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Challenging Architects in Education:
the Smart Environments Integration Project

Maarten Bonnema

– Associate Professor Multidisciplinary Systems Design, UT, NL

– Associate Professor SE in Electric Mobility, NISE, USN, Norway

UNIVERSITY OF TWENTE.

CHALLENGING ARCHITECTS IN EDUCATION: THE SMART ENVIRONMENTS INTEGRATION PROJECT

G.MAARTEN BONNEMA

ASSOCIATE PROFESSOR MULTIDISCIPLINARY SYSTEMS DESIGN (UT)

ASSOCIATE PROFESSOR SE IN ELECTRIC MOBILITY (NISE)

THE BIG PICTURE

Systems enabled individuals

- Able to handle:
  - Complexity
  - Uncertainty
  - Diversity of team members
- Learning oriented
- Big picture oriented

More complex development processes

- Increased interactions
- Multiple disciplines
- Large teams
- Globally dispersed
- Increased pace

Smarter systems

- Increased complexity
- Increased # of disciplines
- Shorter time-to-market
- …

ANSWERS TO THE QUESTION: WHERE DO THE "SYSTEMS ENABLED INDIVIDUALS" COME FROM?

a) They will emerge on the job
b) It will take 10+ years on the job
c) It will take 5+ years on the job
d) They come from programs offered by <fill in your favorite institution>
e) I don't care, as long as they have a xSEP certification
f) …

CONSIDER THIS

- The needed number of SE individuals increases
- The SE individuals need to be productive faster

- Ever more organizations work in an SE manner

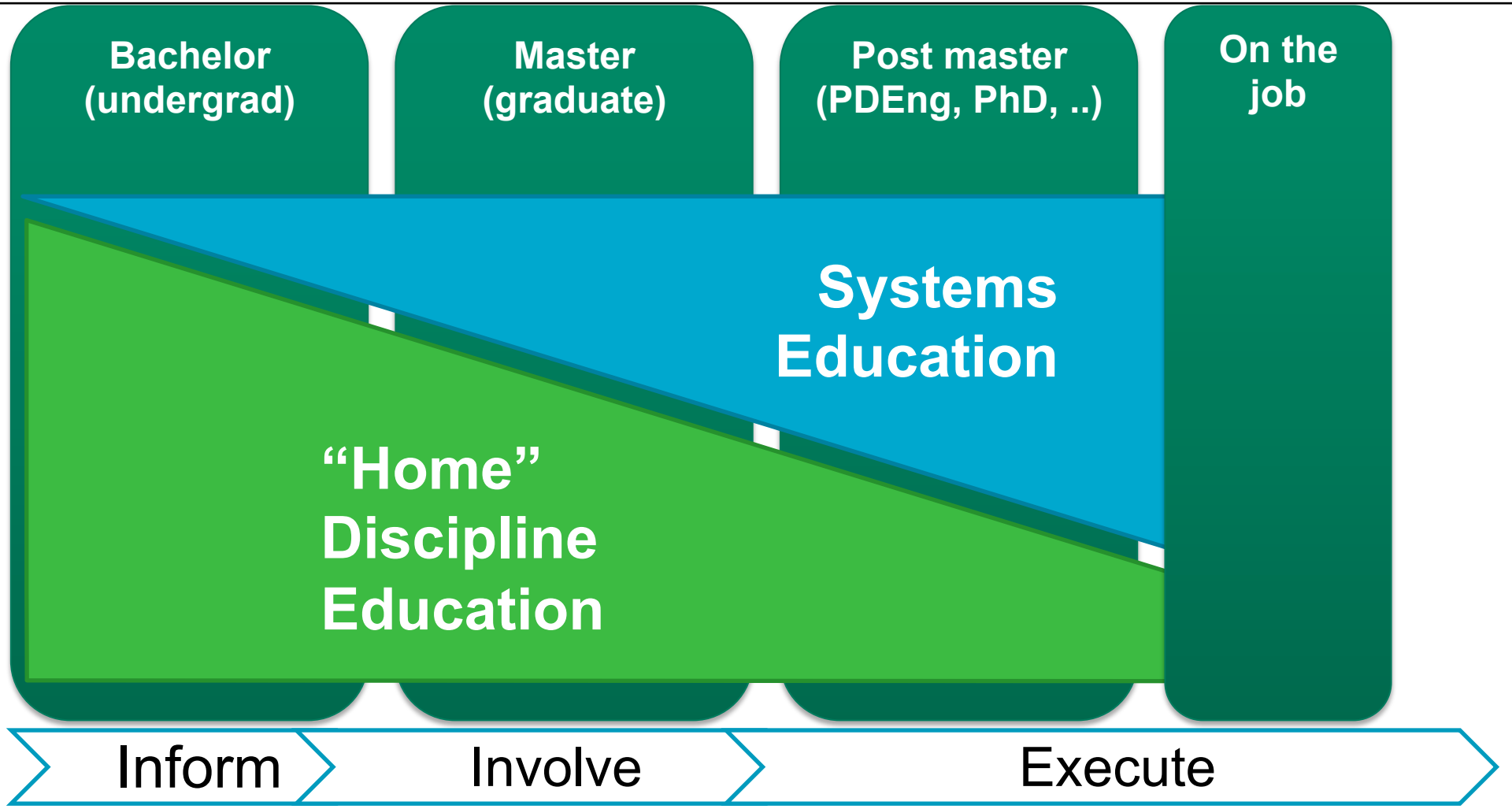
➔ We need more systems enabled individuals

THIS IS A CHALLENGE

- Systems enabled individuals:
  - Are aware of the systems job
  - Know the basics of SE
  - Might develop into systems engineers/architects
  - Might develop into individuals that can work well in complex development projects

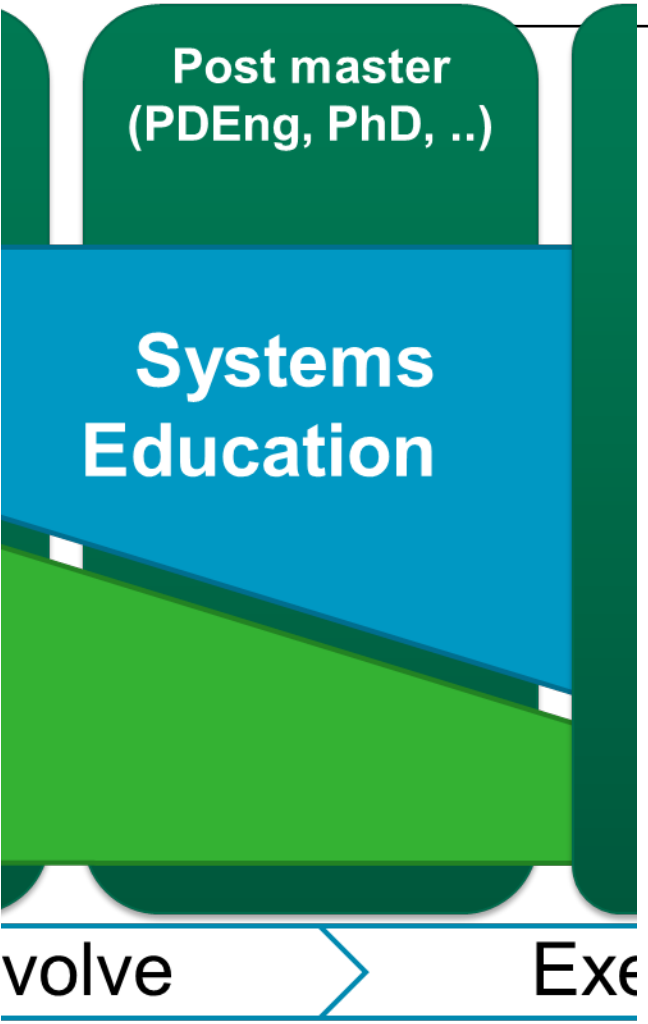
The challenge is thus to get more system enabled individuals to the work place

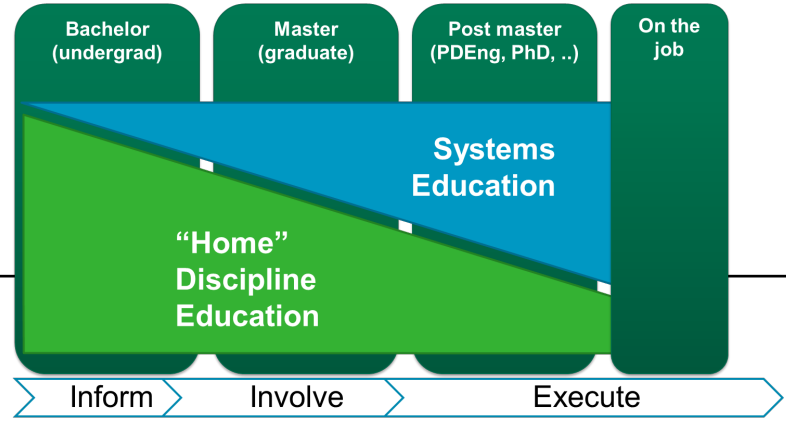
IN TWENTE, WE ACCEPTED THE CHALLENGE



Bonnema, G. M. (2010). Multi-level Systems Engineering Education. European Systems Engineering Conference (EuSEC 2010). Stockholm, Sweden: **pp.**2.3--2.5.

POST MASTER



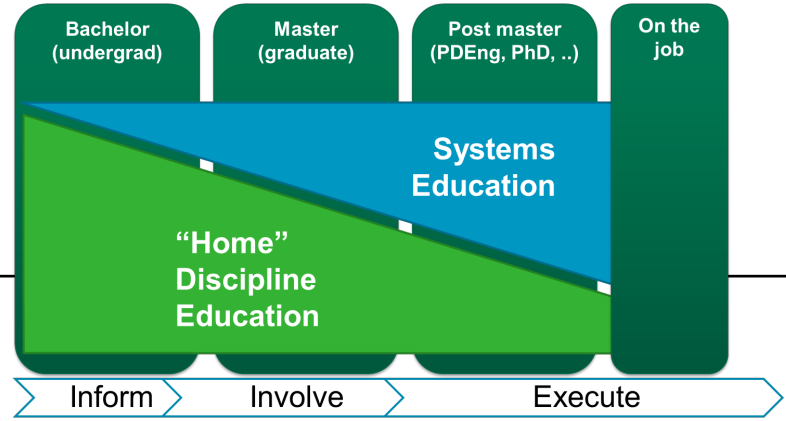


- PhD,
- Professional Doctorate in Engineering (PDEng)

Education:

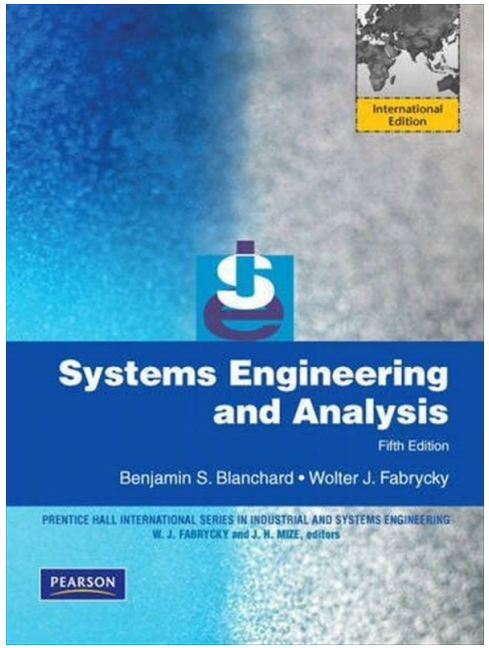
- SE for PDEng:
  - Value Management
  - MBSE
  - Systems Architecting
  - Systems Thinking, etc.
- International Spring School on Systems Engineering
  www.is3e.eu

MASTER



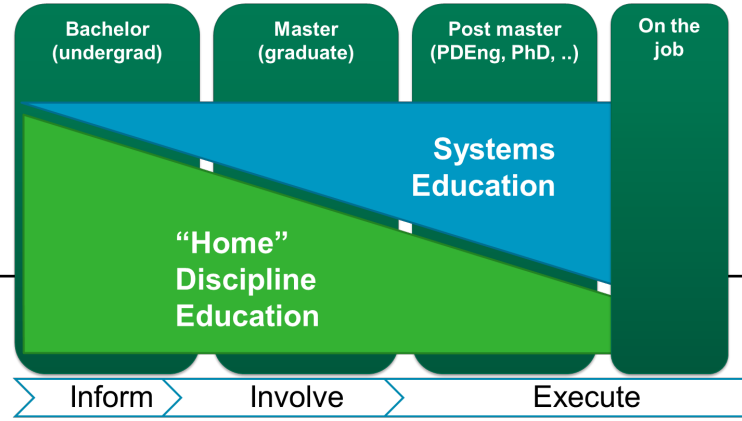
Education:

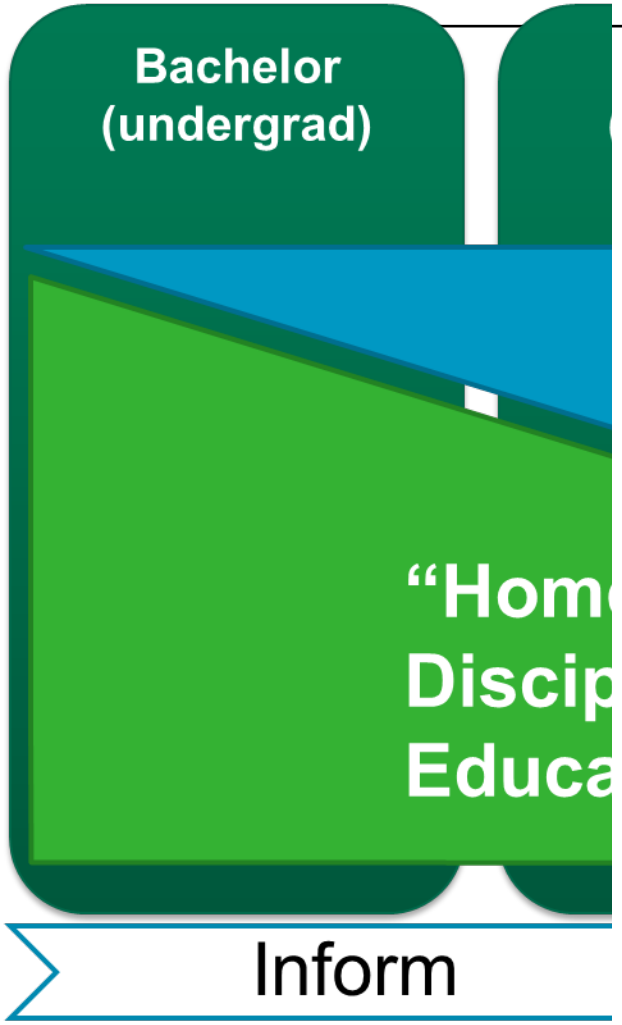
- Systems Engineering based on Blanchard&Fabrycky
- Integration Project (follows, subject of paper)
- Capita selecta courses
- Multiple disciplines are explored



BACHELOR

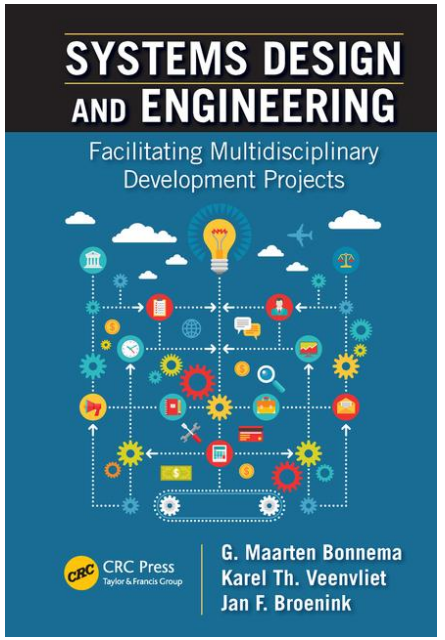
FOCUSED ON INDUSTRIAL DESIGN ENGINEERING





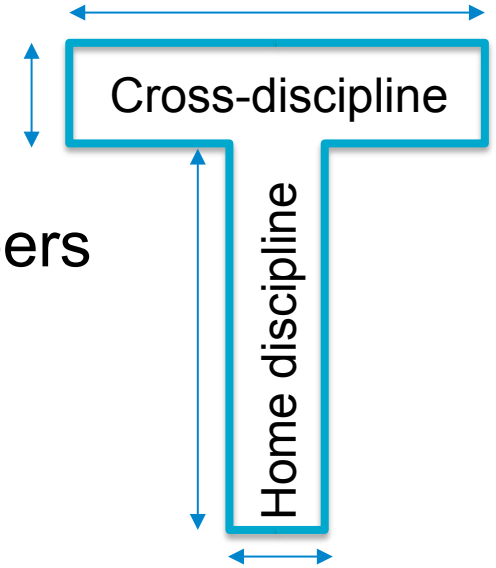
Education:

- Introduction to Industrial Design (1st year, 1st course), bases on SE principles:
  - Separation of the what from the how
  - Functions, Stakeholders, Context
  - Requirements and needs
- SE-focused project (3rd year)
  - Systems in Context (IDE)
  - Production Systems Engineering (ME)
  - Electronic Systems Engineering (EE)
- Systems Engineering using SDE-book by Bonnema, Veenvliet & Broenink



A FEW MORE WORDS ABOUT BACHELOR SE EDUCATION

- UT bachelor: educate T-shaped professionals
- In the bachelor we not so much educate systems engineers
- We much more raise interest in the systems field
- By doing that, we create influx to SE-directed (master) programs



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MASTER PROGRAMS

Industrial Design Engineering (IDE) master tracks:

- Human Technology Relations
- Management of Product Development
- Emerging Technology Design, with themes:
  - Biomedical Product Design;
  - Smart Environments and Virtual Reality;
  - Sustainable Technology for Product Development;
  - Product and Surfaces;
  - Advanced Materials Engineering; and
  - Structural Dynamics, Acoustics and Control

- Dive into a technology
- How can this be used in the consumer market
- Communicate across disciplines
- Root in one or two disciplines/technologies

SMART ENVIRONMENTS AND VIRTUAL REALITY

- Track that allows for SE education
- Create outward looking attitude
- How can a new technology be applied in user-friendly products/systems?
- “Intelligent”* systems
- Application of virtual and augmented reality
- Tailor made program, fixed core, one/ two technologies

Examples of capstone projects:

- Energy island
- Litter collecting robot

* Verbeek, P.-P. (2009). "Ambient Intelligence and Persuasive Technology: The Blurring Boundaries Between Human and Technology." Nanoethics **3(3): 231-242.**

INTEGRATION PROJECT?

- In the ETD-SE&VR master, we let students practice *systems architecting*
- Individual project
- Tailored assignment
- Create a system architecture

INTRODUCTION

The master track on smart environments and virtual reality has an essential component of joining different engineering disciplines into products that are useable and useful for customers. In this project two or three subjects are integrated into one system design.

CONTENT

A system architecture and design has to be developed. Depending on the courses followed in the first part of the master program, an assignment to define a system architecture is formulated by the coordinator. Techniques as taught in Systems Engineering and project competences from the Bachelor's curriculum in combination with tools and methods from research have to be used to arrive at a coherent and useable system design.

Aspects that have to be treated:

- Systems architecture
- Modules
- Interfaces
- User interfaces
- Context of use

Figure 1: The short course description.

LEARNING GOALS

- Perform system architecting on typical consumer systems.
- Translate theoretical findings (as learned in courses) into a user-directed product.
- Formulate and present a coherent and balanced system design.
- Recognize opportunities of a new technology for use by consumers.
- Balance stakeholders' interests into a balanced system architecture.

SET-UP

Start:

Written assignment (~2pages)

Reference to architecting literature

In progress:

Multiple student-teacher meetings

Discuss progress, issues, intermediate results

Discuss architecting at meta-level:
- What have you observed here?
- Move between problem and solution domains

End:

Written report

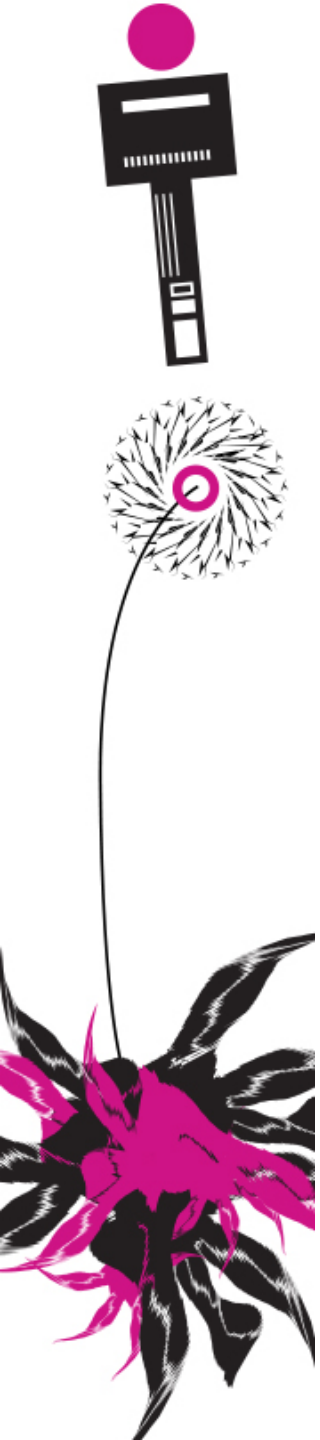
Architecture description (e.g. A3 Architecture Overview)

Preferably a demo/proof of principle

Teacher formulates detailed feedback and determines grade

Example projects

Smart Grid at Home	Develop a system that a home owner can buy and use to (1) save energy and (2) minimize energy expenses.
Drones in Traffic	Help avoid and solve traffic jams by employing drones. These could for instance create an ad-hoc vehicle-to-infrastructure system.
Office on the Go	Develop an in-car system such that in an autonomously driving car, the driver can do useful office work, and at the same time keep a watch on the car driving.
Drones for Agriculture	How can drones be used in agriculture in sparsely populated areas?
E-bikes support system	Develop a system that on the one hand helps E-bike users to plan their route using available charging points. On the other hand, it should stimulate people in the countryside to set-up a charging point.



DOES IT WORK?

- Conducted a short survey
- Audience: students in different phases:
  - Just started with the project
  - Project just finished, but still in the program
  - Project finished, program completed
- 17 invitations sent successfully, 11 completed surveys
- Small number, yet significant compared to total of ~25 completed projects

SURVEY

- Online platform
- Eight questions:

subject	# of questions
Student/respondent	2
Learning elements	2
Assignment	1
Usefulness of project	2
Remarks/feedback	1

ABOUT THE RESPONDENTS

- 10 from ETD, SE&VR theme
- 1 from other theme

- 6 completed IDE program
- 1 completed project, still in IDE program
- 4 in progress with project

LEARNING ELEMENTS

What are the most important learnings for you (multiple answers possible)?	
doing a project from an open problem statement	8
creating a system architecture	8
dealing with uncertainty	7
applying Systems Engineering tools and techniques	7
managing my time	5
defining the goal (myself)	4
presenting a system architecture	4
inventory the context	4
making tradeoffs	4
integrating different disciplines into one system design	4
selecting Systems Engineering tools and techniques	4
discussing about the architecture	3
inventory the stakeholders	3
taking multiple stakeholders into account	3
writing the report; structuring information	2
recognize opportunities in new technologies	2
other: please specify	0

SE core competences

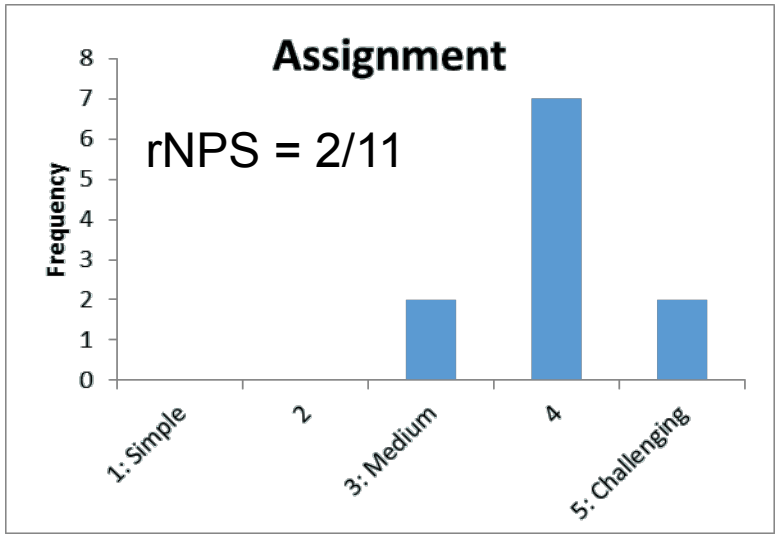
SE core competences

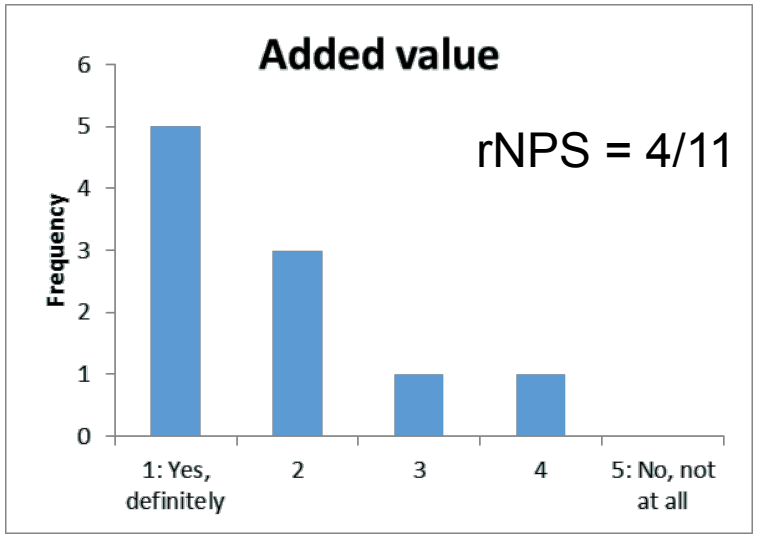
STUDENT-TEACHER MEETINGS

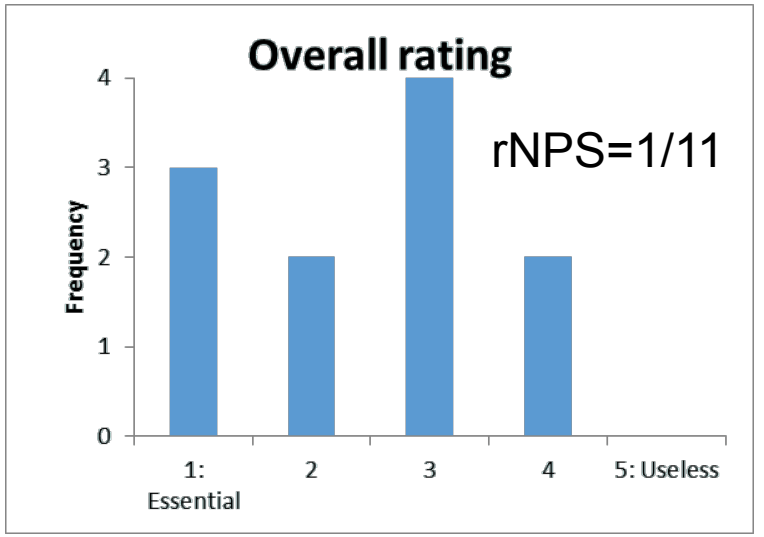
The meetings with the teacher (multiple answers possible):	
helped me to move on	6
helped me to clarify the problem	6
helped me to see the big picture	4
helped me with information on how to architect	4
helped me to think on a more meta-level about architecting	2
helped me to define the solution	0
were not very useful	0

Relevant

MORE RESULTS





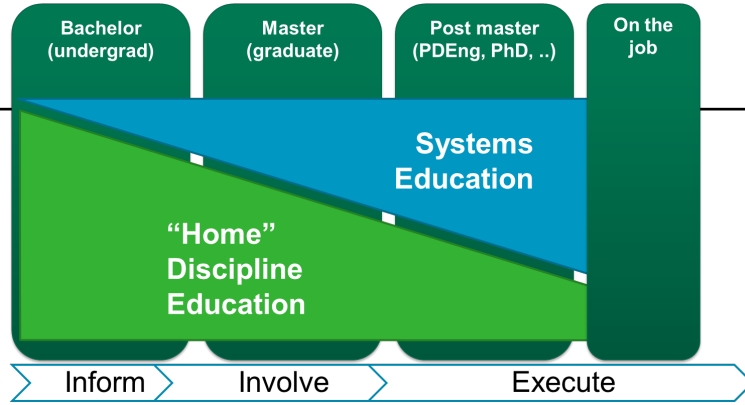


Net Promotor Score (NPS) = Number of Promotors – Number of Distractors
Relative NPS (rNPS) = NPS/#respondents

OTHER FEEDBACK GIVEN

- Takes a lot of time
- Requests for specific information to be given early in the project
- Challenging assignment

OVERALL CONCLUSIONS



- There is a need for systems enabled individuals
- We should start early with developing those

- The project works for practicing systems architecting
- Most students are challenged
- For a limited number of students, it does not work (out) well

To be improved:

- Structure in the student-teacher meetings (checklist)
- Investigate how learning goal on recognizing opportunities of new technologies can be reached

FURTHER RESEARCH/WORK

- Investigate whether these students actually are better prepared as system enabled individual
- Scale up

QUESTIONS?


CLAUDE
PRESBYTERIAN CHURCH
THERE ARE SOME
QUESTIONS THAT
CAN'T BE
ANSWERED BY
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