

# How to educate the systems architecting work force of the future? What we can learn from today's education

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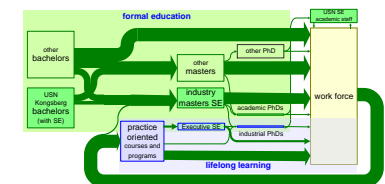
## Abstract

The systems that we engineer have evolved from closed mostly hardware systems 50 years ago to socio-technical cyber physical systems of systems anno 2025. Behind any physical system, we see many related virtual systems, such as digital threads, shadows, and twins, and a variety of simulation models for many purposes. How can we educate the (systems architecting) workforce for the future systems?

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# Figure of Content

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What **systems** do we expect in the **future**?

What **systems education** do we have?

What **systems education** do we need for the **future**?

# What do you Perceive as the Main Trend in Systems?

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<https://www.menti.com/>  
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# System Trends

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- anno 2025, systems are **socio-technical cyber-physical systems-of-systems**
- these systems operate in **extensive ecosystems**
- **humans and organizations** cause **complexity**
- climate emergency: **sustainability** is an additional container of qualities
- political emergency: **security** is critical
- **digital technologies** enable capabilities across constituent systems
- biological, clinical, pharmaceutical, material science, **and many more technologies** change rapidly

*legend*

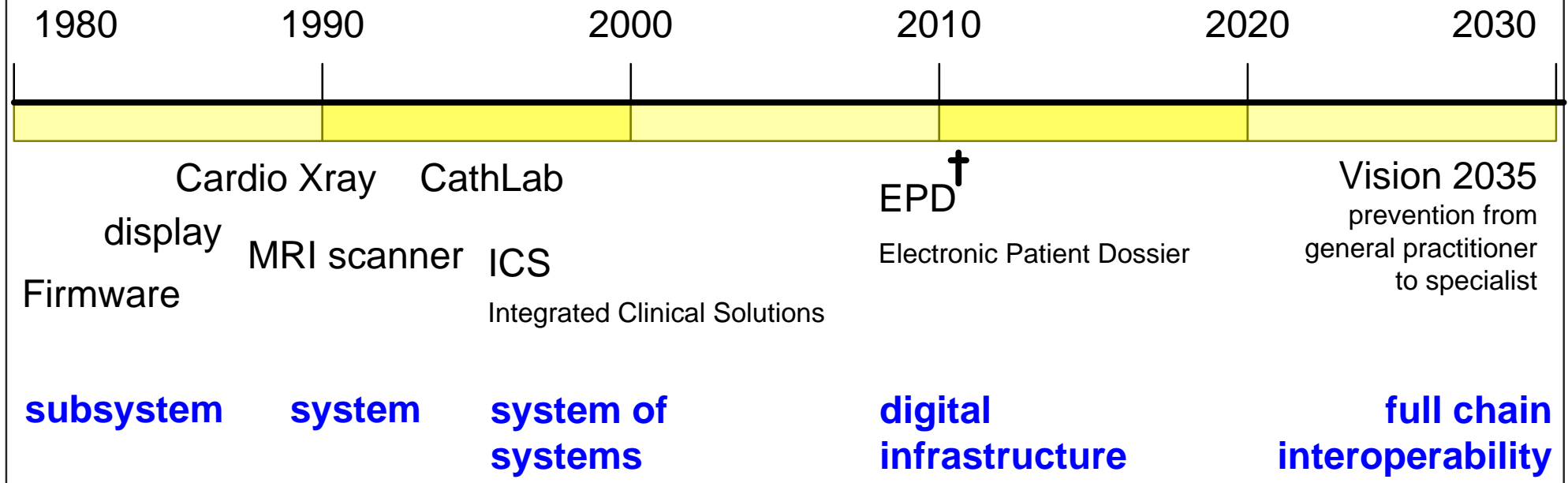
**social**

**technical**

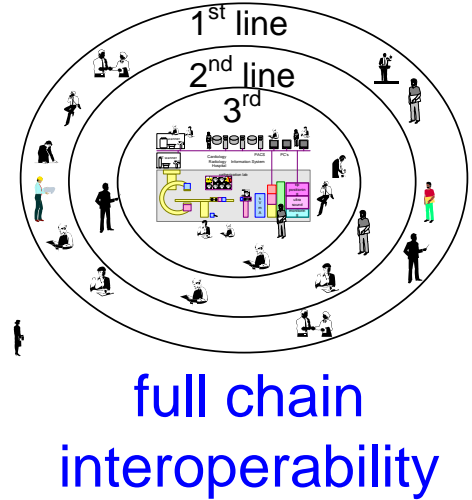
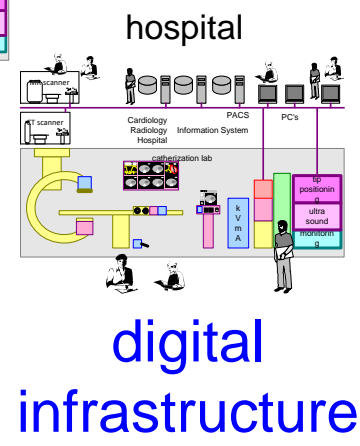
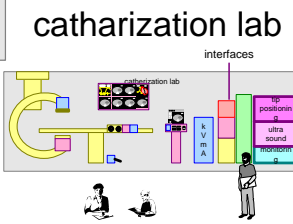
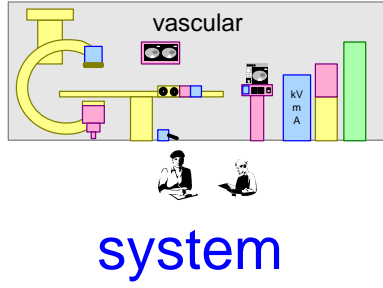
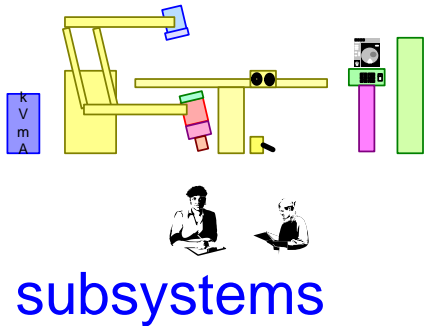
**integral**

# Example Scope Increase in Healthcare

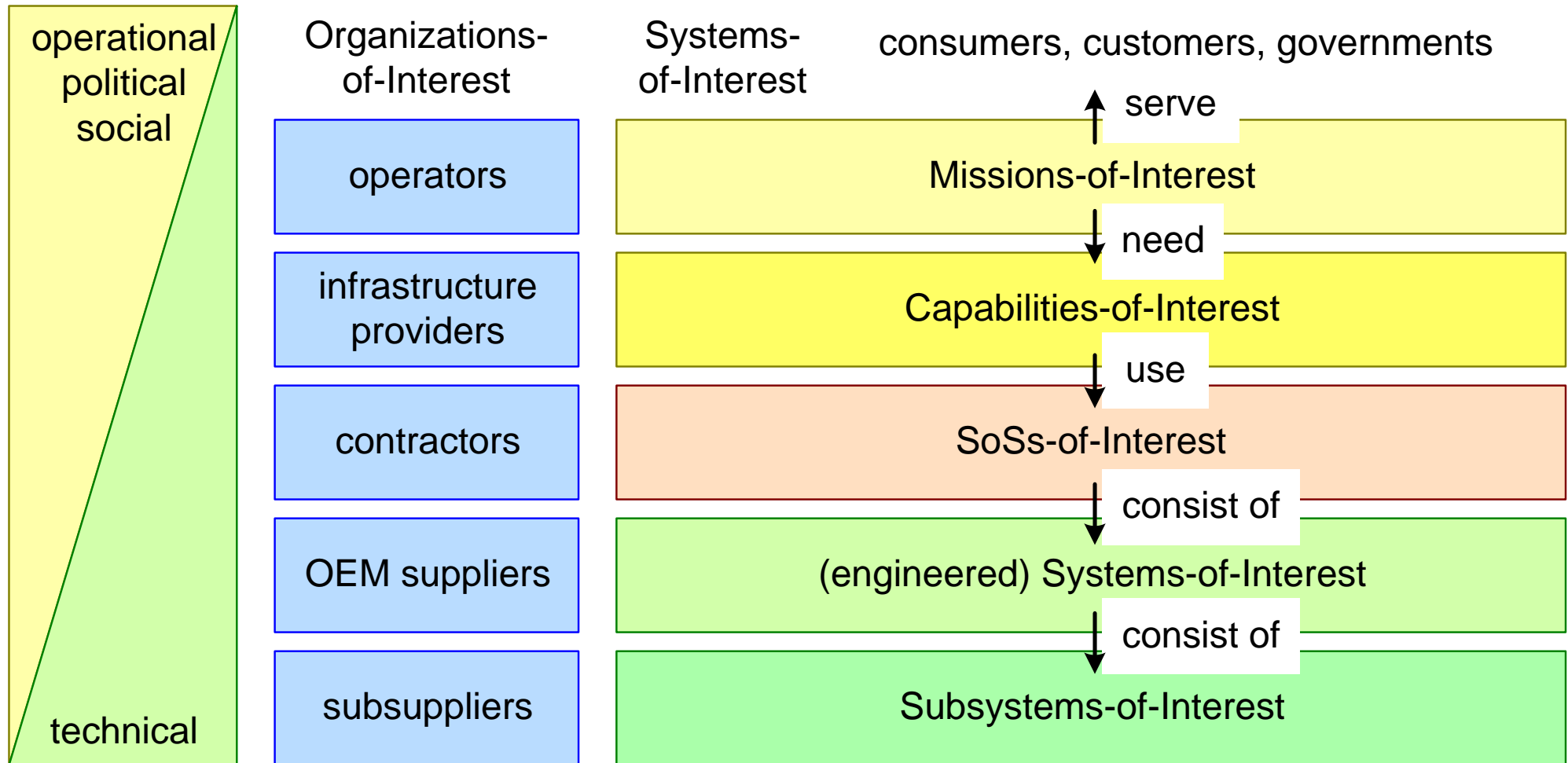
## 1. From component engineering to capability architecting to integral care improvement



# Example Scope Increase in Cardio

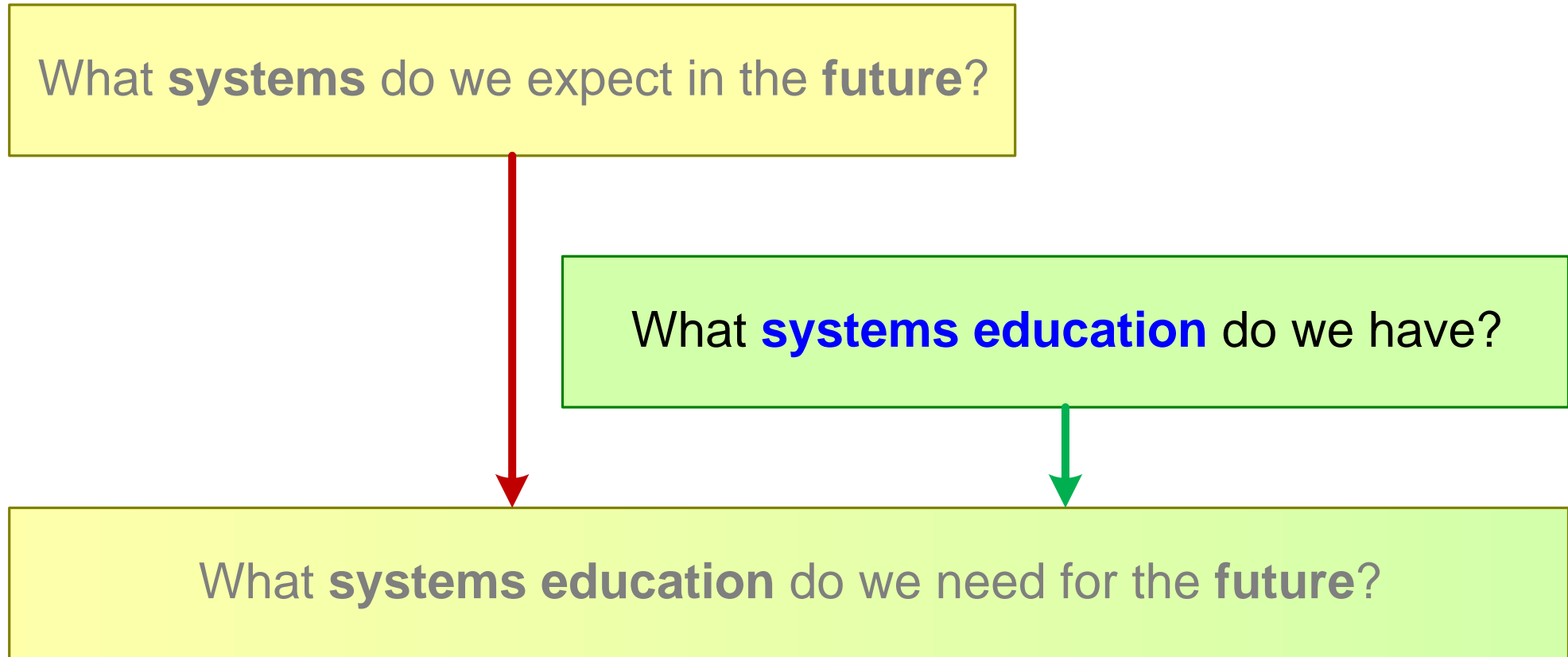


# We Need Many Types of Architects

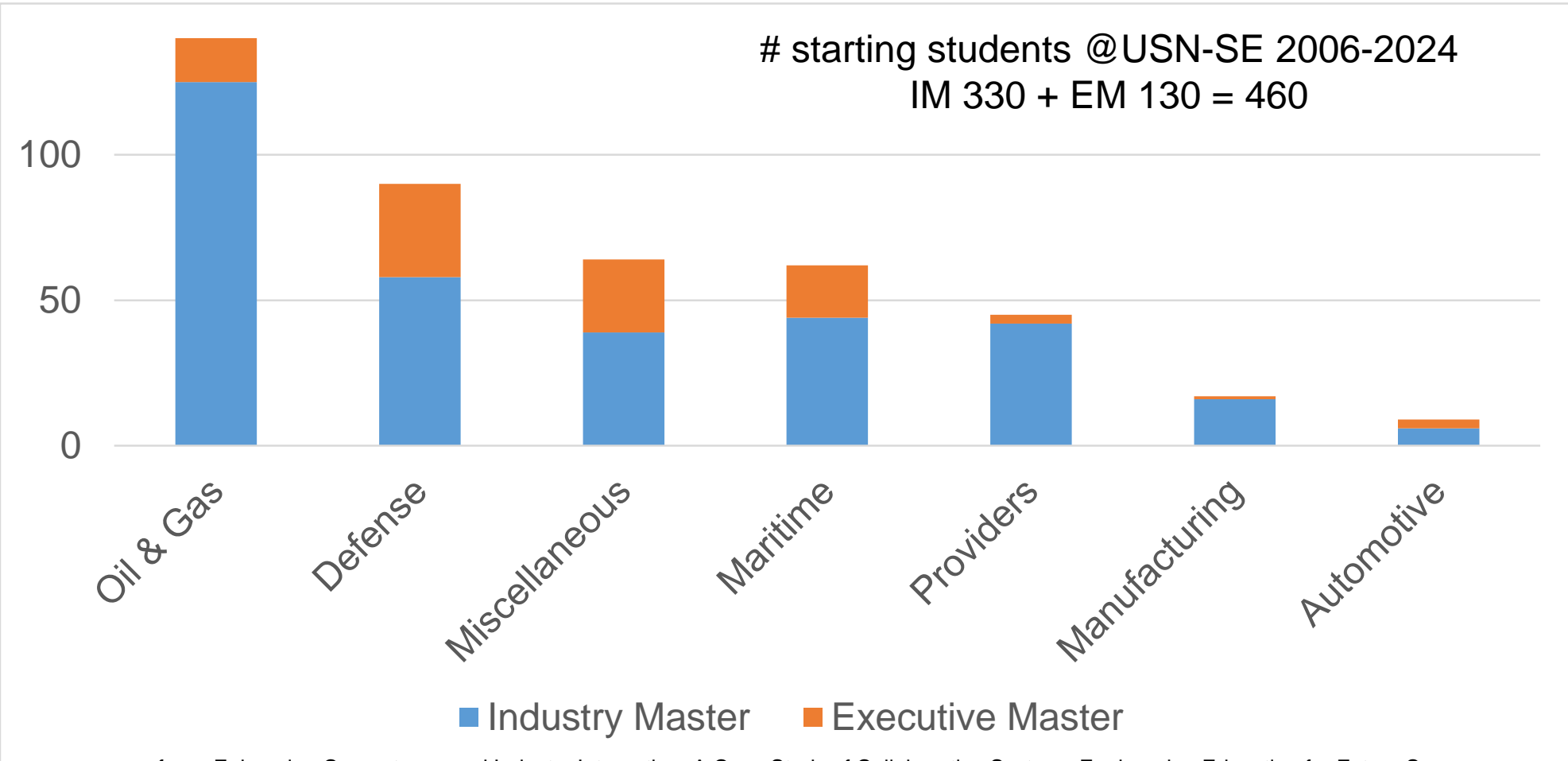


# Figure of Content

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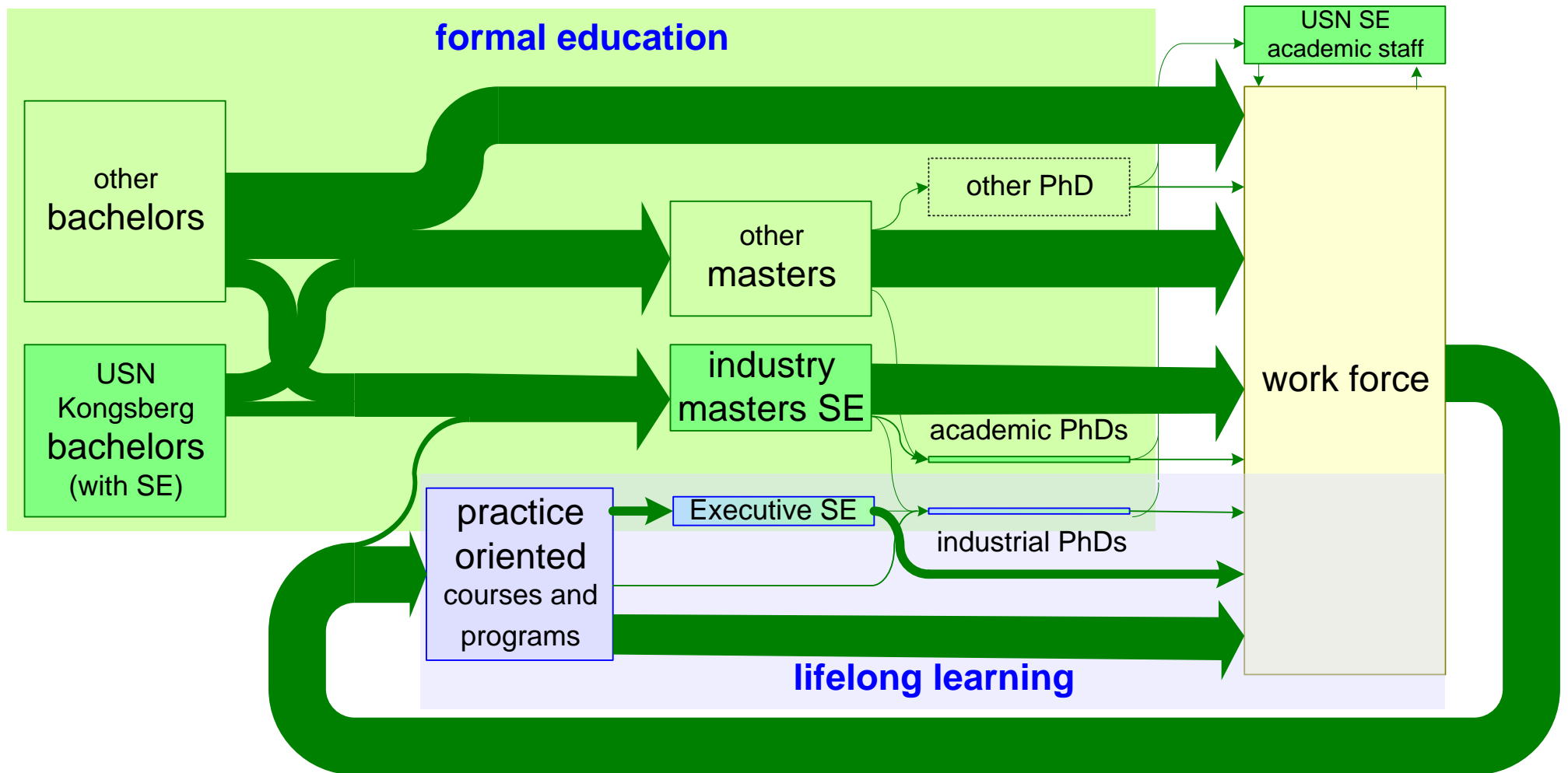


# University of South-Eastern Norway (USN): SE Master



from: Enhancing Competency and Industry Integration: A Case Study of Collaborative Systems Engineering Education for Future Success  
Omid Razbani, Gerrit Muller, Satyanarayana Kokkula, and Kristin Falk, MDPI Systems 2023, 11(9), 463; <https://www.mdpi.com/2079-8954/11/9/463/pdf>

# Educational Pathways, There are many Paths to Rome

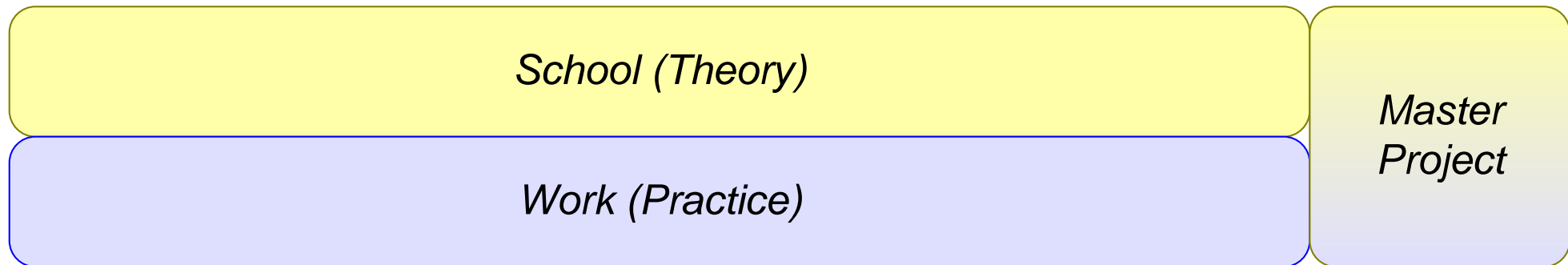
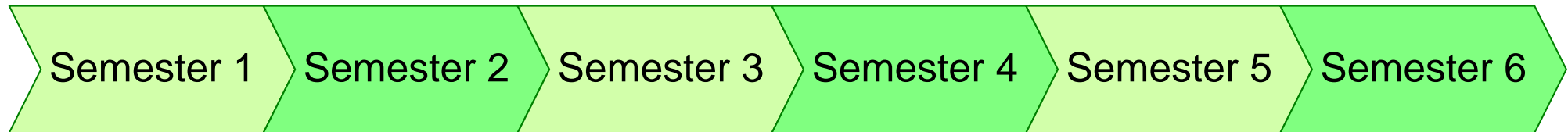


The objective of the industry master in systems engineering is to **accelerate** the **competence development** of new systems engineers, from e.g. 10..20 years in the past to 5..10 years.

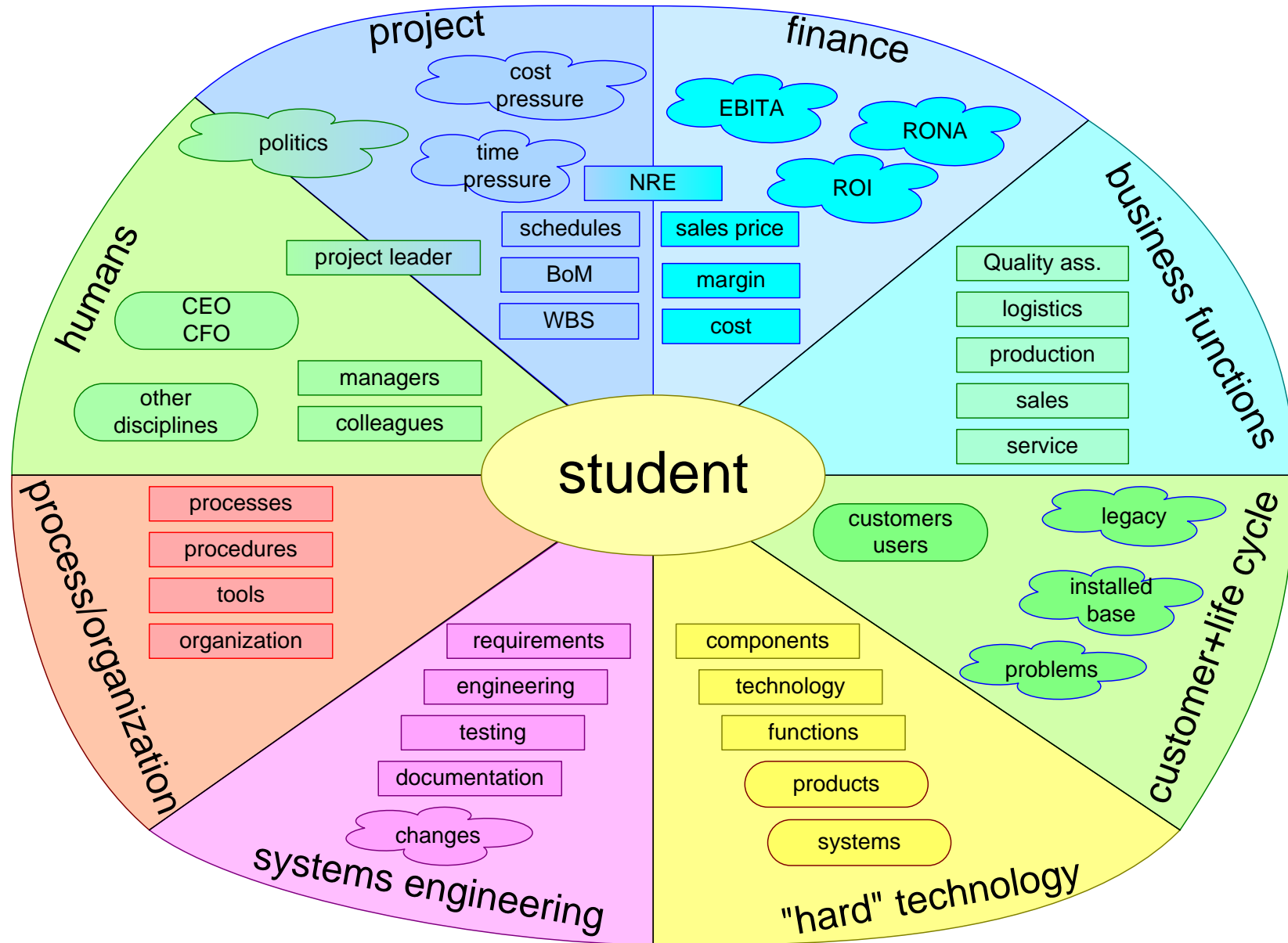
Core of the acceleration is **experiential learning**, where offering **theory** and building up **experience** happens **concurrently** and is used to **reinforce learning**.

# Work and Study Concurrently

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# Overload of Impressions for Fresh Bachelors



# What is Competence?

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Attitude (perseverance, faith, critical, constructive, etc.)

*train*

Ability (know when to use what skill and knowledge)

*apply/use often, experience*

Skills (calculate missing angle, calculate hypotenusa)

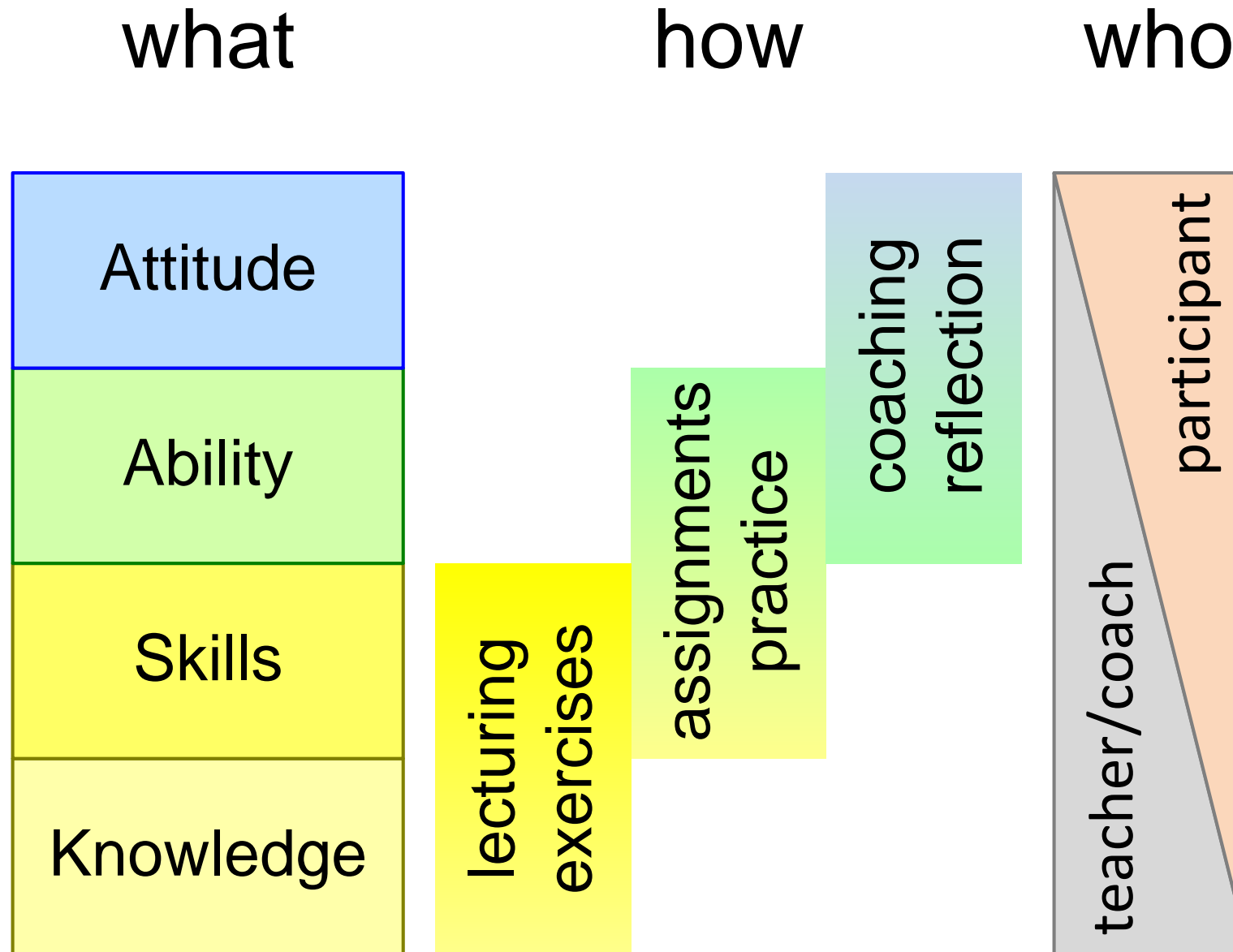
*exercise*

Knowledge (triangle has 3 corners, sum of angles is 180 degrees, Pythagoras  $c^2 = a^2 + b^2$ )

*learn*

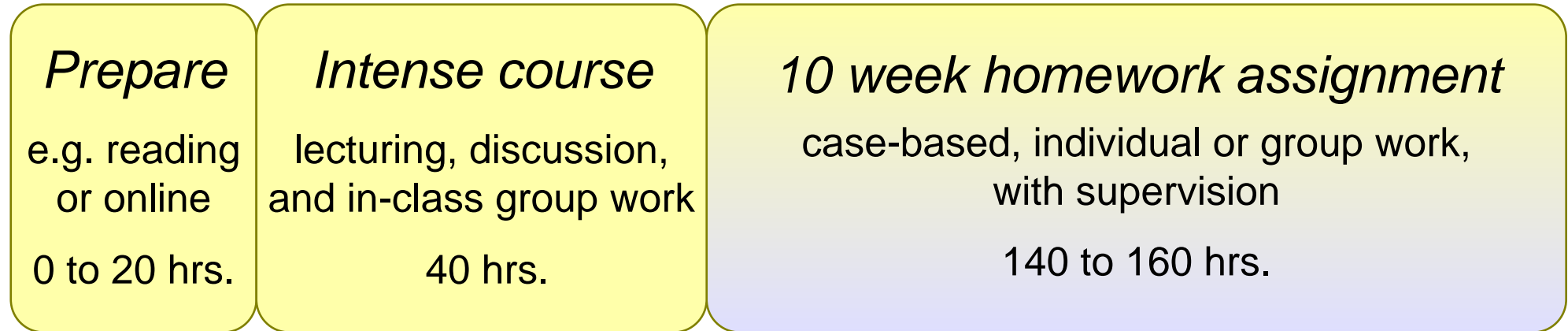
Competence = Knowledge + Skills + Ability + Attitude

# Systems Competence mostly requires Ability and Attitude



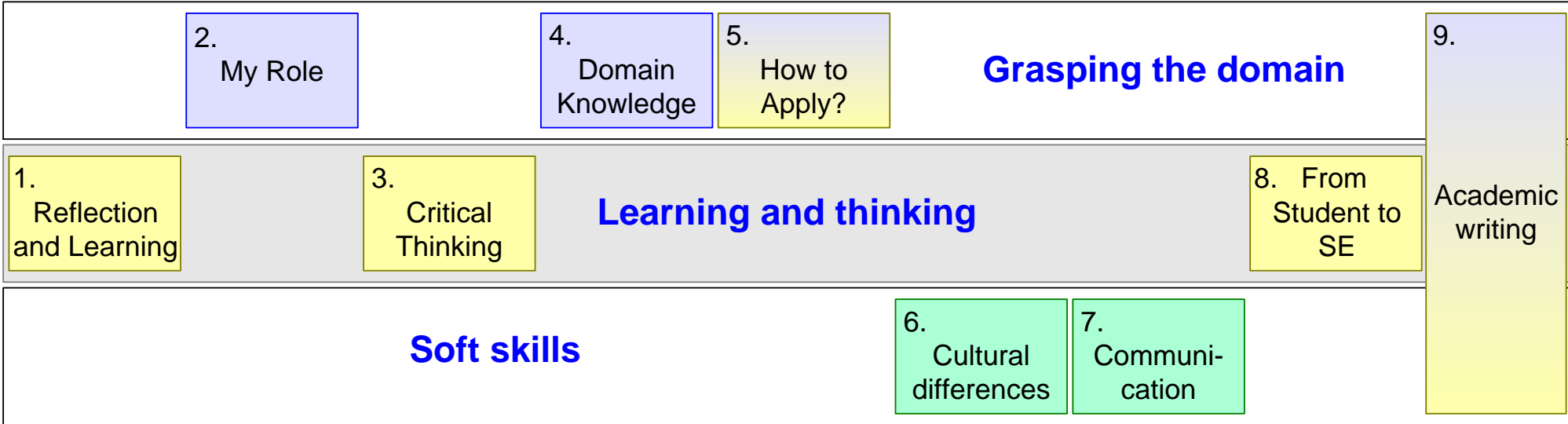
# Course Format and Pedagogic

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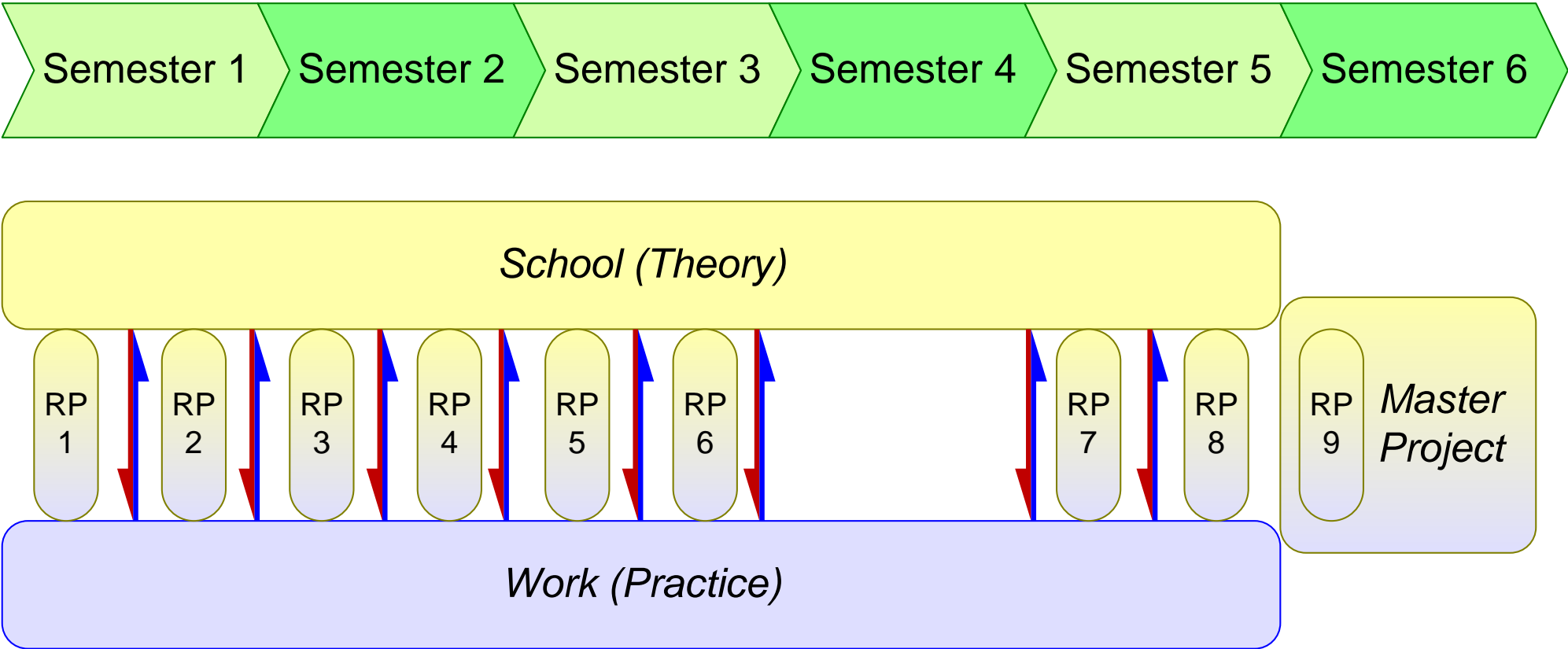


- Students travel 3 to 6 times per year
- Study and work planning is flexible
- Active learning, case-based
- Actual industry cases are possible (depends on course)

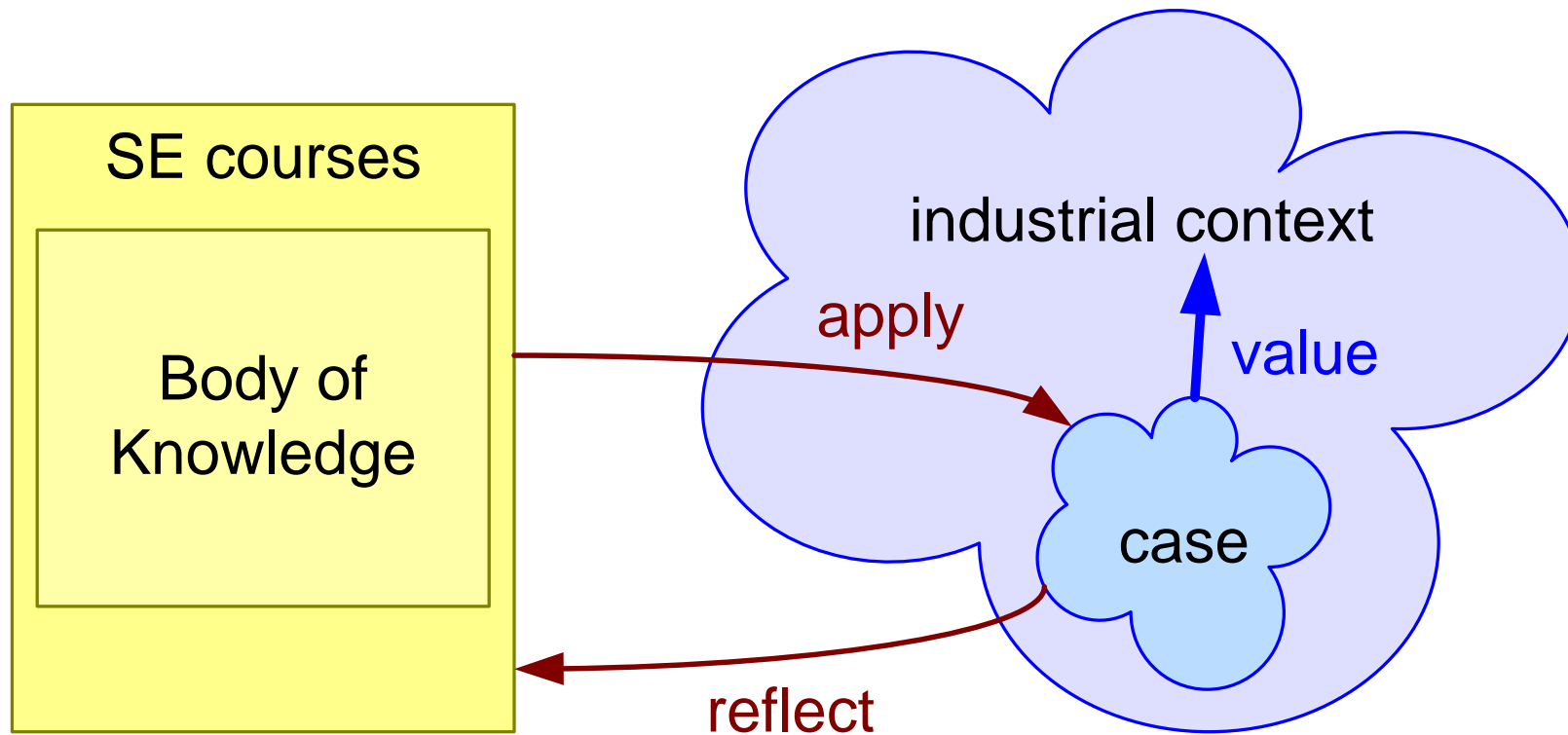
# Reflective Practice; 9 Workshops in 3 Years



# Reflective Practice Connects Study and Work

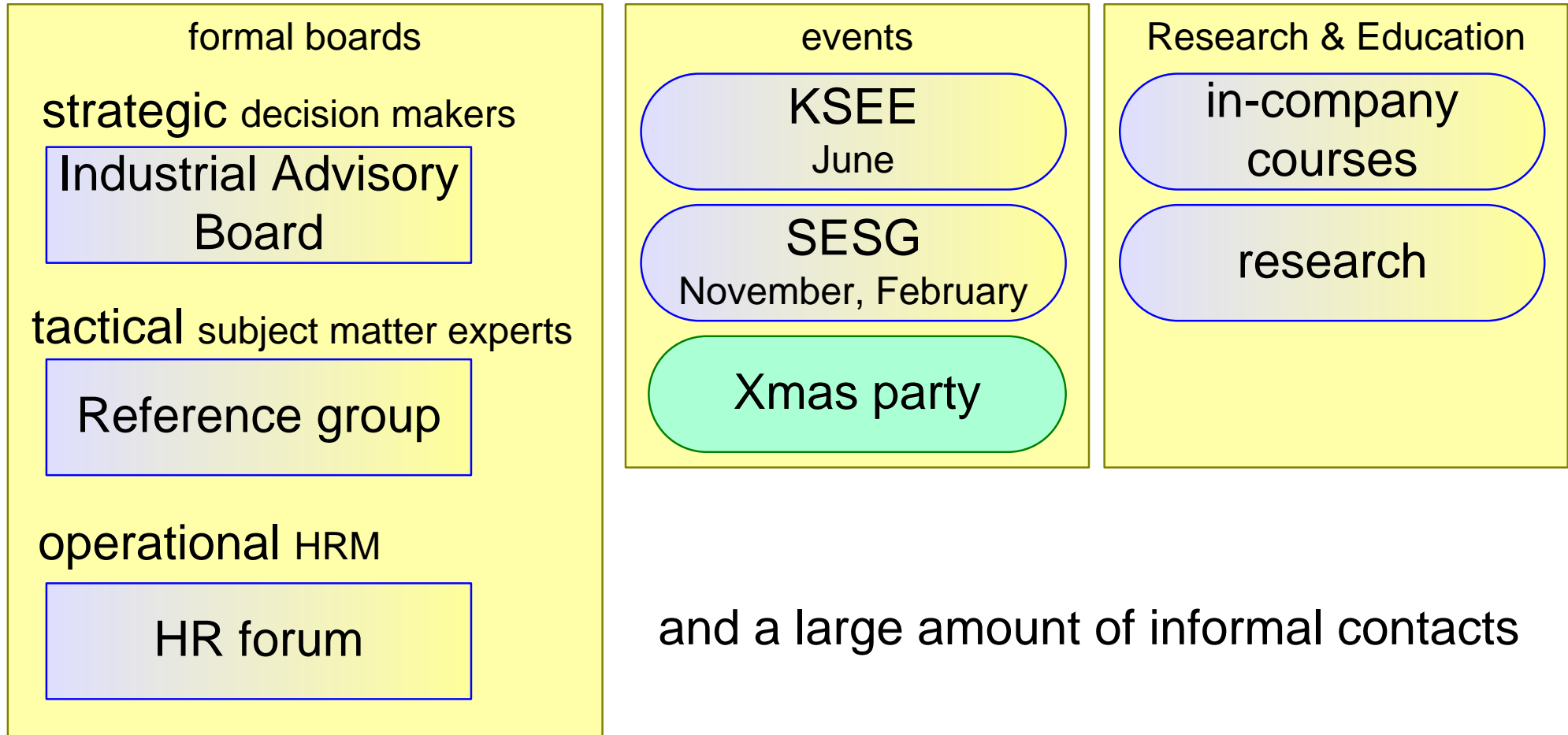


# Objectives of Master Project



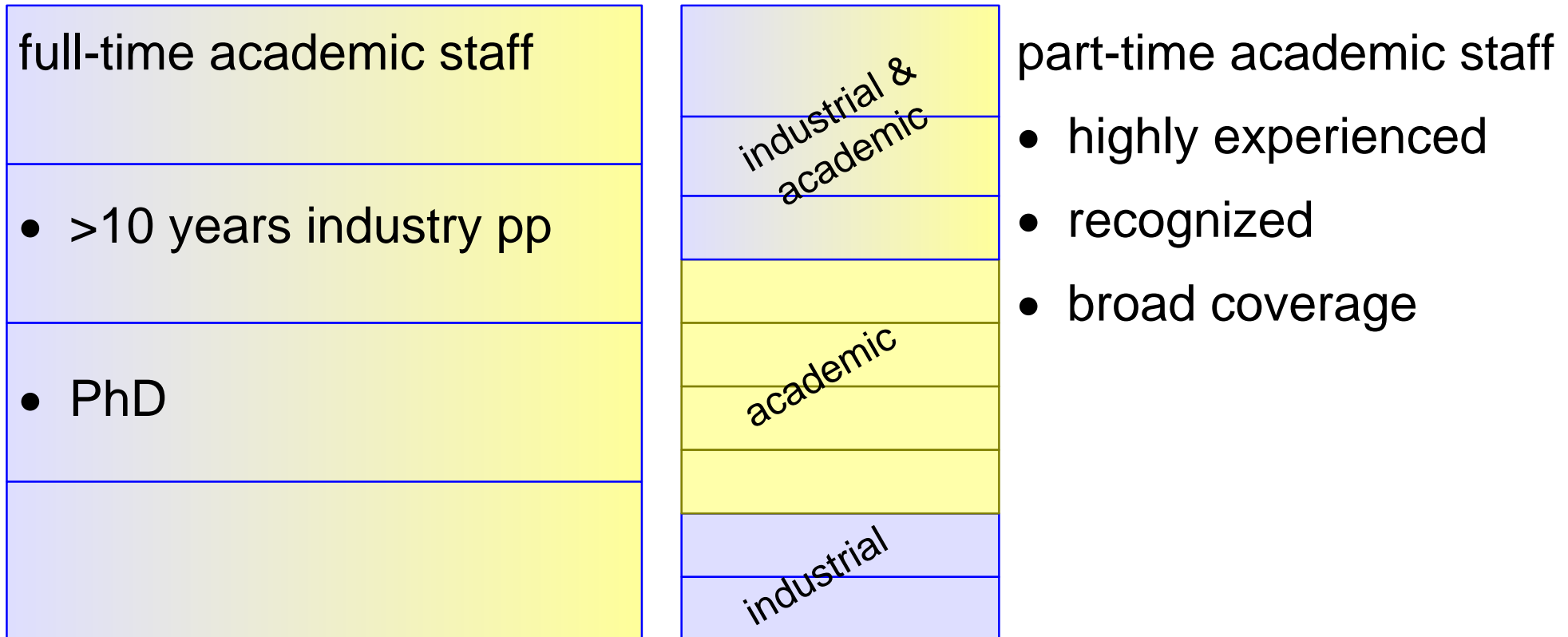
**Apply** part of the SE body of knowledge in practice and **evaluate** and **reflect** on its application, while **providing value** to the industrial sponsor

# Embedding the Program in Industrial Networking

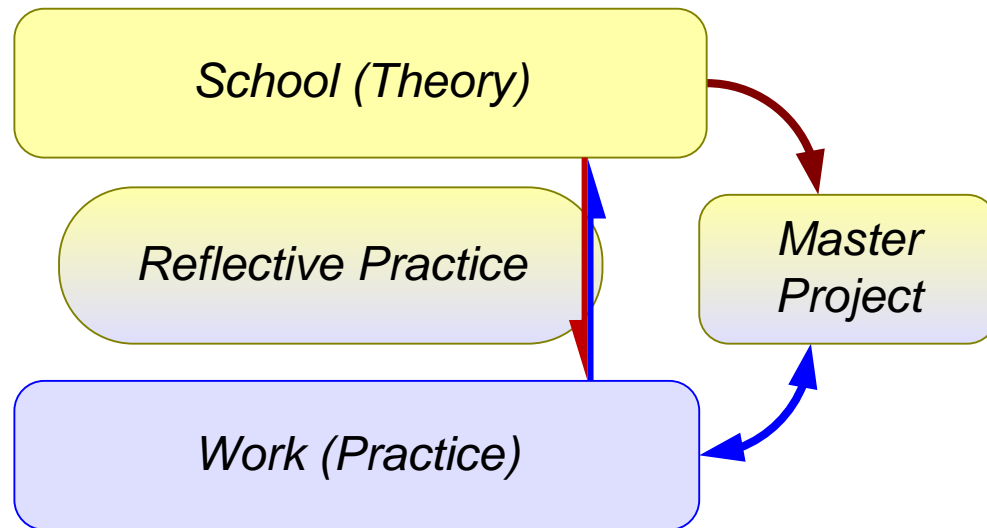


and a large amount of informal contacts

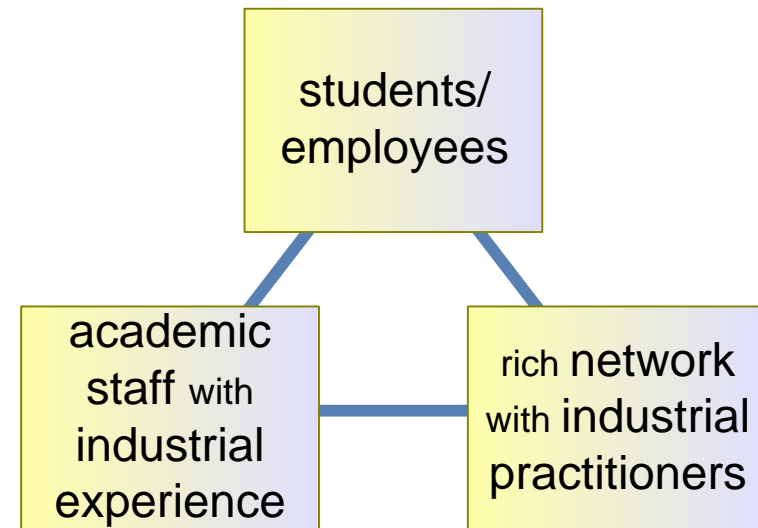
# Challenge: Recruiting Industrial and Academic Staff



# Summary

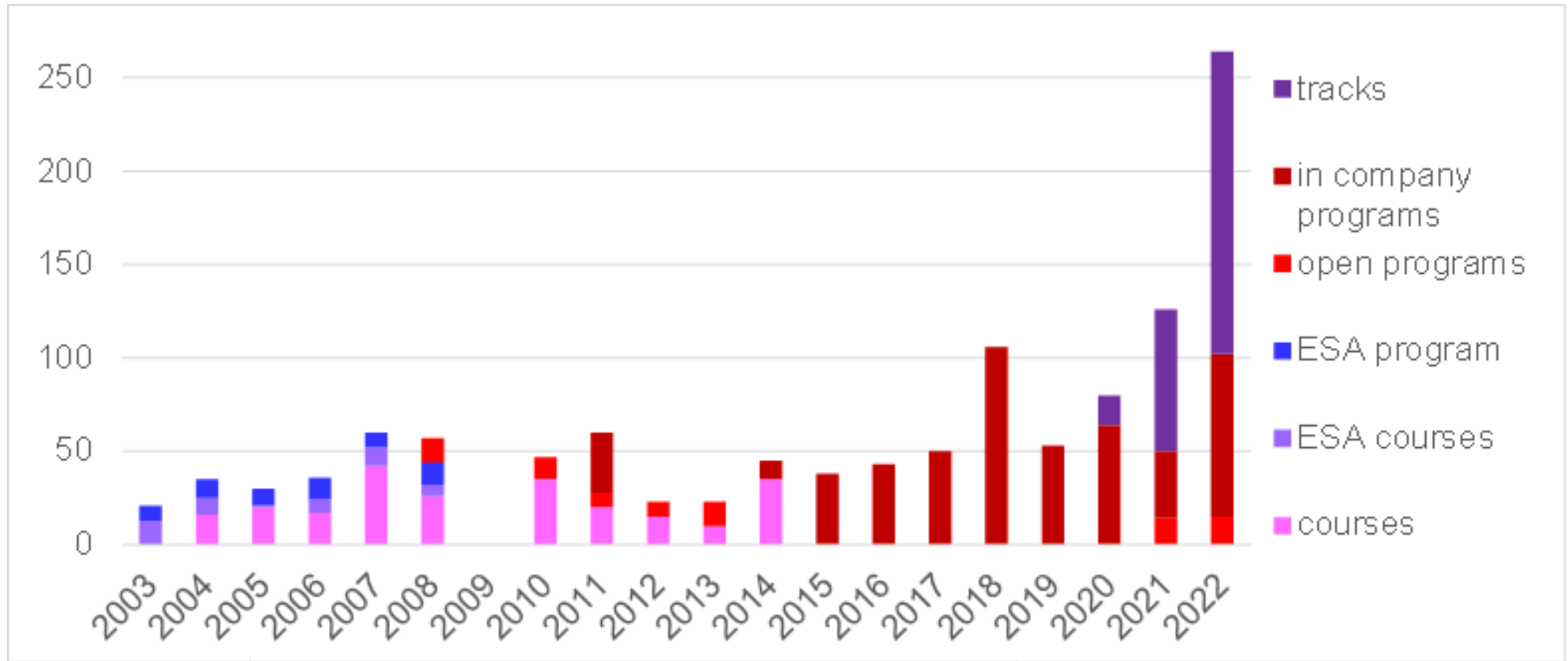


Studying and working concurrently  
Format and pedagogic of courses fits industry  
Reflective Practice connects study and work  
The master project is the closure



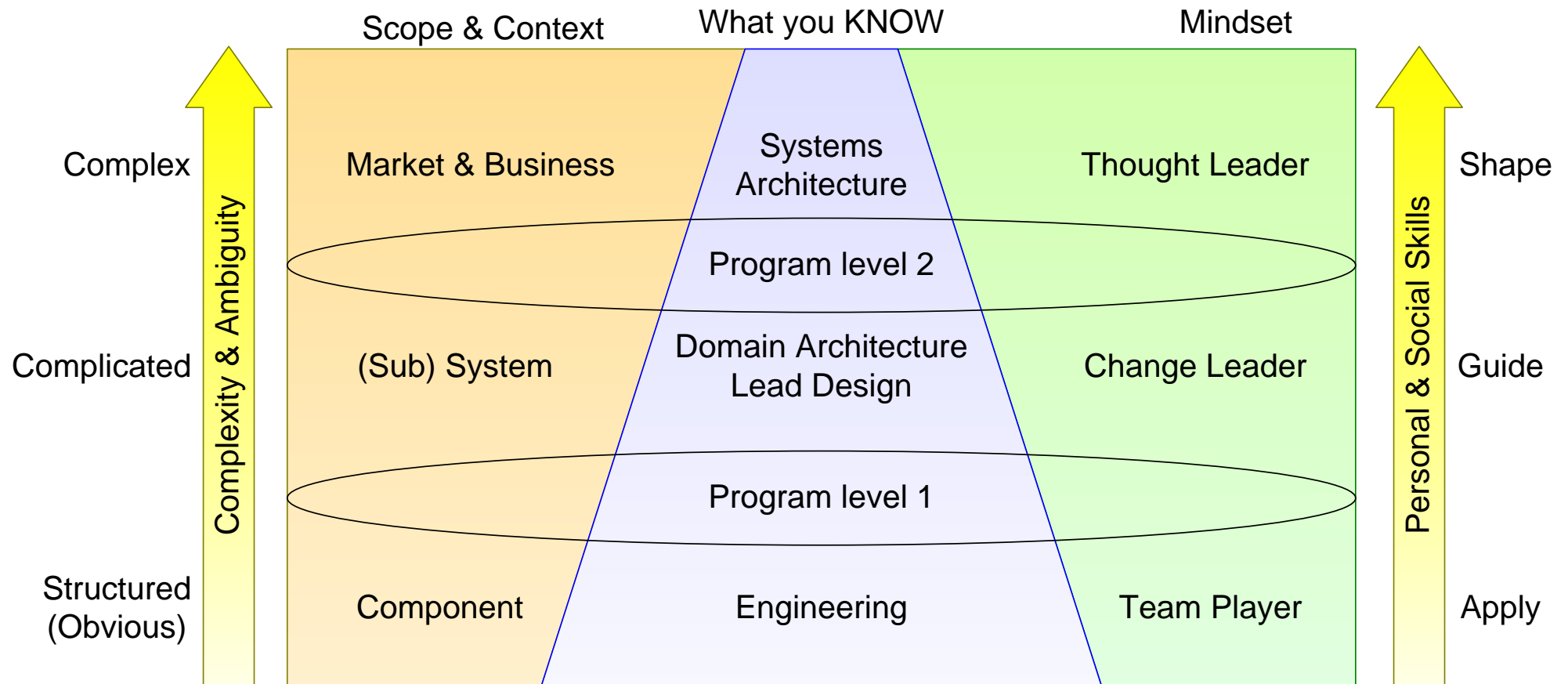
Continuous investment in industrial relations  
Offering an inspiring environment and network  
for practitioners, students, and staff

# TNO-ESI Systems Education Participants



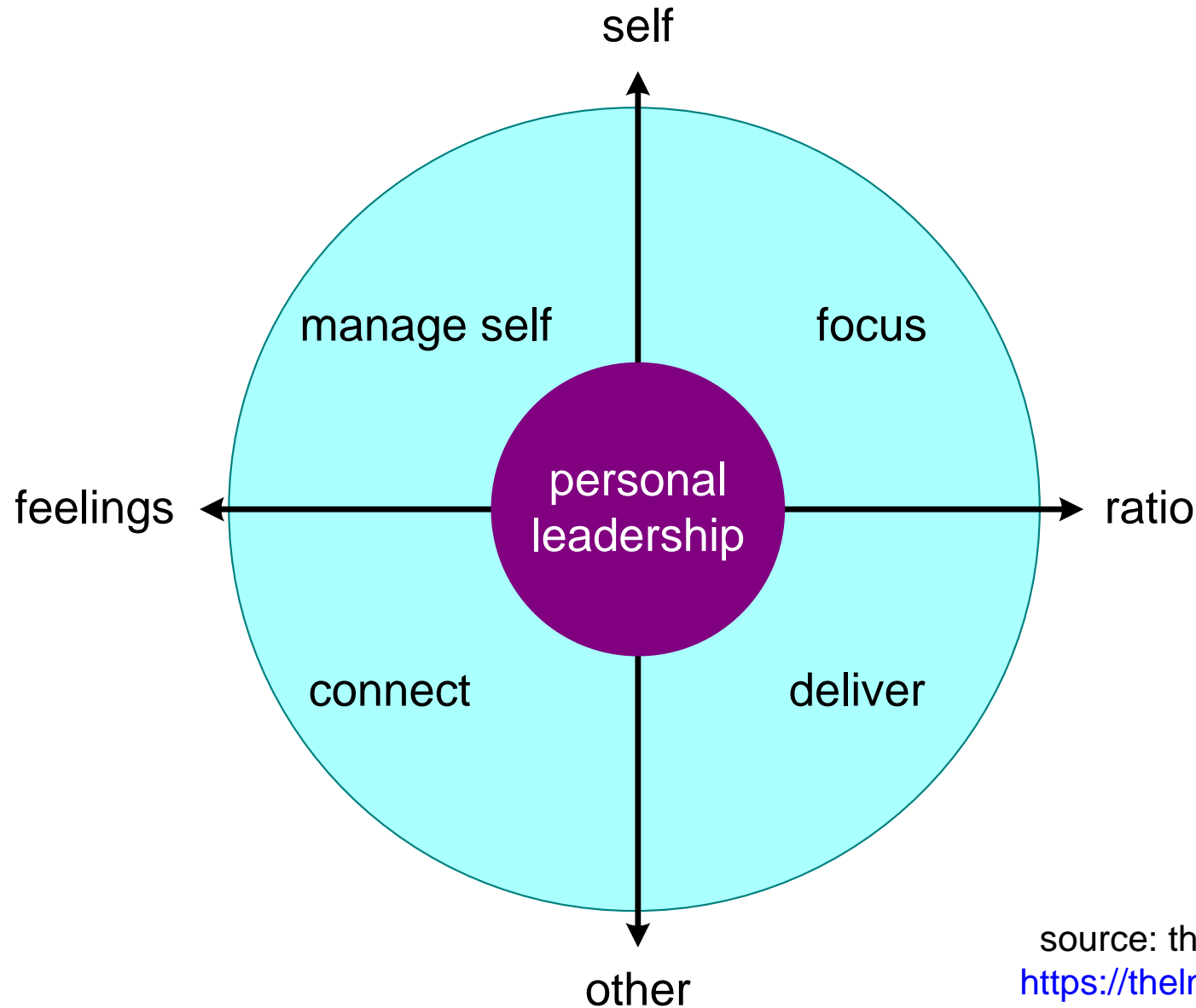
Systems Engineering Education: From Learning Program to Business Value Gerrit Muller, Laura van Veen, and Joris van den Aker  
MDPI Systems 2023, 11(10), 510; <https://www.mdpi.com/2079-8954/11/10/510/pdf>

# TNO-ESI Systems Education Model



Systems Engineering Education: From Learning Program to Business Value, 2023,  
 Gerrit Muller, Laura van Veen, and Joris van den Aker <https://www.mdpi.com/2079-8954/11/10/510/pdf>

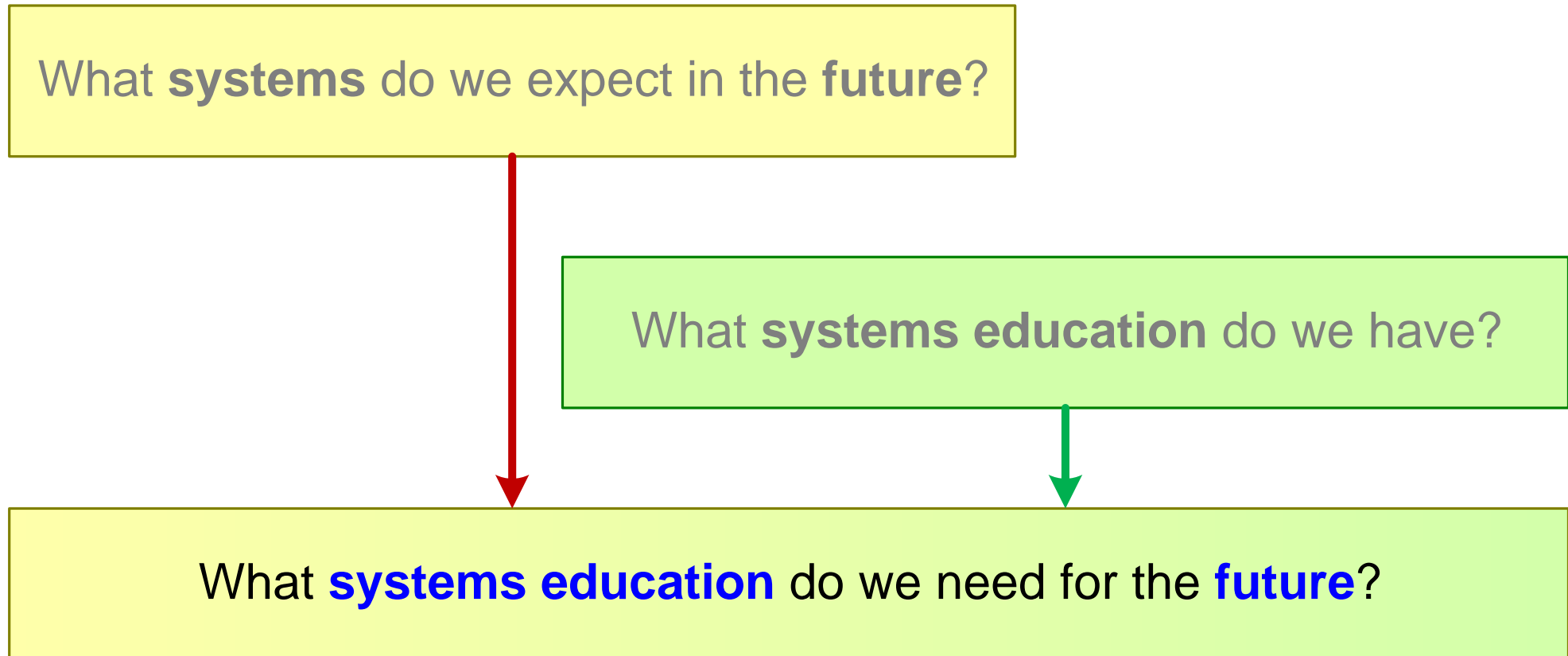
# Leadership is the Key to Increase Systems Effectiveness



source: the LMS group  
<https://thelmsgroup.nl/en/>

# Figure of Content

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# What Competences do We Need to Offer for Future Systems?

<https://www.menti.com/>  
menti meter code 2114 4370



# Mitigation of System Trends

- socio-technical cyber-physical SoSs
- extensive ecosystems
- complexity due to humans and organizations
- sustainability
- security
- digital technologies
- many more technologies

leadership & professional  
competencies  
fundamental societal  
skills (PESTEL)

depth education  
“playing with”

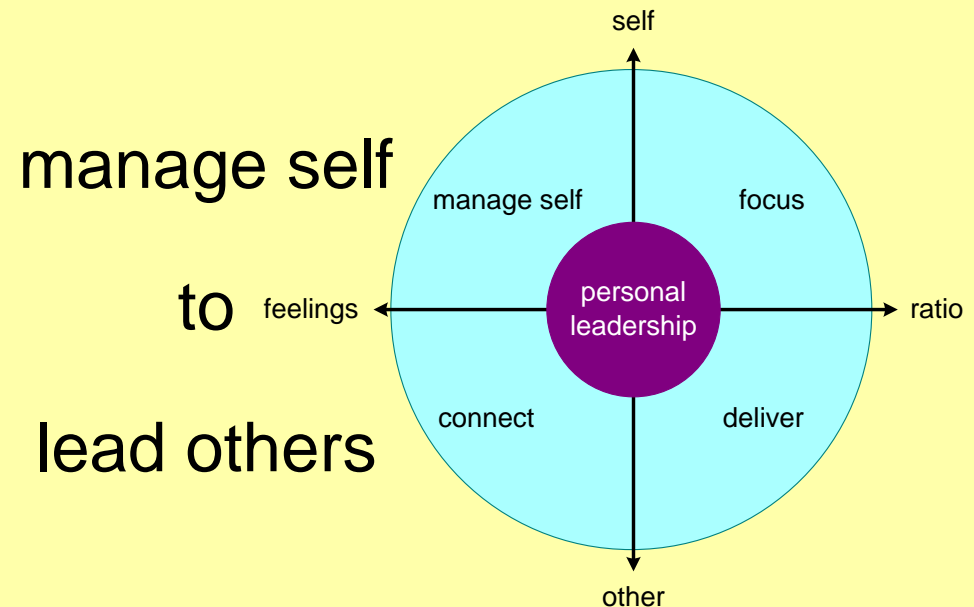
- we have to educate **organizations**, not only **individuals**
- each system architect is a **unique individual**
- education needs to be **flexible to fit** individuals and organizations
- individuals learn architecting in **practice**
- therefore they need **reflection and coaching**; learn to learn
- architects must be **fast learners** to absorb domain and technology knowledge

# Conclusions

**Keep learning** by refreshing, doing, and playing

**Adapt** the **learning to** your and your organization's **needs**

**Leadership** is the biggest enhancer for content-full architects



# References

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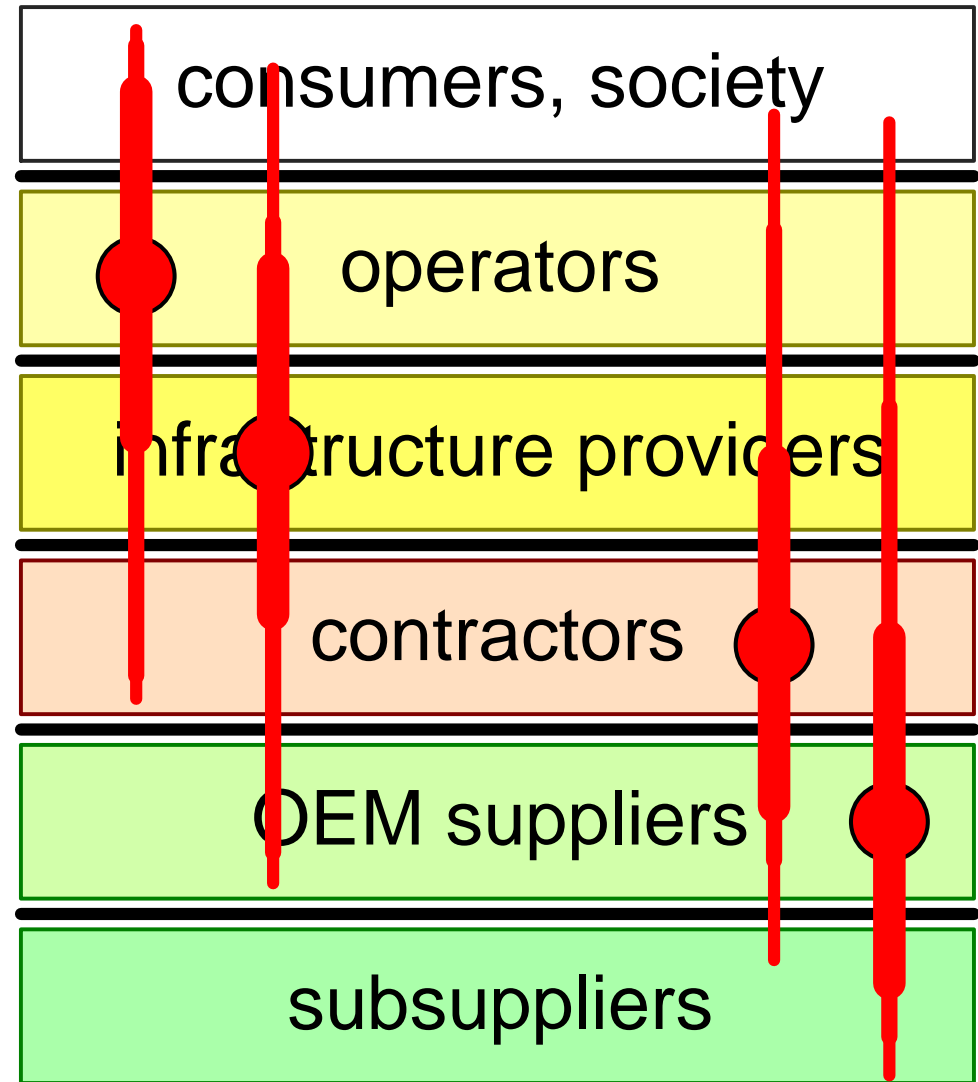
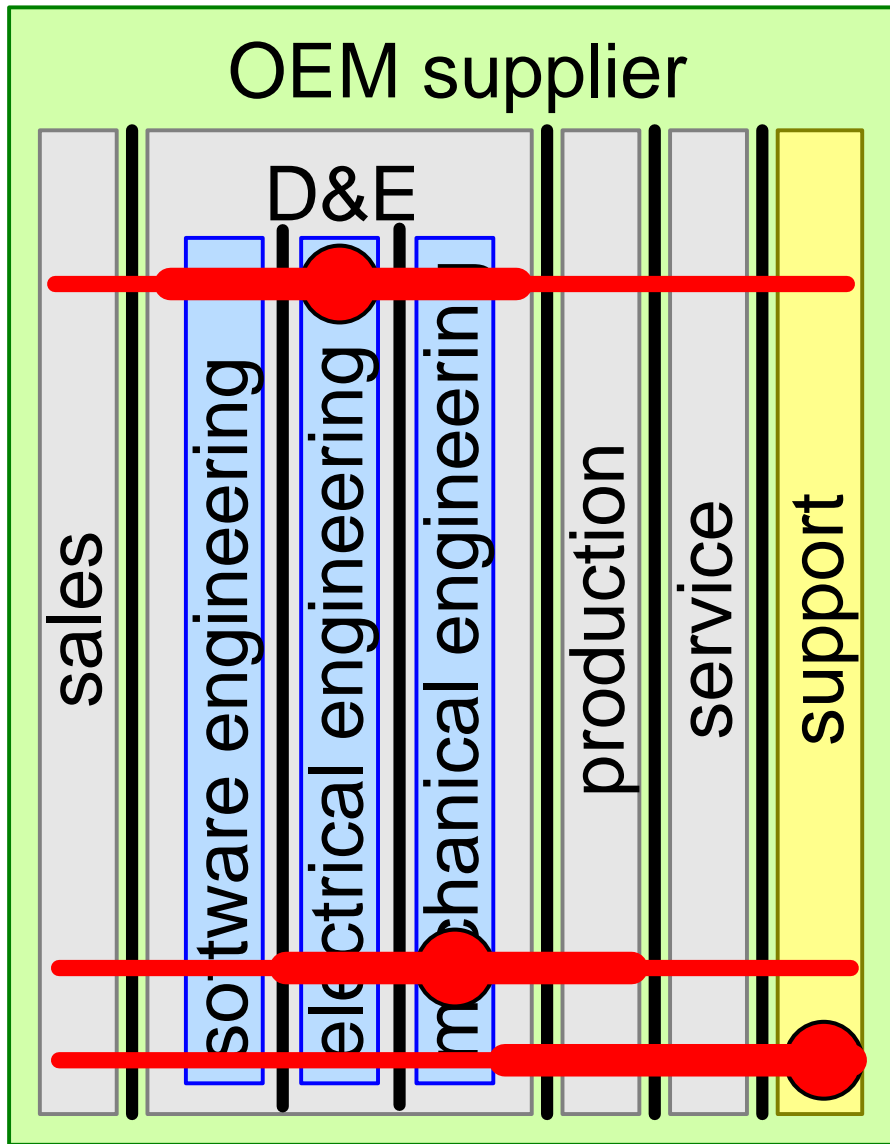
<https://www.mdpi.com/2079-8954/11/10/510/pdf>

Can generative systems design solve the flaws of MBSE?

Oluf Tønning, KSEE 2024

[https://www.gaudisite.nl/KSEE2024\\_Tønning\\_GenerativeSystemsDesignForMBSE.pdf](https://www.gaudisite.nl/KSEE2024_Tønning_GenerativeSystemsDesignForMBSE.pdf)

# Architects Need Orchestration Competency



# Capability Architecting

