Enhancing Competence and Industry Integration

by Gerrit Muller  USN-SE

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Abstract

Systems Engineering education and research requires a close relation with a context. This is a case study of the way that USN-SE runs a program that enhances competence and integrates with industry.
Genealogy of the Industrial Driven Approach

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ECII timeline
Evolve Research Education, and Practice Together

- **Research**
  - New methodologies, inspiration
  - Needs, practices, validation
  - Cross system/project, cross company, cross domain, sampling

- **Education**
  - Competence, inspiration
  - Needs, practices, validation

- **Practice**
  - New methodologies, inspiration
  - Industry as laboratory
  - Industrial PhD
  - Problem, need, goal, driven

- **Industry**
  - Reflective practice
  - Case based education
  - Industry as classroom
  - Industry in the classroom

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ECIIresearchIndustryPractice
One of several prerequisites for architecture creative synthesis is the definition of 5-7 specific key drivers that are critical for success, along with the rationale behind the selection of these items.

The essence of a system can be captured in about 10 models/views.

A diversity of architecture descriptions and models is needed: languages, schemata and the degree of formalism.

The level of formality increases as we move closer to the implementation level.

Architecting education must be framework and standard agnostic, but architects must have seen or used multiple frameworks and standards.
Various Types of Systems Form More Complex Systems

- natural environment
- man-made artifacts
- humans and organizations
- system of interest

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MECPcontexts
How Far Do We Expand Our Scope?

Enhancing Competence and Industry Integration

CyPhERS
Cyber-Physical European Roadmap & Strategy
CPS: Significance, Challenges and Opportunities
http://www.cyphers.eu/sites/default/files/D5.2.pdf

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ECIIextendedCyphers
## Relevant Social, Political, and Legal Perspectives

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RFSBpestel
Especially in Society’s Major Challenges

Transdisciplinary competence integrates many disciplines to achieve objectives with desired quality attributes.
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**.
Historical: Growing Systems Engineers Takes Decades

Traditionally, systems engineers "grow" in decades. Systems engineers need to maintain a deep understanding of their individual systems while also gaining breadth in other areas. This requires a combination of depth and breadth of knowledge.

Legend:
- System
- Mono-disciplinary

Depth of knowledge:
- Engineer
- All-round engineer
- Aspect systems engineer

Breadth of knowledge:
- Systems engineer

To be maintained:
- Mono-disciplinary root knowledge
Work and Study Concurrently

Semester 1  Semester 2  Semester 3  Semester 4  Semester 5  Semester 6
School (Theory)
Work (Practice)
Master Project
Intended Growth of Industry Master students

- Theory
- Practice
- On the job training
- Systems engineer

- Mono-disciplinary root knowledge to be maintained
- Breadth of knowledge
- Depth of knowledge
- Time

Enhancing Competence and Industry Integration
**What is Competence?**

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<th>Attitude (perseverance, faith, critical, constructive, etc.)</th>
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<tr>
<td>Ability (know when to use what skill and knowledge)</td>
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<td><em>apply/use often, experience</em></td>
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<td>Skills (calculate missing angle, calculate hypotenusa)</td>
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<td><em>exercise</em></td>
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<td>Knowledge (triangle has 3 corners, sum of angles is 180 degrees, Pythagoras $c^2 = a^2 + b^2$)</td>
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<td><em>learn</em></td>
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Competence = Knowledge + Skills + Ability + Attitude
Various Ways to Develop Competence

- **what**
  - Knowledge
  - Skills
  - Ability
  - Attitude

- **how**
  - Lecturing
  - Exercising
  - Assignments
  - Practice
  - Coaching
  - Reflection

- **who**
  - Teacher/coach
  - Participant
Course Format and Pedagogic

- Prepare: e.g. reading or online, 0 to 20 hrs.
- Intense course: lecturing, discussion, and in-class group work, 40 hrs.
- 10 week homework assignment: case-based, individual or group work, with supervision, 140 to 160 hrs.

- Students travel 4 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

1. Reflection and Learning
2. My Role
3. Critical Thinking
4. Domain Knowledge
5. How to Apply?
6. Cultural differences
7. Communication
8. From Student to SE Academic writing
9. Academic writing

Learning and thinking

Grasping the domain

Soft skills
Reflective Practice Connects Study and Work

Semester 1  Semester 2  Semester 3  Semester 4  Semester 5  Semester 6

School (Theory)

Work (Practice)

Master Project

Semester

RP 1

RP 2

RP 3

RP 4

RP 5

RP 6

RP 7

RP 8

RP 9

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IMNSTEPtimelineWithRP
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.
formal boards

strategic decision makers

Industrial Advisory Board

tactical subject matter experts

Reference group

operational HRM

HR forum

events

KSEE
June

SESG
November, February

Xmas party

Research & Education

in-company courses

research

and a large amount of informal contacts
## Challenge: Recruiting Industrial and Academic Staff

### Full-time Academic Staff
- >10 years industry pp
- PhD

### Part-time Academic Staff
- Highly experienced
- Recognized
- Broad coverage

### Industrial & Academic Staff
- Academic
- Industrial
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