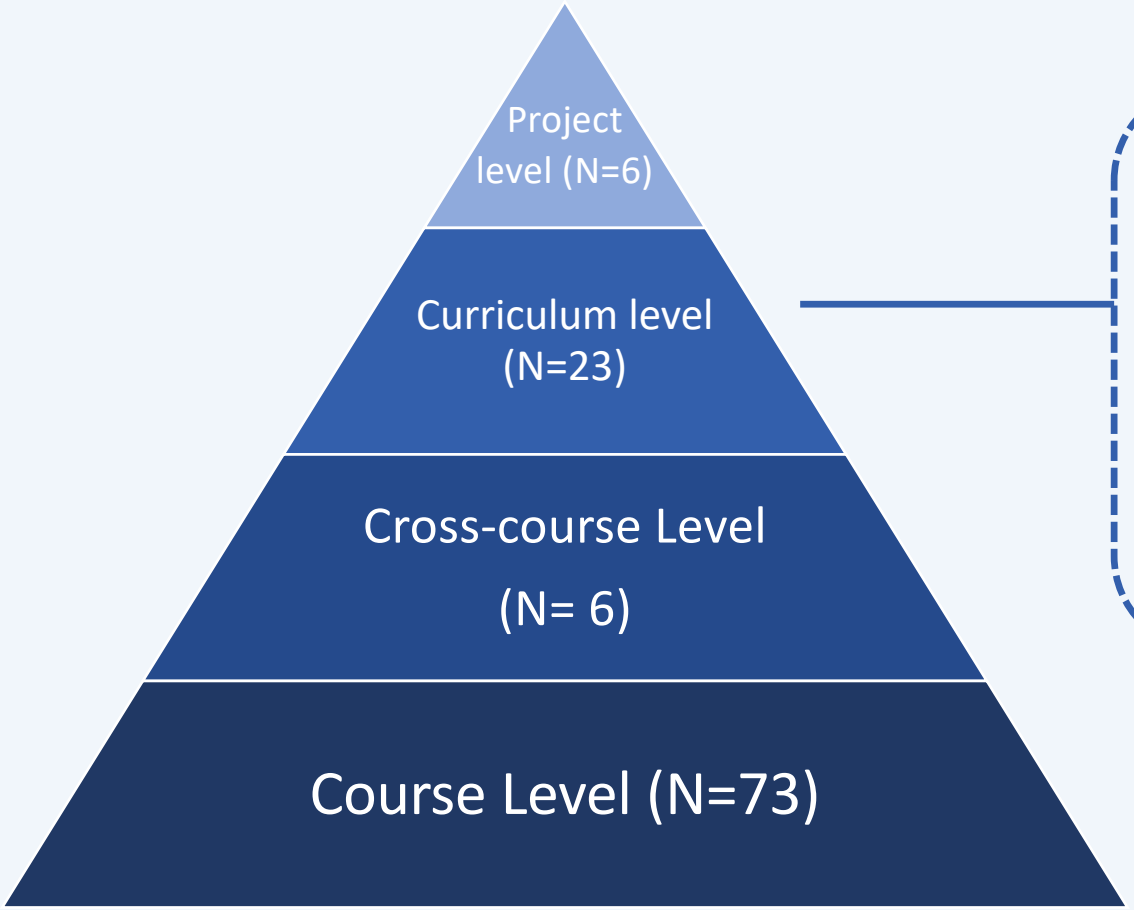
Problems for students to solve

- Open-ended or real-life problem given by instructors
- Open-ended or real-life problem proposed by students
- Multidisciplinary problems

Duration of the courses

- Two semesters
- One semester

Findings – Implementation of PBL in EE



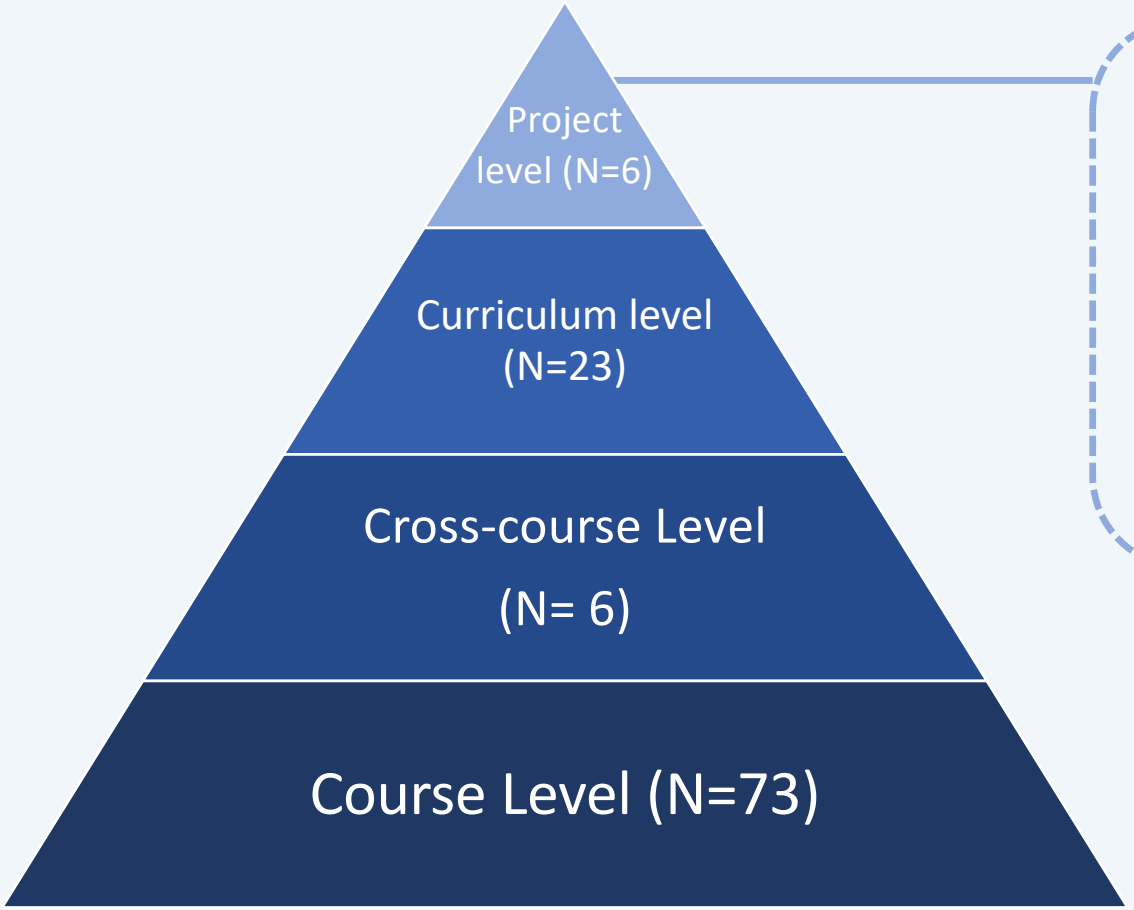
Problems for students to solve

- Open-ended or real-life problem given by instructors or proposed by students
- Real-life problems given by clients or companies
- Interdisciplinary problems

Program Duration

- Four years
- First three years (bachelor)
- Last two years (master)

Findings – Implementation of PBL in EE



Problems for students to solve

- Real-world problem identified by students
- Practical problems given by companies
- Real-world design proposed by industrial partners
- Multidisciplinary problems

Project Duration

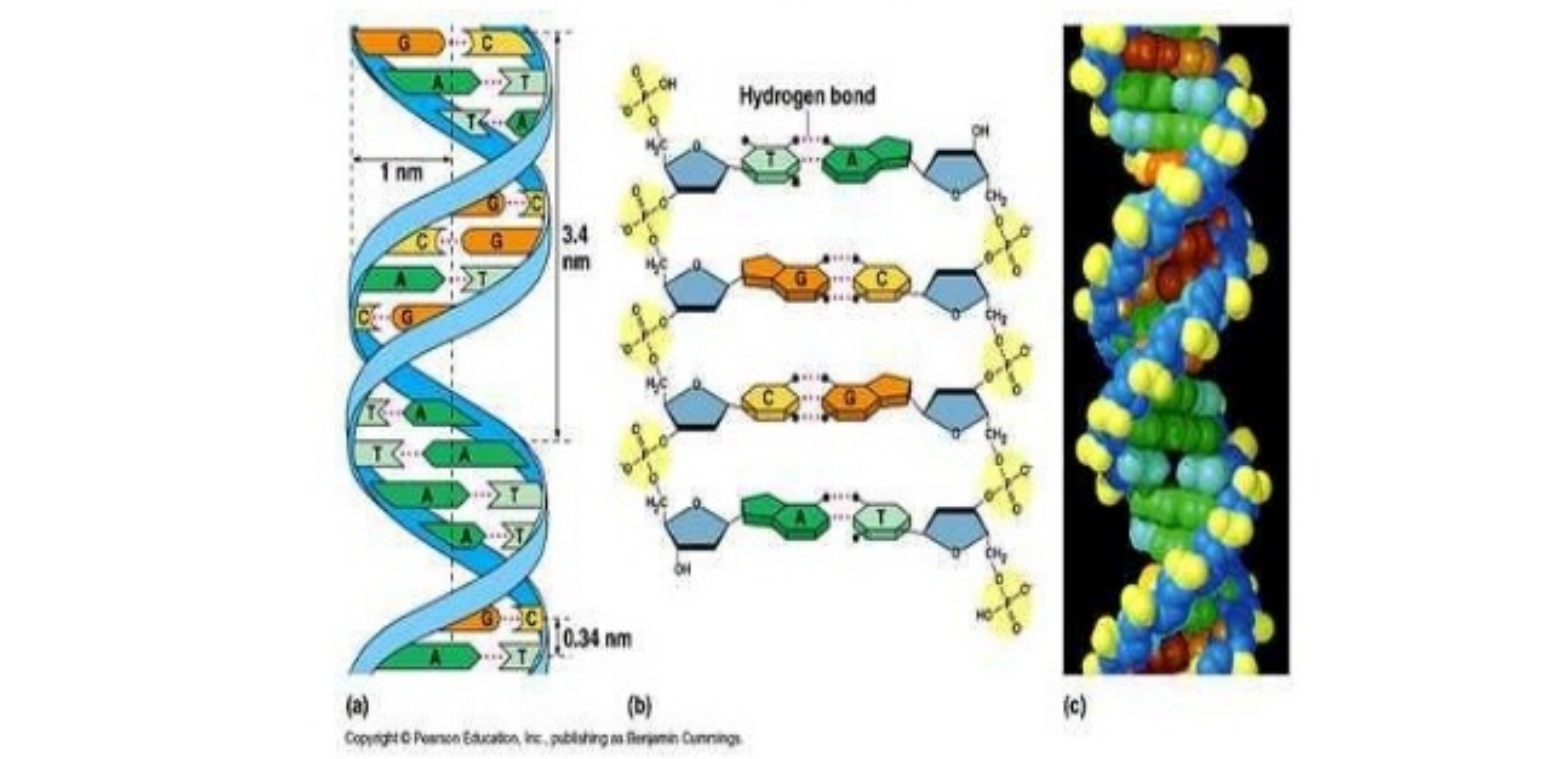
- One year
- Six months
- 15 weeks

Variation

Is the answer student centred Problem and Project Based Learning?

- It might be yes, if:
  - there is a **variation** in the learning experience – both problems, projects, size
  - students **learn to reflect on the learning process** and compare their experiences across teams and across the semesters in the curriculum
  - there is a **strategy for integrating** AI, IoT, anticipation and blended learning

Variation of all living forms at the genetic levels: genes alleles and nucleic acids



https://www.slideshare.net/shainamavreenvillaroza/genetic-diversity-lecture-notes

Variation is a condition in evolution

Variation:
Ladybugs

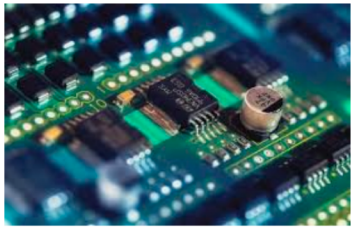
https://www.pinterest.dk/pin/134826582567083870/

Variation: Printed circuit boards

Printed circuit board - Wikipedia
en.wikipedia.org

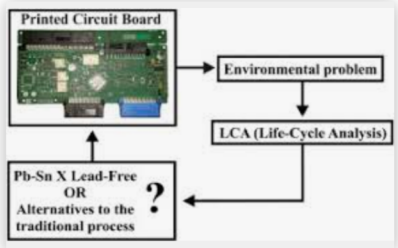
Printed Circuit Board Assemblies...
connectsales.net

Flex-rigid circuit boards: Standard for the third dimension ...
we-online.com

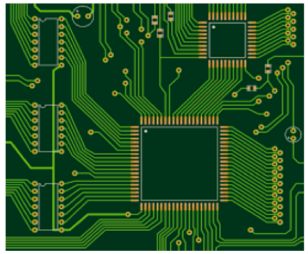


This paper can finally summarize the variat...
pinterest.com

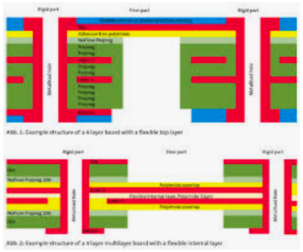
Nintendo Super Famicom PCB Game Board Ja...
cheaplightning.com · På lager



Printed circuit boards: A review on the perspecti...
sciencedirect.com

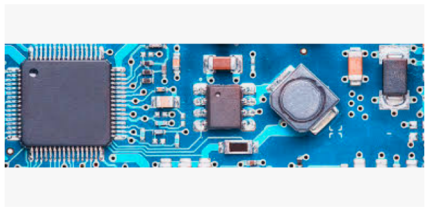


Why Do We Use Copper to Make PC...
yic-assm.com



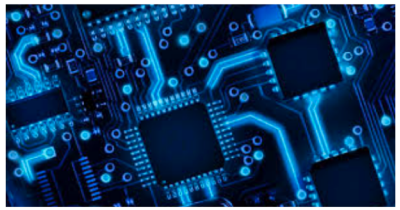
Rigid-flex printed circuits - CONTAG ...
contag.eu

Nintendo Super Famicom PCB Game Boar...
cheaplightning.com · På lager



Your PCB substrate: a guide to materials | Knowledg...
essentracomponents.com

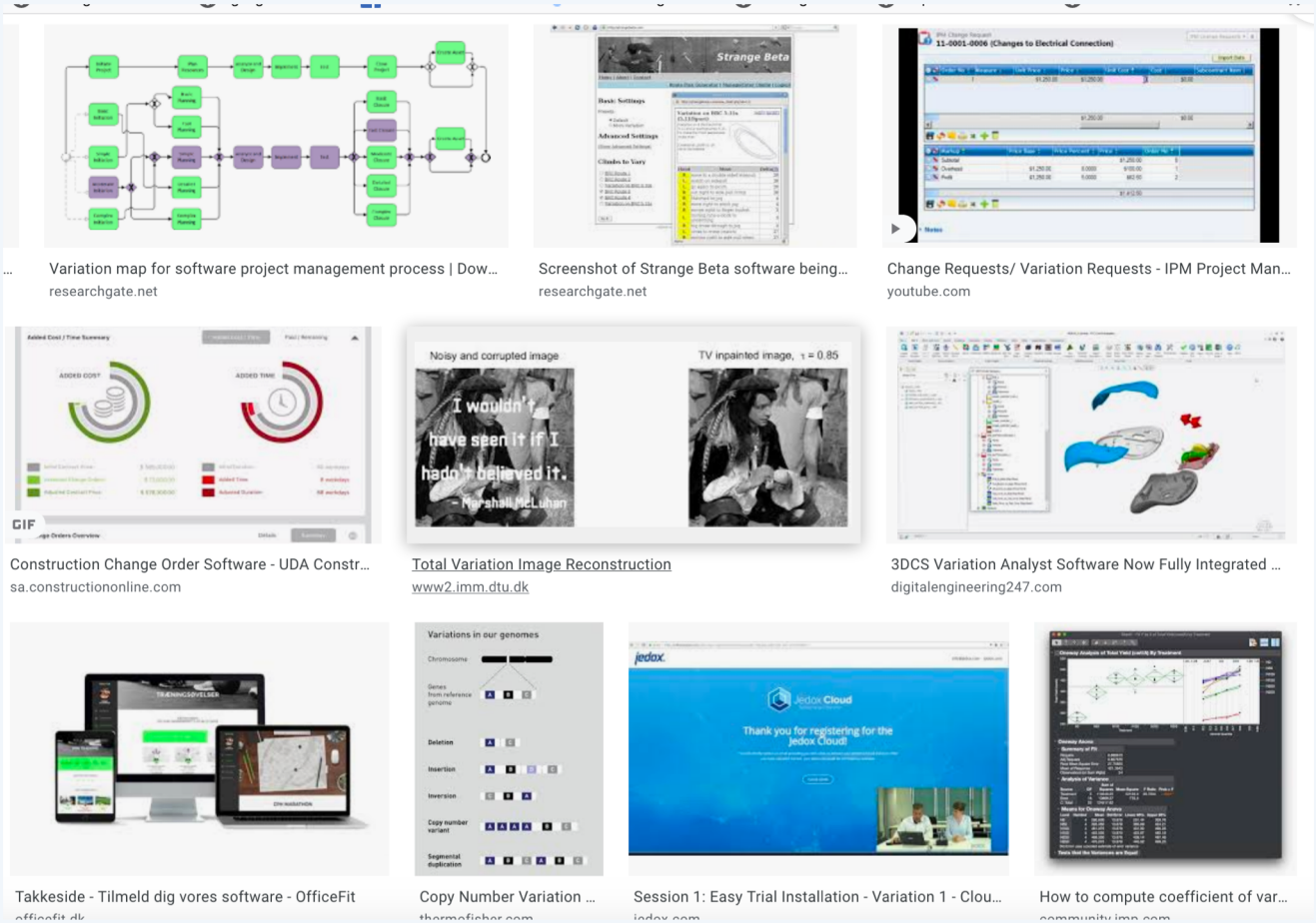
Printed Circuit Board Icon, ...
individual.icons-land.com



Conduction heat transfer in a printed circuit boar...
electronics-cooling.com

Creativity?

Variation: software development



Variation map for software project management process | Dow…
researchgate.net

Screenshot of Strange Beta software being…
researchgate.net

Change Requests/ Variation Requests - IPM Project Man…
youtube.com

Construction Change Order Software - UDA Constr…
sa.constructiononline.com

Total Variation Image Reconstruction
www2.imm.dtu.dk

3DCS Variation Analyst Software Now Fully Integrated …
digitalengineering247.com

Takkeside - Tilmeld dig vores software - OfficeFit
officefit.dk

Copy Number Variation …
thermofisher.com

Session 1: Easy Trial Installation - Variation 1 - Clou…
jedox.com

How to compute coefficient of var…
community.jmp.com

Not one answer…..

Variation in learning – sameness and difference

Phenomenography, Marton, Booth, Swedish tradition

Variation in individuals' perspectives ⟹ collaboration

Variation in the progression of learning experiences ⟹ the individual and collaborative learning

https://pubs.rsc.org/en/content/articlelanding/2013/rp/c2rp20145c#!divAbstract

Variation in learning – sameness and difference

Sameness in order to transfer (Martens)

(Vygotsky's definition of zone of proximal)

Difference in order to learn

Something which is recognisable (theory, methods, context, issues..)

https://pubs.rsc.org/en/content/articlelanding/2013/rp/c2rp20145c#!divAbstract

Variation in learning – content

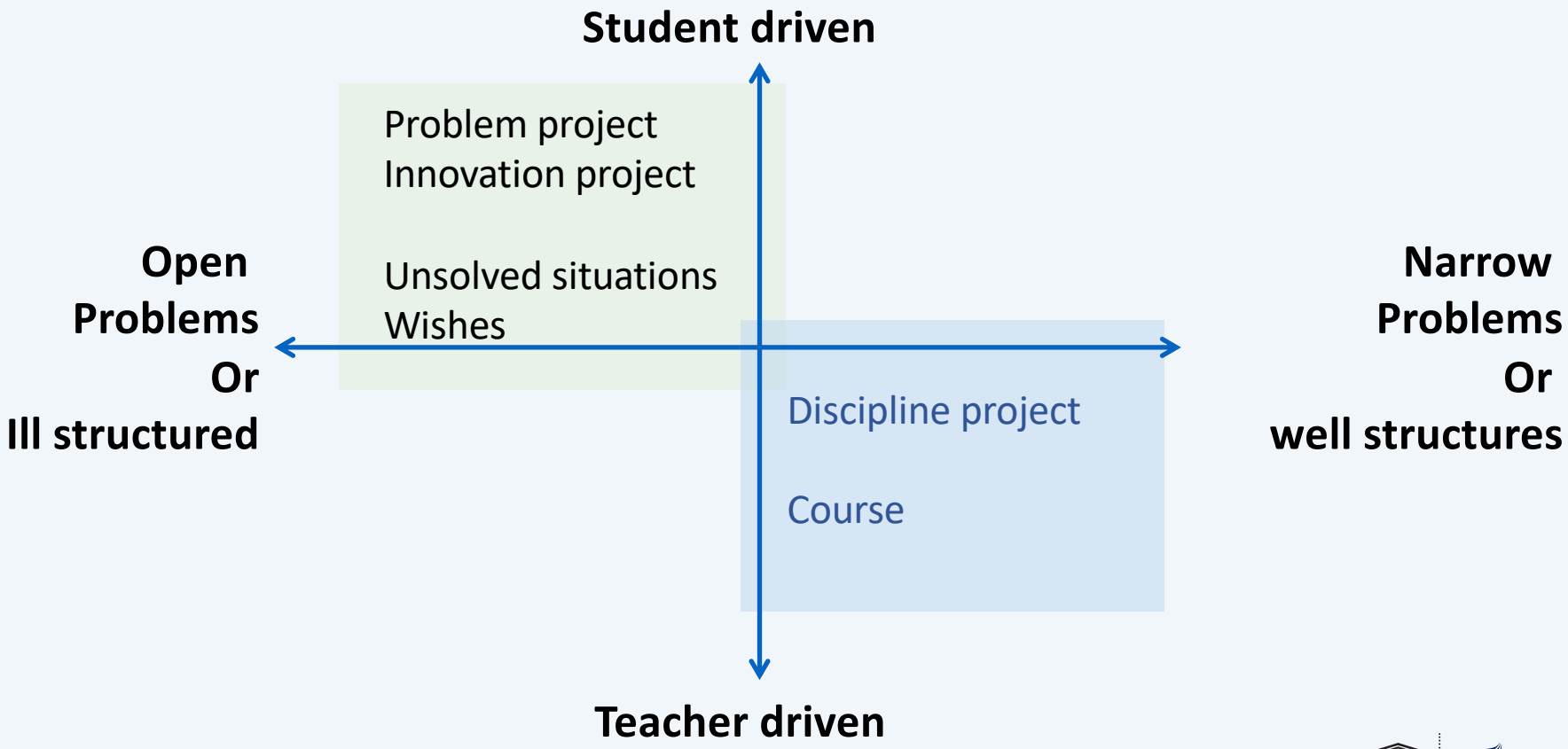
- Content learned by theory and practice/examples/cases
- Normally taught and learned as a deductive process
- Daily practices in any facilitation: variation in examples, advises, etc … but maybe not at an aware level?
- Especially in mathematics, chemistry (Kullberg, 2017)

Variation – the learning process becoming competences

- Process/generic/PBL competences learned by experience and theory
- Normally left to the learner in the curriculum as an inductive process – very few places are doing it as a part of a formal curriculum
- Individual – team/collective aspects
- Management of learning process (project management, collaboration, communication in blended learning environments)

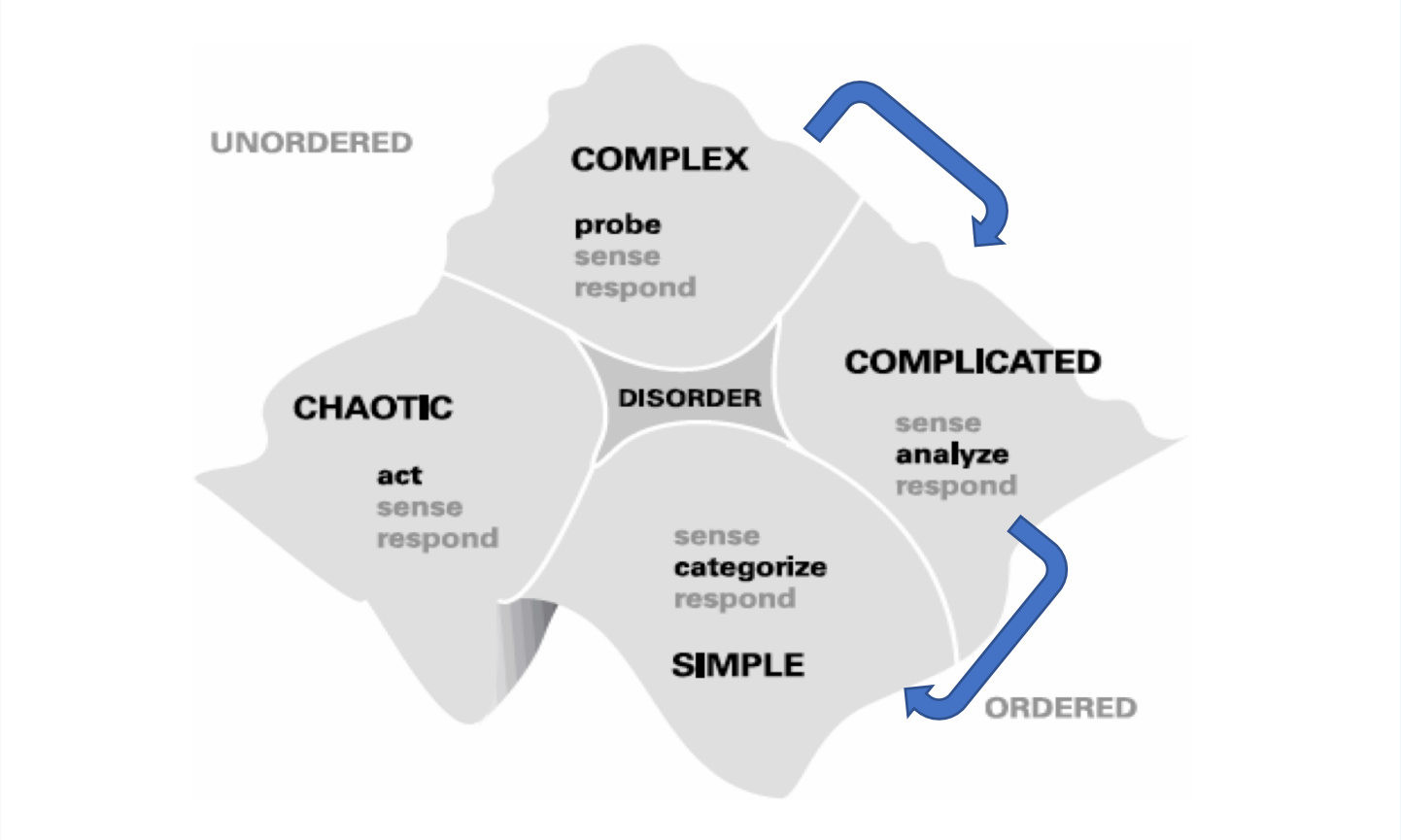
Variation in PBL

Variation in problems

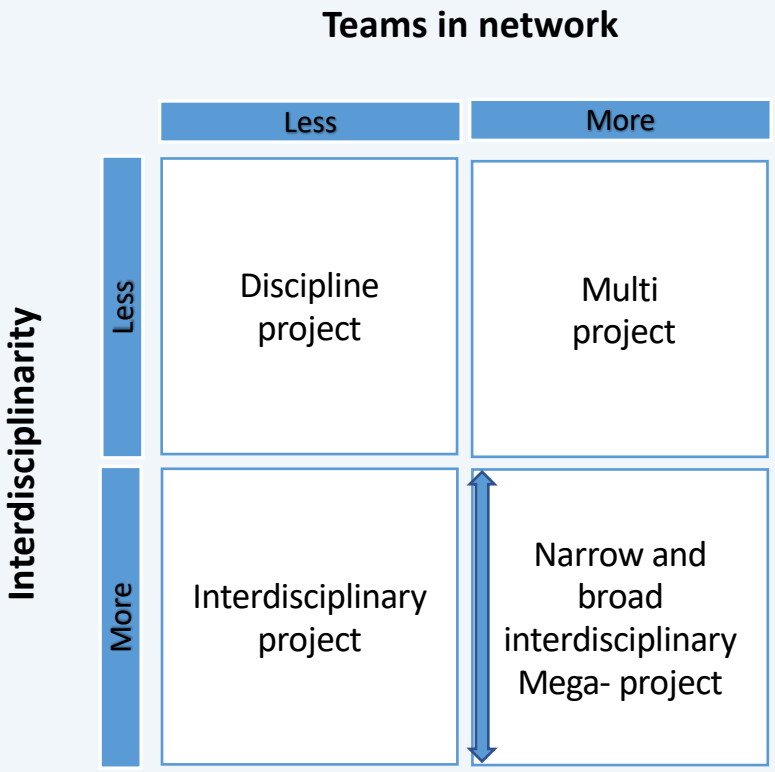


Holgaard and Kolmos, 2019

The Cynefin framework (Snowden & Boone, 2007)

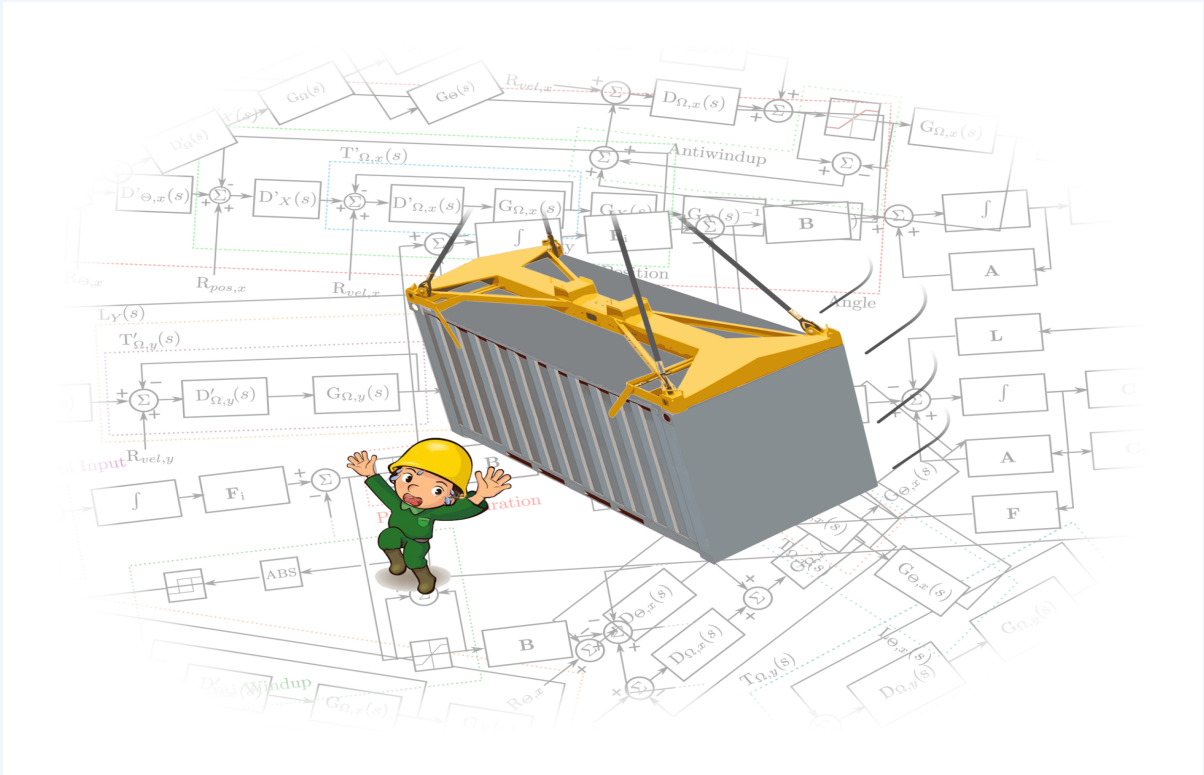


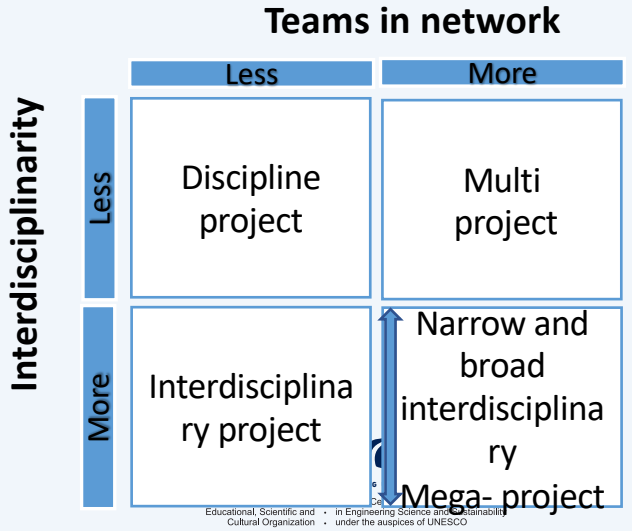
Variations in projects



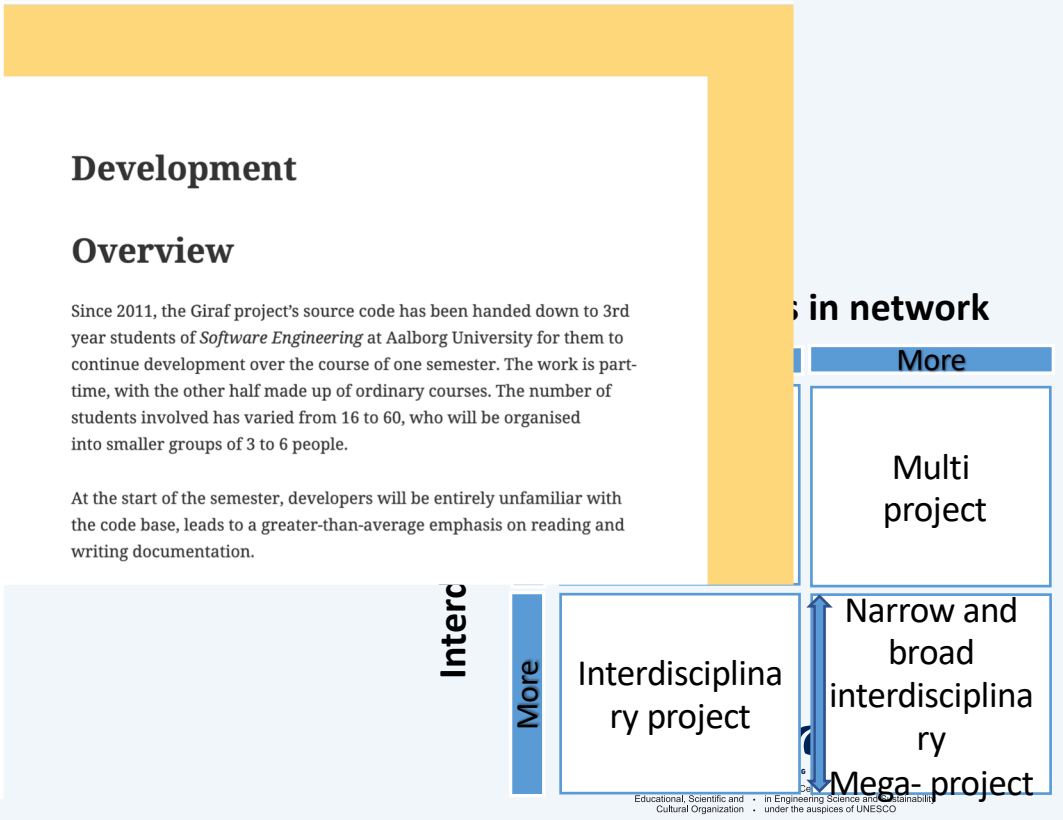
Kolmos et al 2020

Discipline project – e.g Anti Sway System for a Ship to Shore Crane



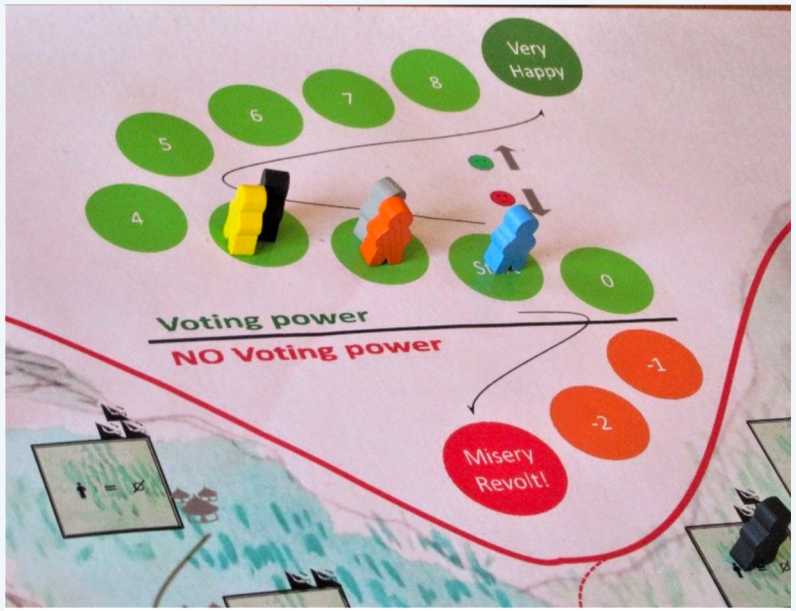


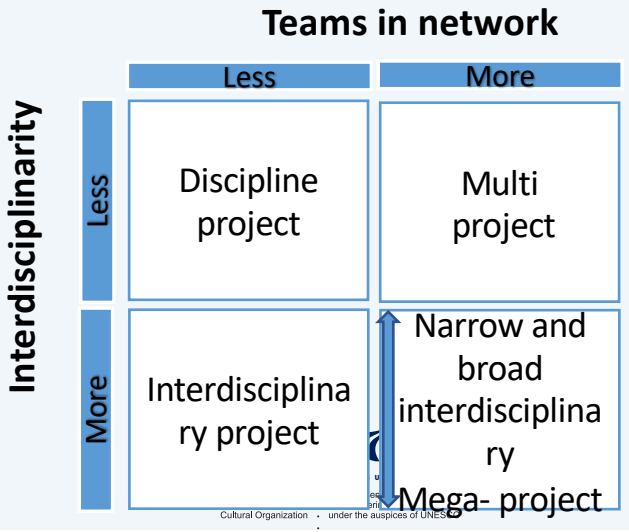
Multi-project https://twitter.com/GirafAutismApp https://giraf.cs.aau.dk/ http://people.cs.aau.dk/~ulrik/Giraf/Projects2012/Oasis_sw604f12.pdf



Interdisciplinary project - mediology

A sustainable city game designed as a medium and catalyzer for learning activities





Different type of problems –
different strategies for problem analysis

- **An unsatisfactory situation**
  - Bottom-up analysis – from practice to technology
  - WHO and WHY questions are dominating

An Un-Utilized Potential

- Top down analysis – from technology to practice
- WHAT-IF questions are dominating

- **Unknown Impacts**

- Theoretical analysis – from technology and within
- WHAT questions are dominating

http://www.gsmnation.com

http://quotes-pictures.feedio.net

http://kikomatching.wordpress.com/2009/10/23/are-you-a-facebook-addict/

Variations in interdisplinary collaboration in mega-projects

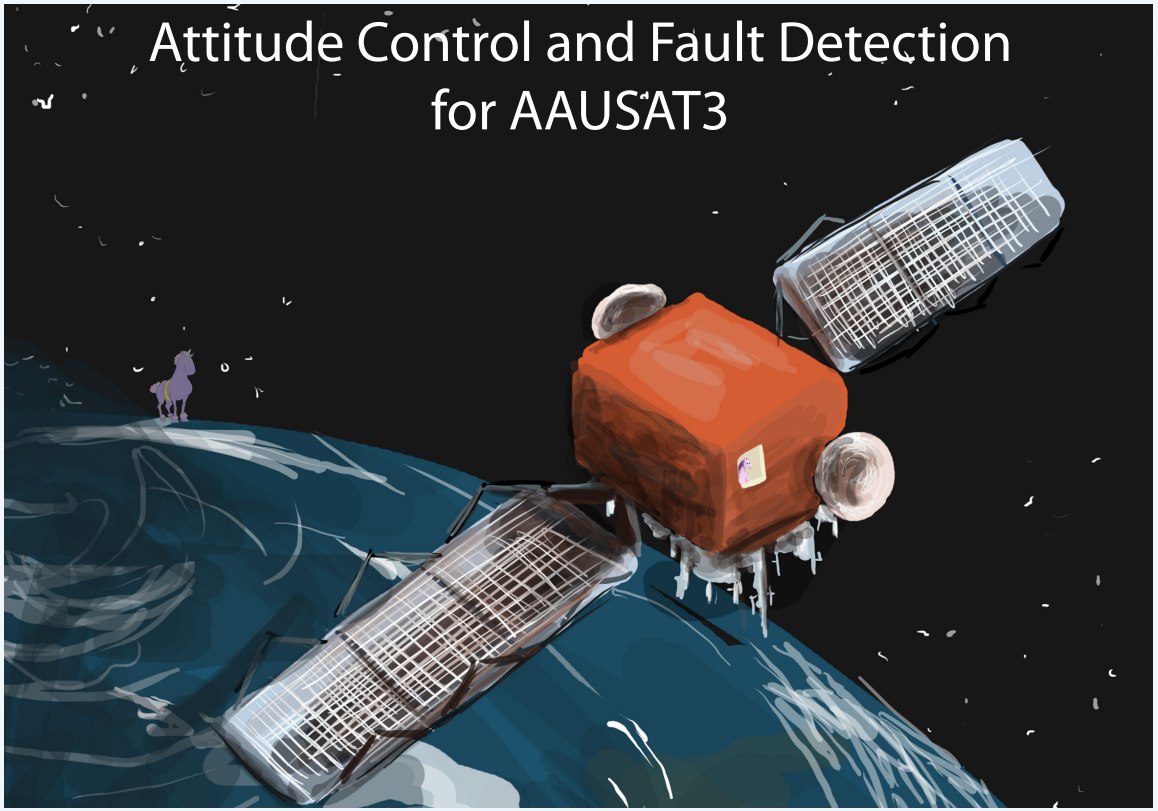
Disciplinary and Multi project	Involvement of one or parallel subgroups with collaboration among teams within disciplines	Simple communication and collaboration	Hierarchical project management with stable teams and structures
Narrow interdisciplinary project	Involvement of disciplines with more or less similar paradigms, methods and sharing knowledge cultures	Complicated communication and collaboration	
Broad interdisciplinary project	Involvement of many different disciplines and the presence of different paradigms, methods and knowledge cultures	Complex communication and collaboration	Reflective network communication and management With both stable and ad hoc teams with flexible organisation

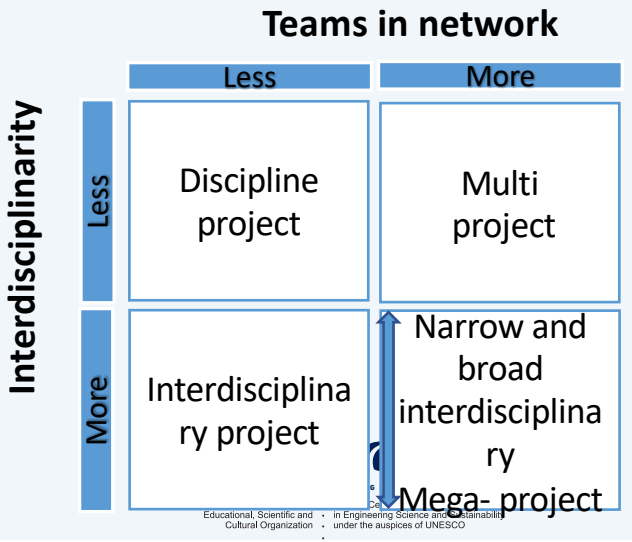
Klein 2010

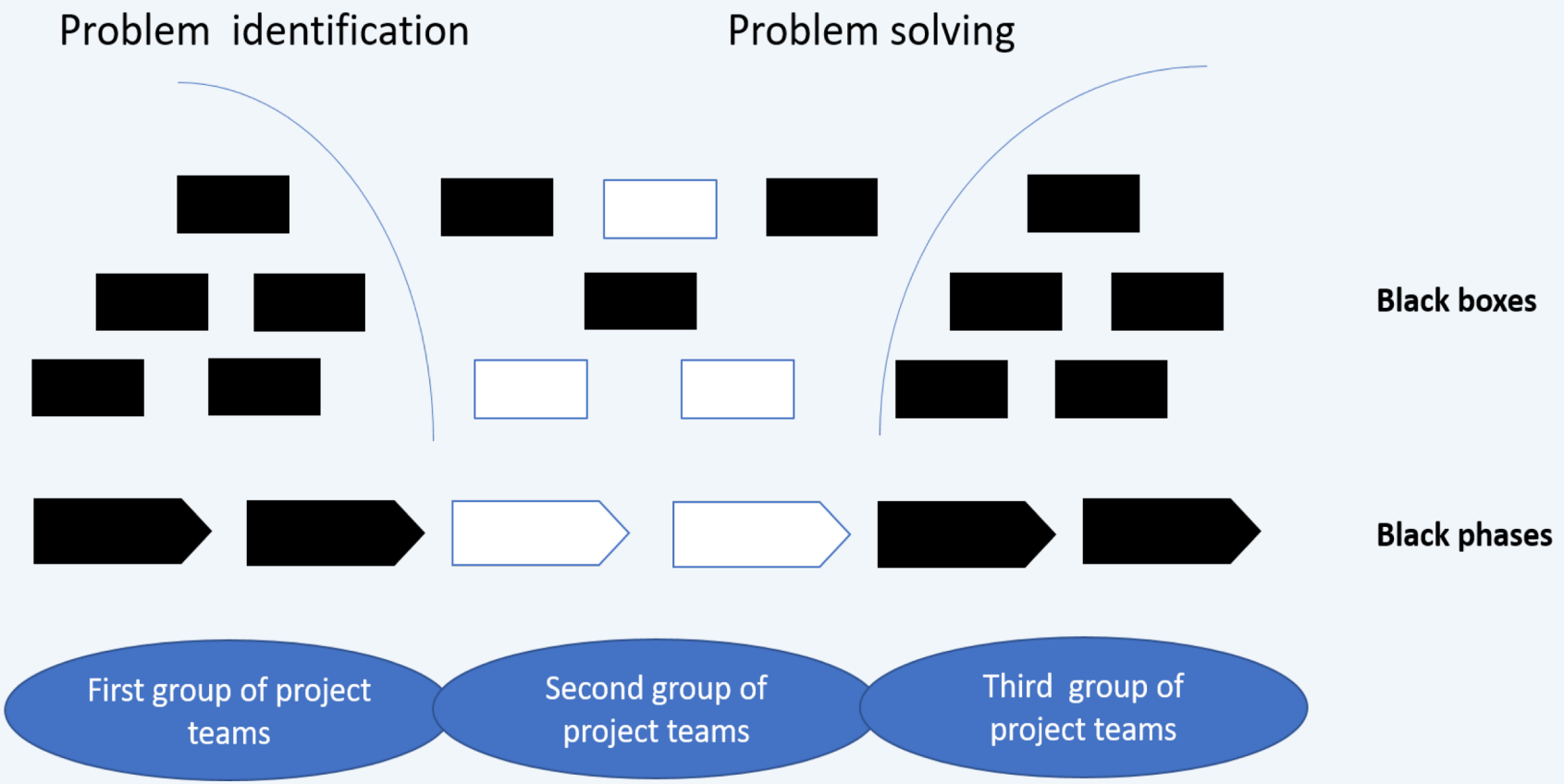
Narrow interdisciplinary megaproject

https://www.youtube.com/watch?v=UMnpVCDeQIE

http://www.space.aau.dk/







Kolmos et al, 2020

Industry 4.0 smart lab – working

Robotics

Automation

Electronics

Computer Science

Management

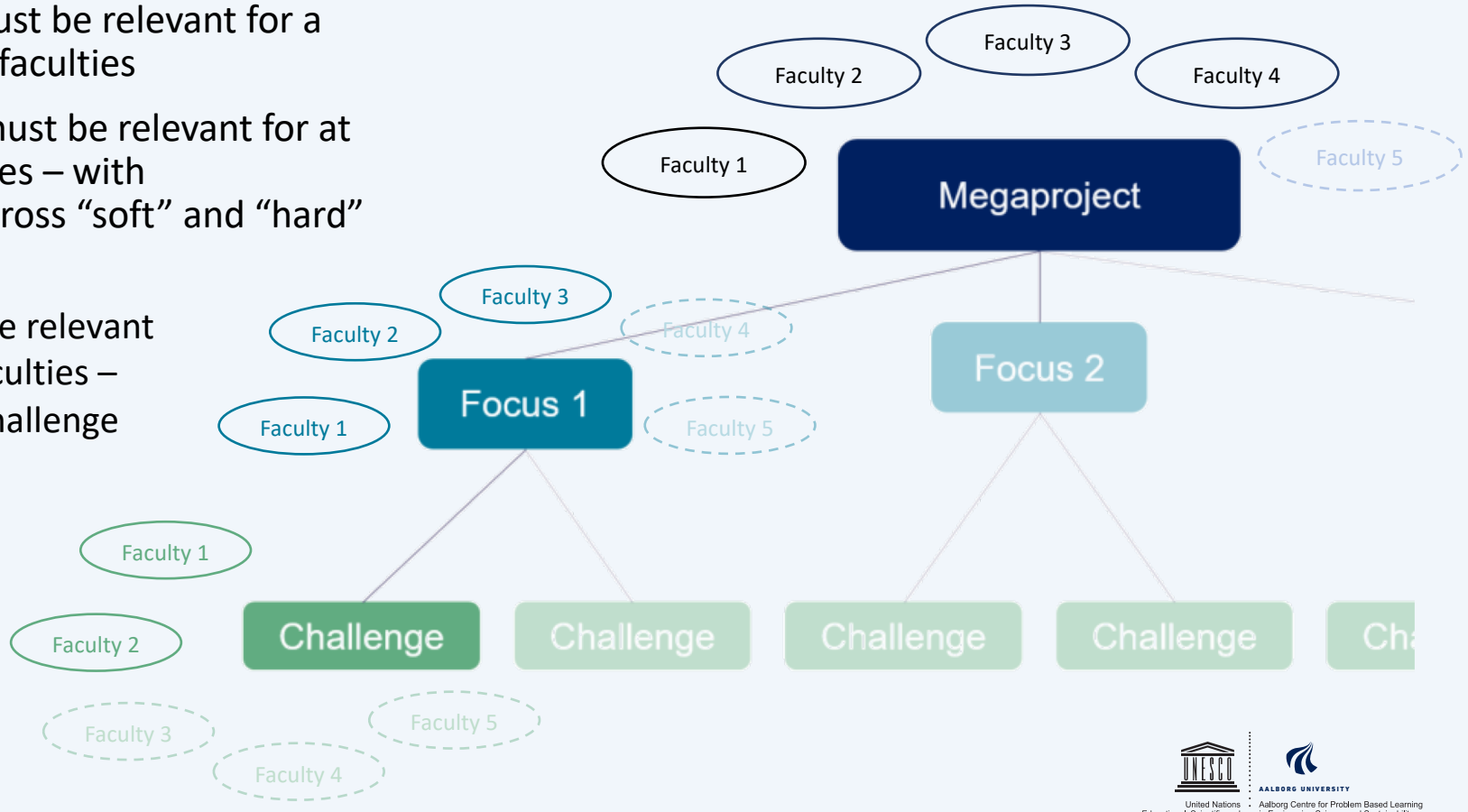
Broad interdisciplinary mega-projects https://www.megaprojects.aau.dk/

- Ambitious project addressing significant societal challenges with sustainable relevance
- Addresses the UN SDGs
- Consists of semester projects that all contribute to the solution for the megaproject's challenges
- Characterised by being interdisciplinary and extending over several years
- Involves student interaction and knowledge sharing among the participating groups
- Open for collaboration with external partners, including public and private organisations, and other universities

MEGAPROJECTS OF SPRING 2020

MEGAPROJECT INTERDISCIPLINARITY

- A megaproject must be relevant for a minimum of four faculties
- The focus areas must be relevant for at least three faculties – with representation across “soft” and “hard” sciences
- Challenges must be relevant for at least two faculties – one besides the challenge proposer

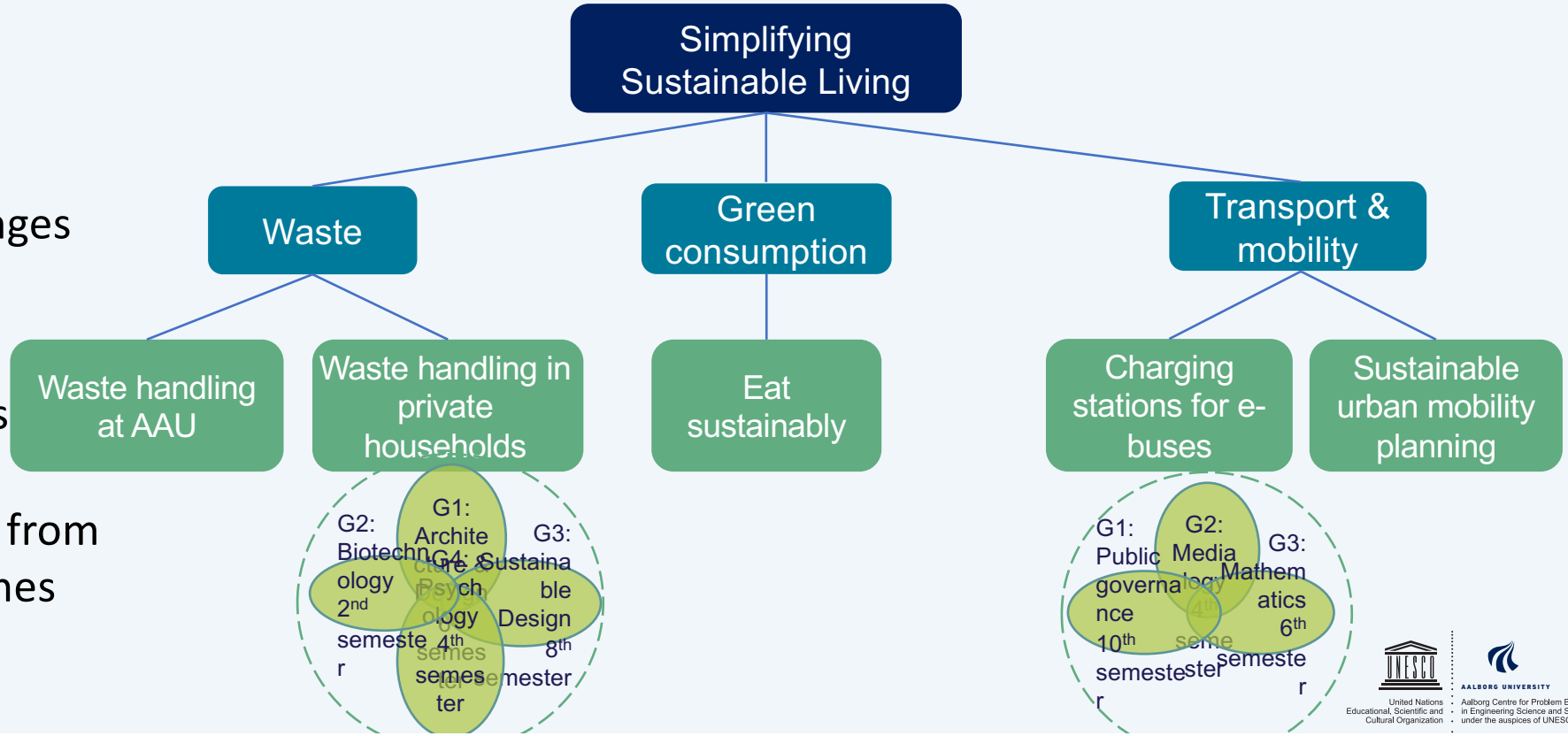


SIMPLIFYING SUSTAINABLE LIVING

Focus

Challenges

Clusters with Groups from disciplines

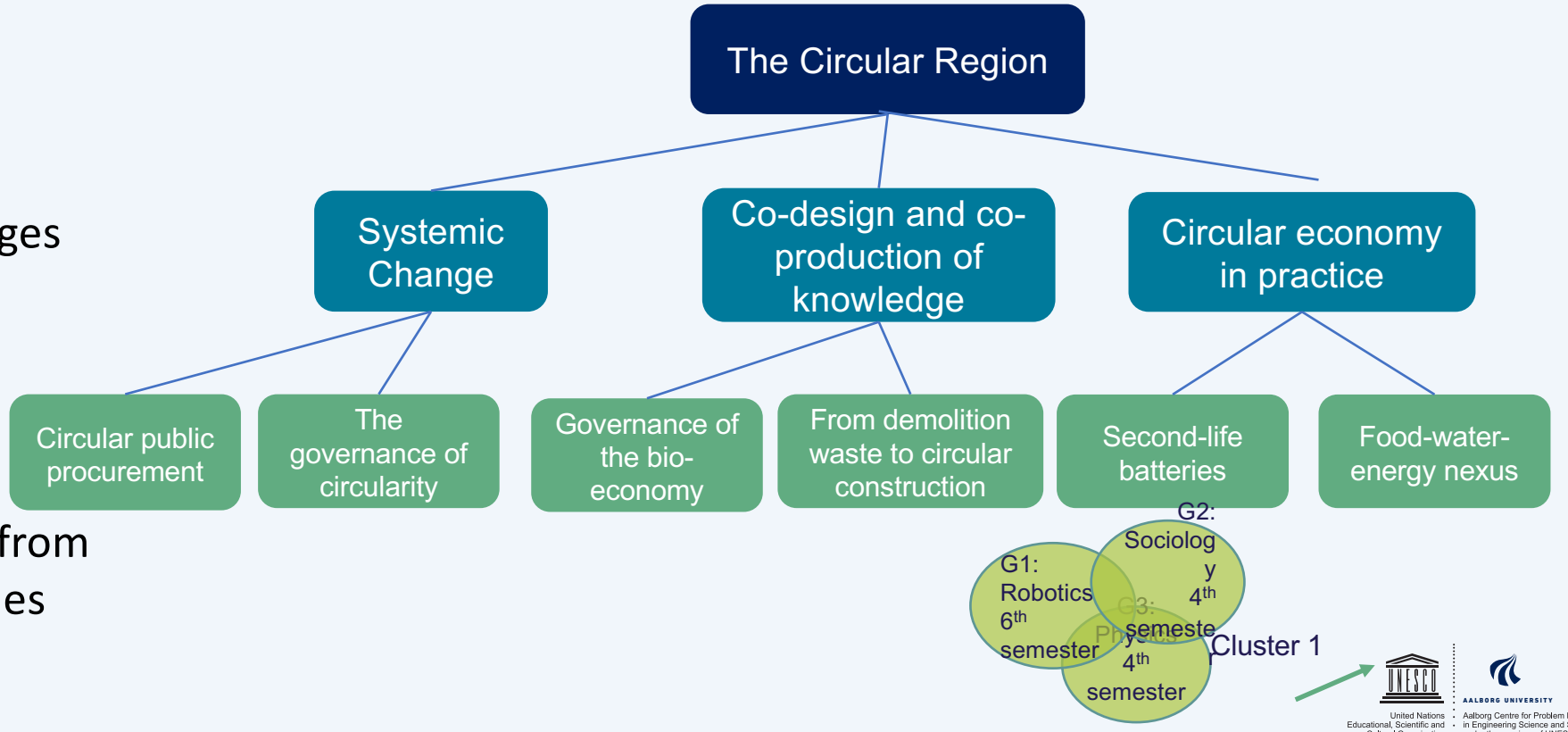


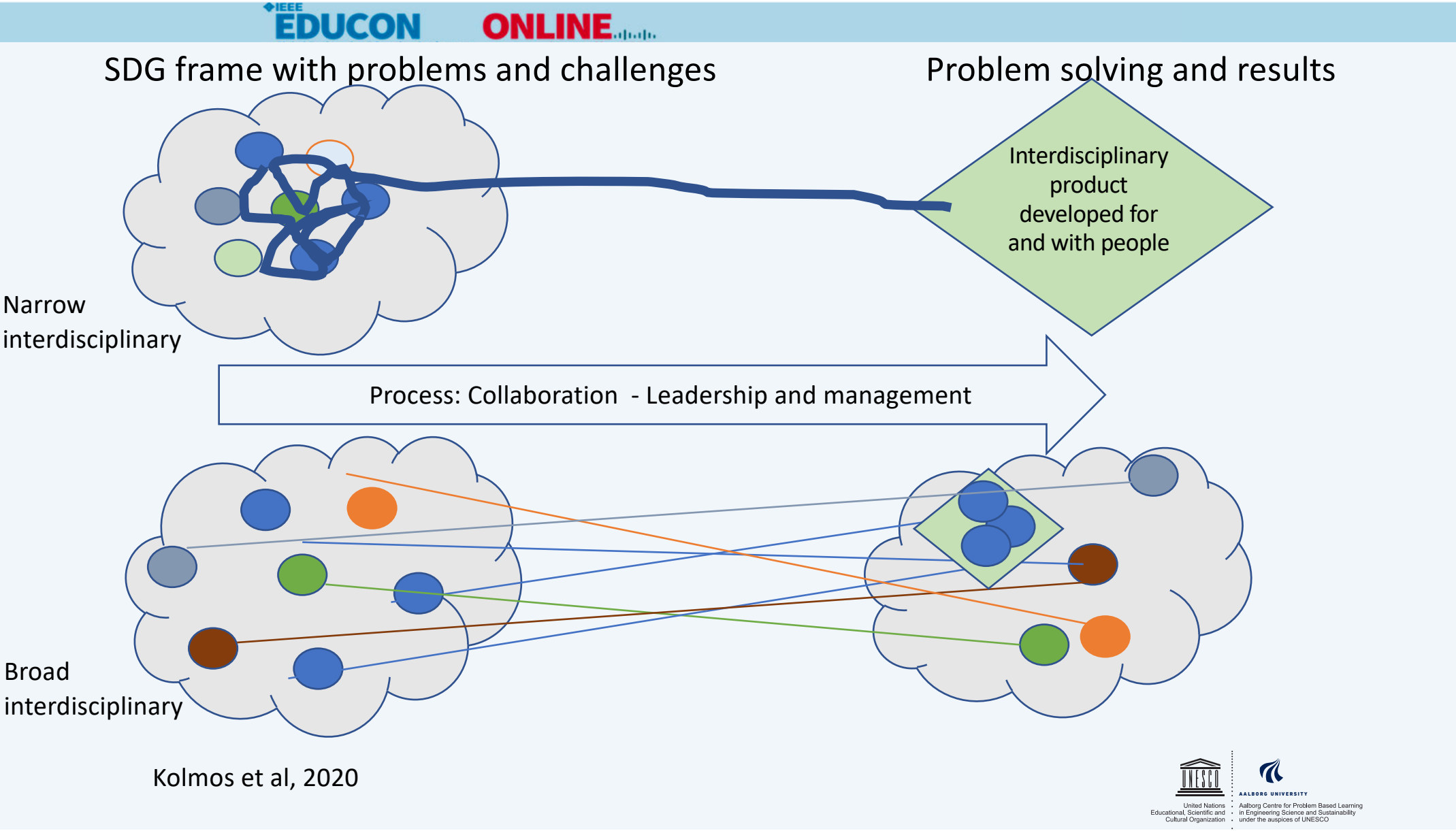
THE CIRCULAR REGION

Focus

Challenges

Clusters with Groups from disciplines

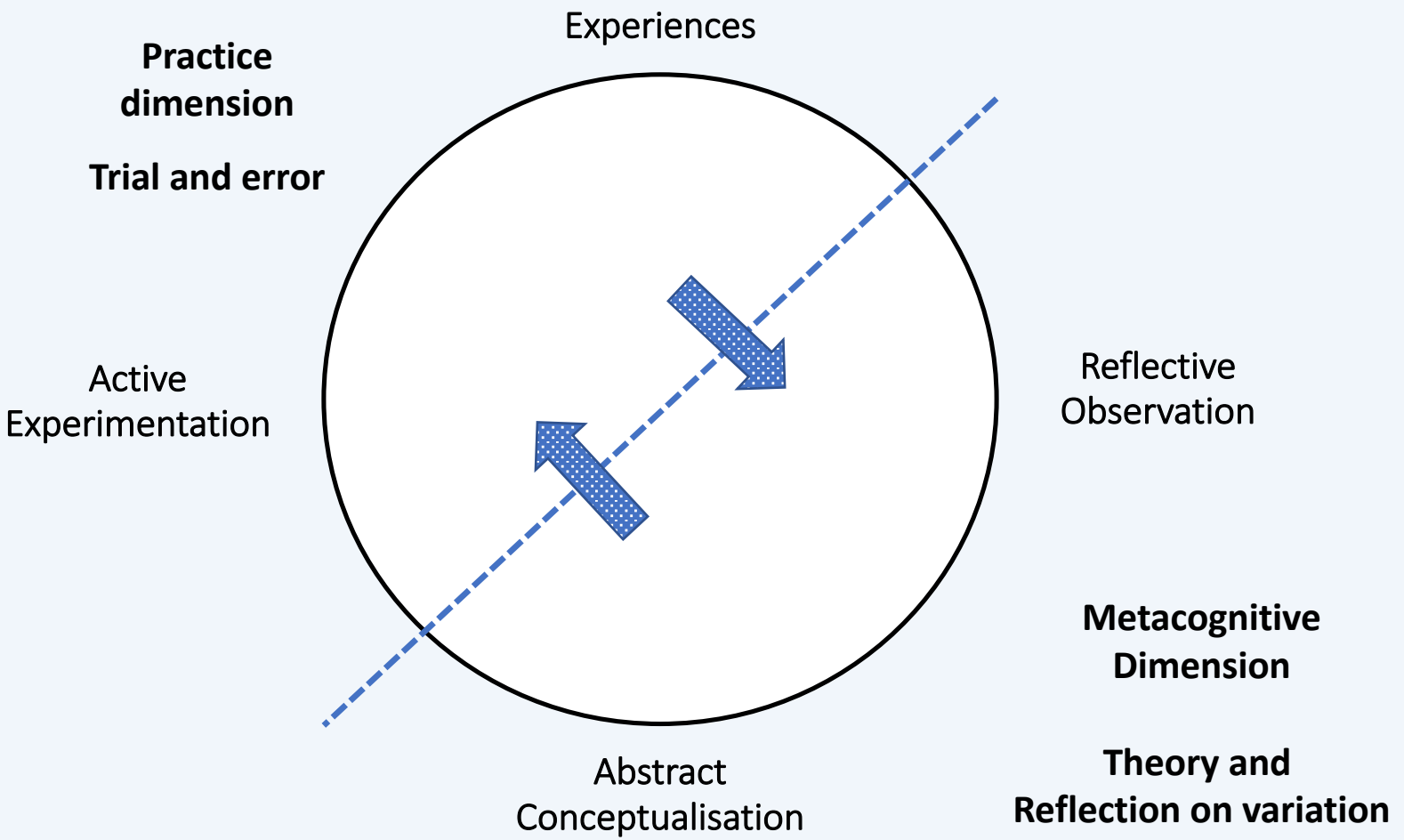




Kolmos et al, 2020

	Disciplinary approach	Narrow interdisciplinarity	Broad interdisciplinarity
Project types	Discipline and multi-projects	Interdisciplinary projects Narrow mega-projects	Broad interdisciplinary mega-projects
Problem analysis	Understanding the problems in the discipline domain and how the discipline relates to other disciplines	Understanding problems related to parts of a system or parts of a process by combining a few core disciplines	Understanding problems in a comprehensive system perspective by making a synthesis of different discipline approaches
Project management	From stable teams and structures ⇨ agile systems/flexible structure with ad hoc groups		
Collaboration	From simple within same knowledge paradigm ⇨ difficult with different knowledge paradigms		

Kolmos et al, 2020



Kolmos, Bøgelund and Spliid, 2019

Process/PBL competences

Metacognitive competences, e.g.:

- Personal competence profile
  - Professional understanding
  - Collaboration
  - Project competences
  - Career and learning goals
- Individual and collective learning goal and strategies
- Use of digital learning- and collaboration in learning strategies
- Optimising individual learning
- Motivation for learning
- Strategies for change

Holgaard and Kolmos, 2019

Problem oriented competences, e.g.:

- Problem identification
- Problem types
- Methods for problem analysis
- Creativity
- User involvement
- Actor analysis
- Understanding cultural contexts
- Sustainability
- UN global goals
- Ethics
- Problem formulation
- Criteria for problem solving

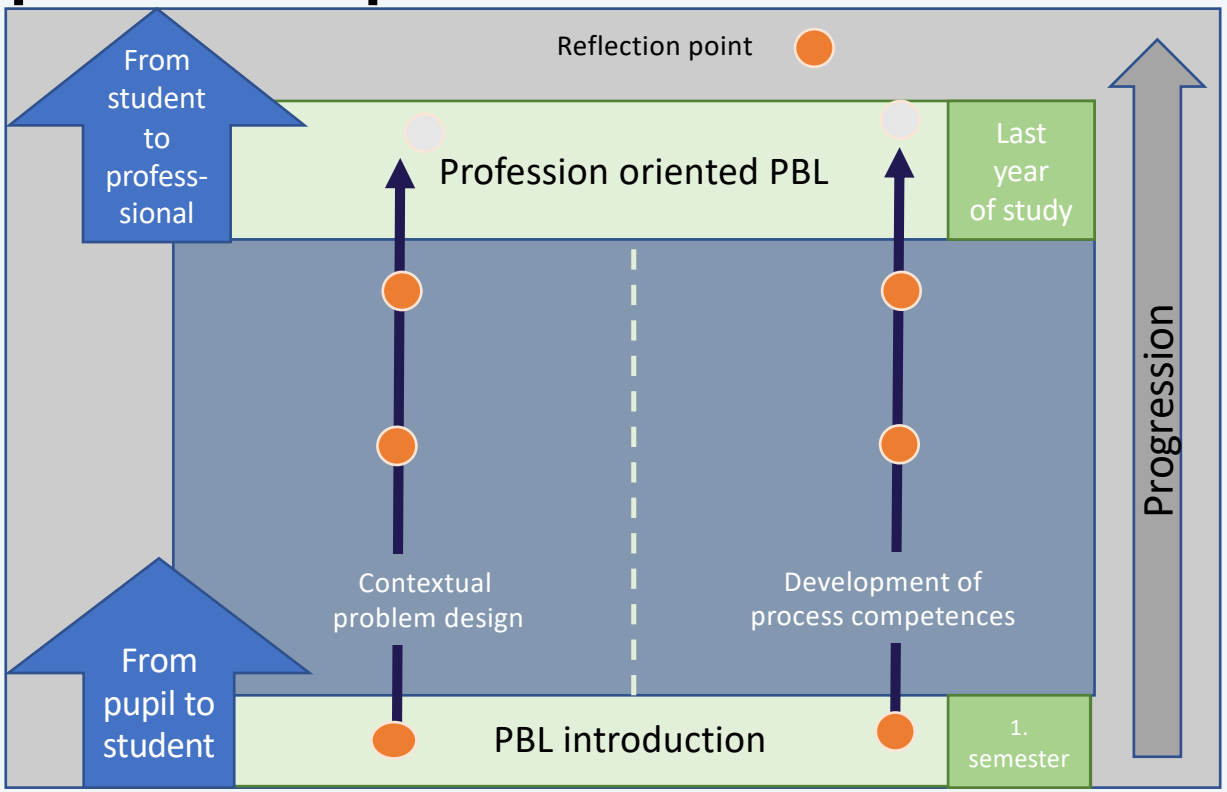
Interpersonal competences, e.g.:

- Teambuilding
- Team culture
- Team roles
- Digital collaboration
- Communication-strategies
- Managing diversity
- Conflict prevention and management
- Creating a constructive dialogue
- Decision making processes
- Collaboration in and between groups
- Collaboration with supervisors and external partners

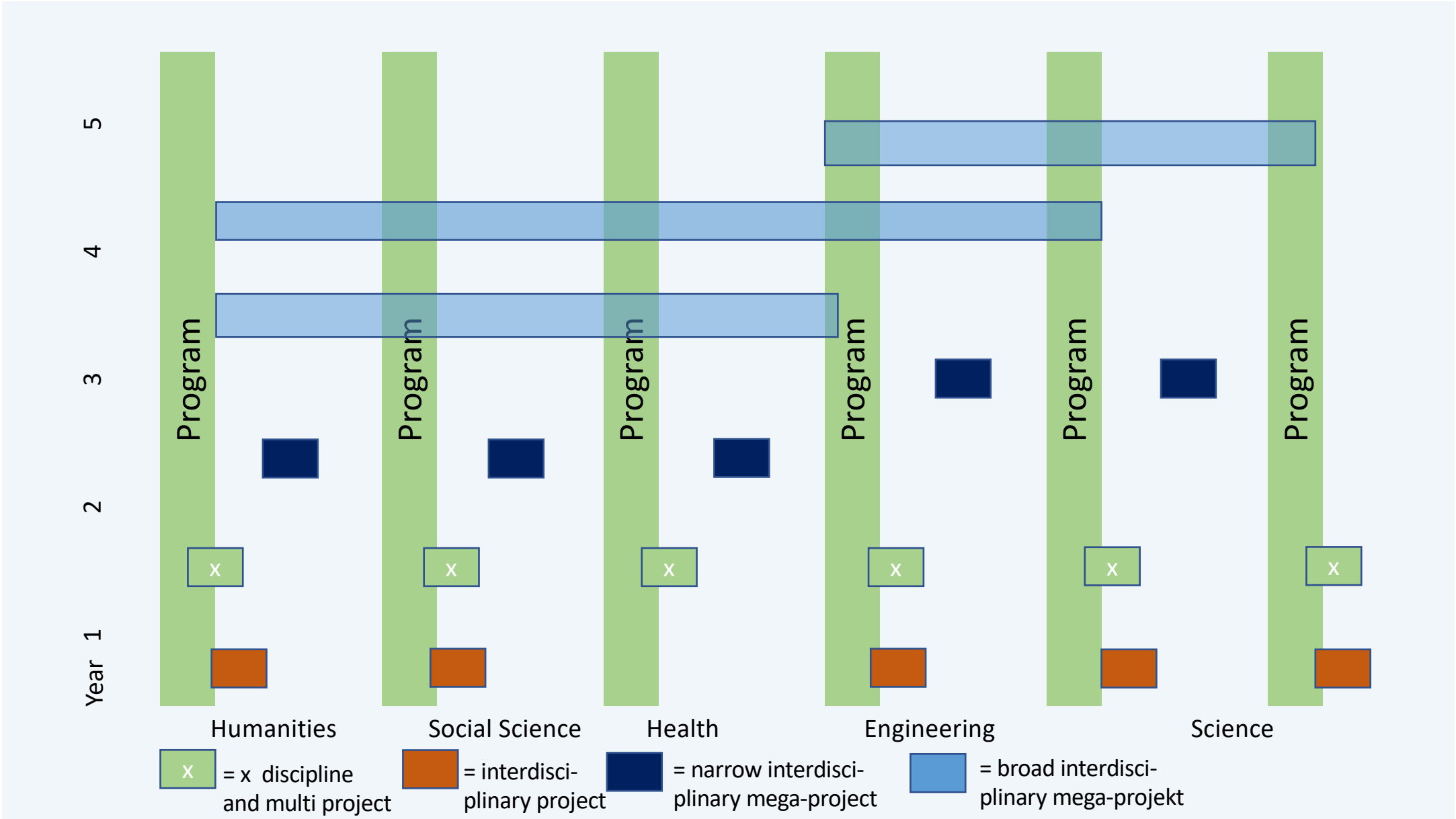
Structural competences, e.g.:

- Project management
- Delegation of work and team roles
- Setting objectives
- Defining and structuring activities
- Time- and activity management
- Agile management systems
- Digital project management tools
- Managing different types of meetings
- Scientific communication
- Management of external collaborations

A potential strategy for progression in process competences



Holgaard and Kolmos, 2019


Year 1
2
3
4
5
Program
Program
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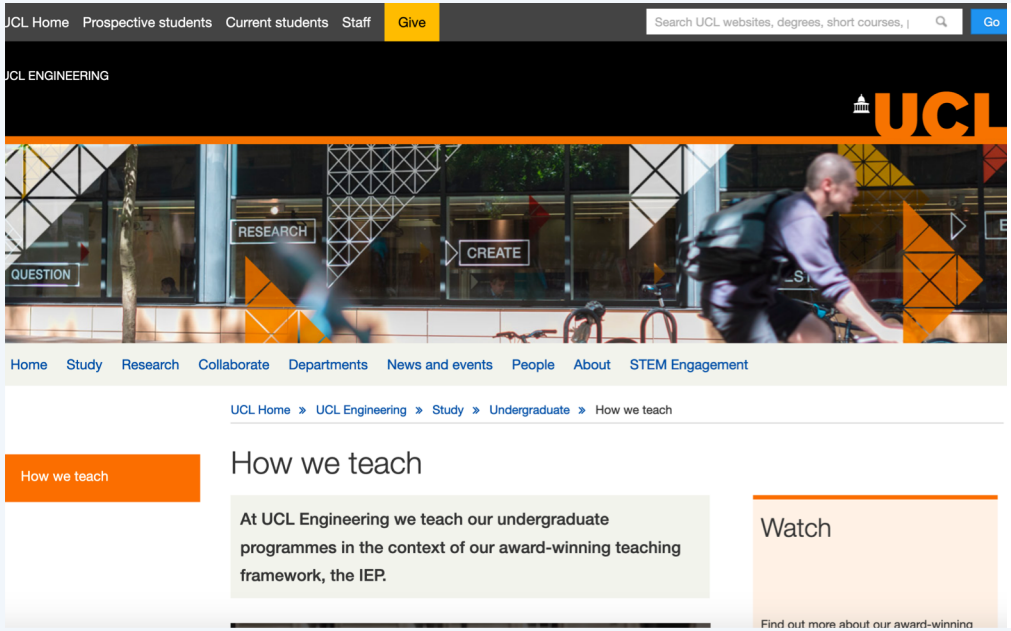
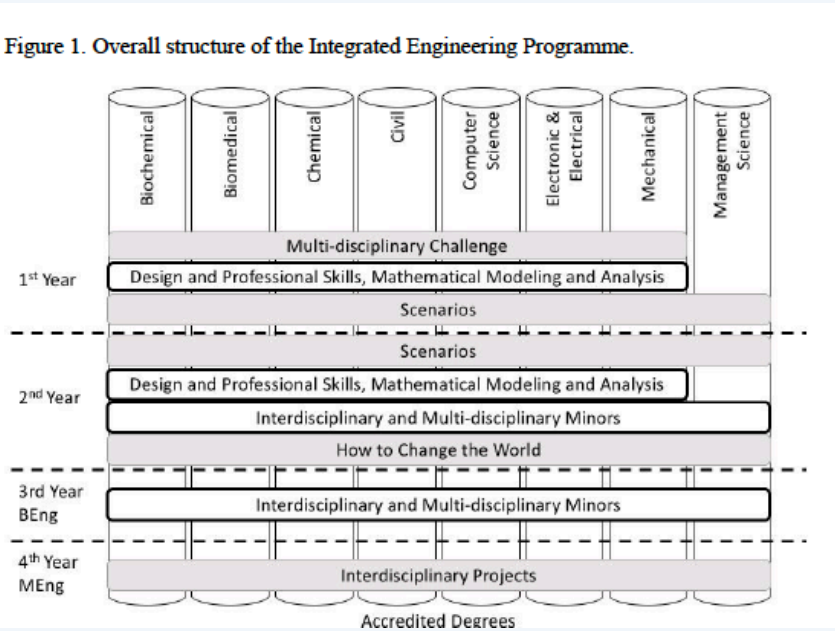
x
x
x
x
x
x
Humanities
Social Science
Health
Engineering
Science
x = x discipline and multi project
= interdisci-plinary project
= narrow interdisci-plinary mega-project
= broad interdisci-plinary mega-projekt

University College London (Mitchell et al., 2019) https://www.ucl.ac.uk/engineering/study/undergraduate/how-we-teach





Thank you

Thank you very much ☺

- Aalborg University. (2020). *Megaprojects*. Retrieved from https://www.megaprojects.aau.dk/
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