Teaching Systems Engineering to Undergraduates; Experiences and Considerations

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Abstract

Undergraduates need a teaching style that fits their (lack of) experience. Especially in systems engineering this is an issue, since systems engineering connects to so many different stakeholders with so many different concerns. Students need to get aware of the inherent ambiguities, uncertainties and unknowns in the systems world, in contrast to the focused world of mono-disciplinary engineering.

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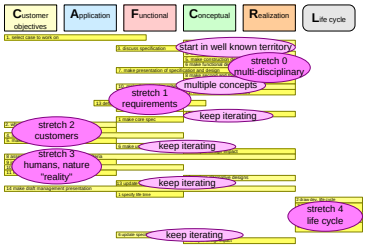


Mono-disciplinary Engineering Education

Well-defined problems	strength of bridge
Well-defined methods, techniques, formalisms	Bode plots in control
Questions have the right answer	bridge will sustain upto x ton control is converging and stable
Dominant teaching style: knowledge transfer and skill training	
Subject of interest is technical	no unpredictable humans no inconceivable nature

Goals of Teaching SE at Undergraduate Level

to make students aware of

+ the impact of working in a large organization, e.g.

  processes, organizations, roles, responsibilities, economy and financials

+ the communication challenges between:

  various technical disciplines

  various less technical stakeholders

+ the ill-defined and multi-dimensional nature of system problems

  uncertainties, unknowns, ambiguities, dynamics, conflicting needs and goals

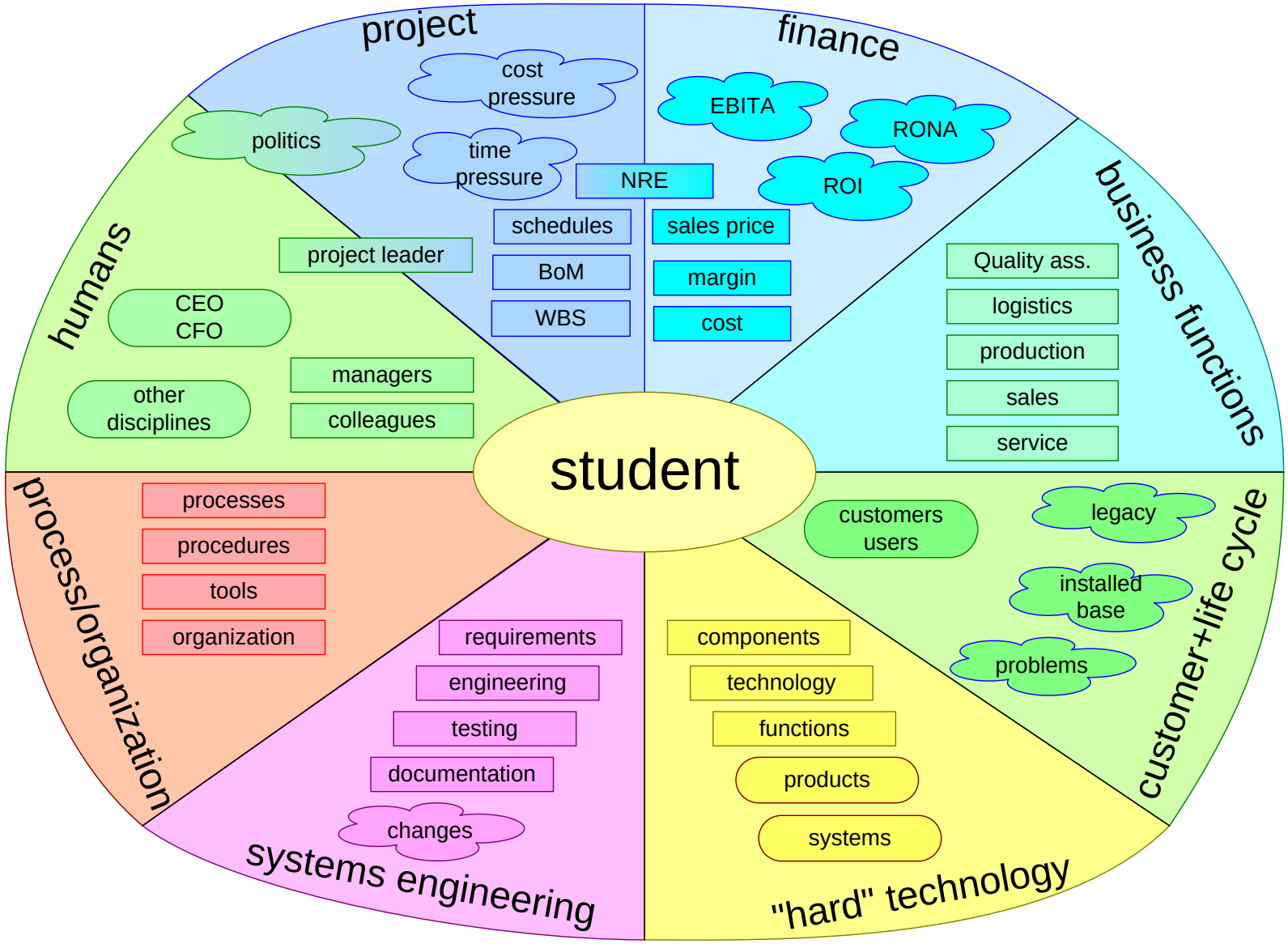
+ the impact of external conditions on the system and its design

  human behavior, natural phenomena

+ system life cycle

to provide insight in available methods, techniques, and concepts

The Context that a Student will Enter



The Challenge of Teaching Systems Engineering

Systems Engineering processes, methods, and techniques have a high "common sense" level.

Without experience they can easily be perceived as open doors.

How to get inexperienced students in a perceptive mode, such that they appreciate the subject matter?

Role Play as Teaching Paradigm

management team

process

organization

people

business, finance

design team

customer understanding

requirement specification

concept selection

partitioning, interfaces, functionality

qualities, e.g. performance, cost, reliability

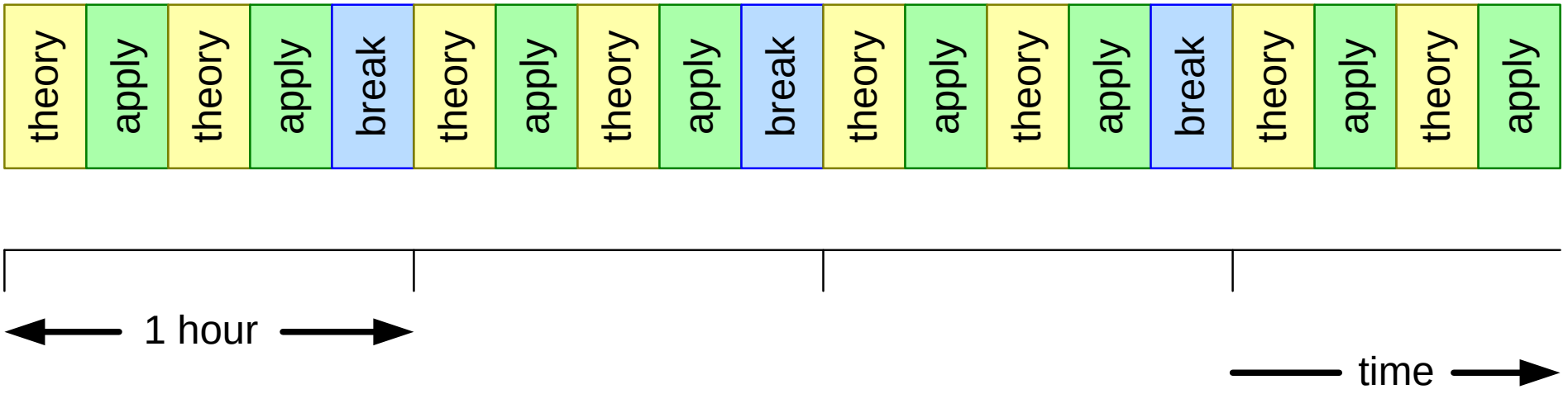
technology choices

teams of 3 to 5 students per team

guided process:
some theory
apply in role play
brief reporting and discussion

case that relates to their knowledge

Didactic Model



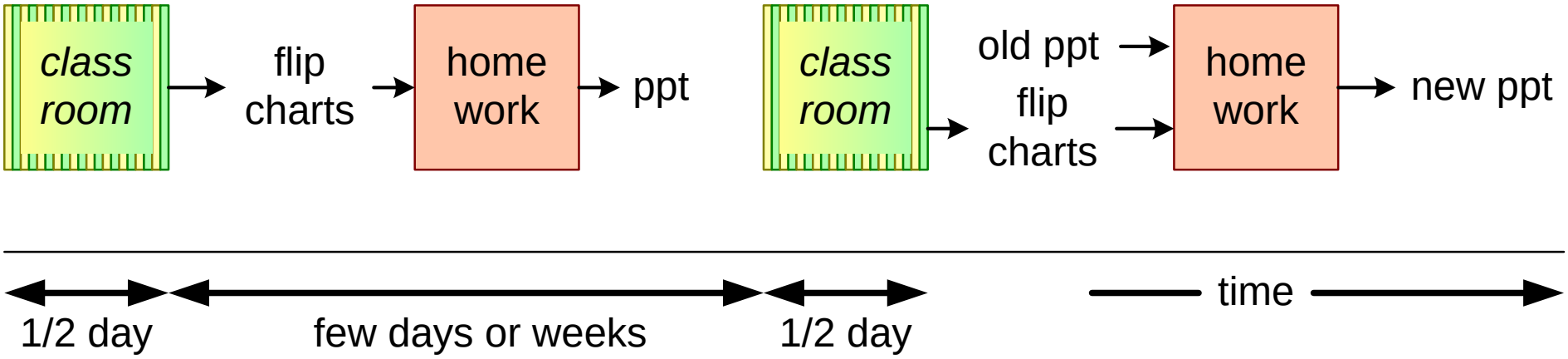
time-box

A time-box is a fixed amount of time allocated to perform one activity.

iteration

We iterate many times over different viewpoints. Every viewpoint is addressed multiple times with new insights from other viewpoints

Didactic Model; Homework



this didactic model is very intense
students are exhausted after 1/2 day

class room

Small steps on flip charts

(or paper)

homework

consolidate results in

PowerPoint or Visio

Case Requirements and Example

case requirements

multi-disciplinary aspects

original discipline of students should be clearly present

students must have some affinity with the application

open definition: unclear problem, large solution space

Example: Tree Cutting Robot for mechanical engineering students

background:

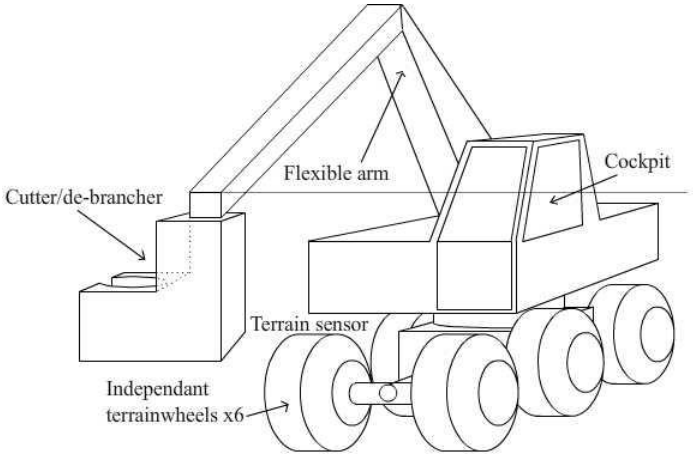
mechanics is dominant
vision and control require
electronics and software

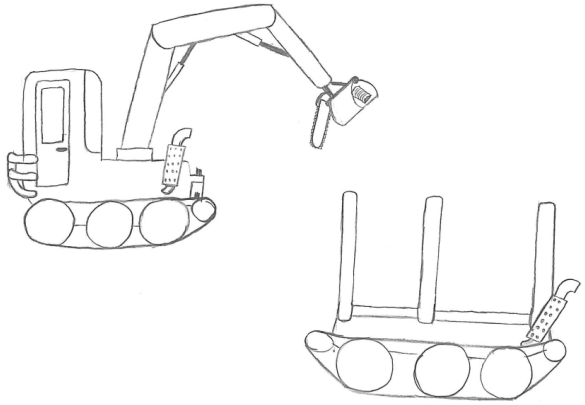
Less young people are willing to work in the wild and mountainous areas in Norway, Canada, or USA to cut trees for wood production.

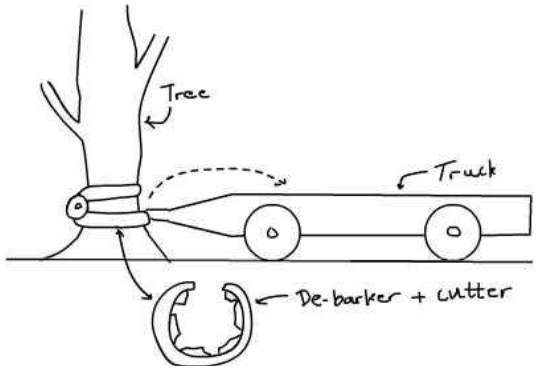
product:

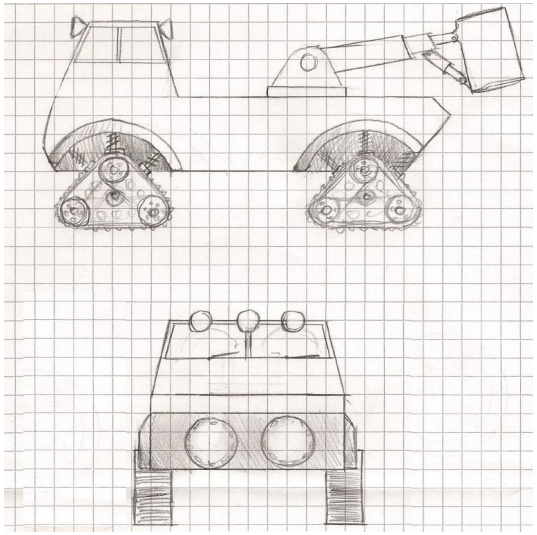
Robot that supports the cutting and processing of trees so that less people are needed.

Example Designs of Tree Cutting Robot

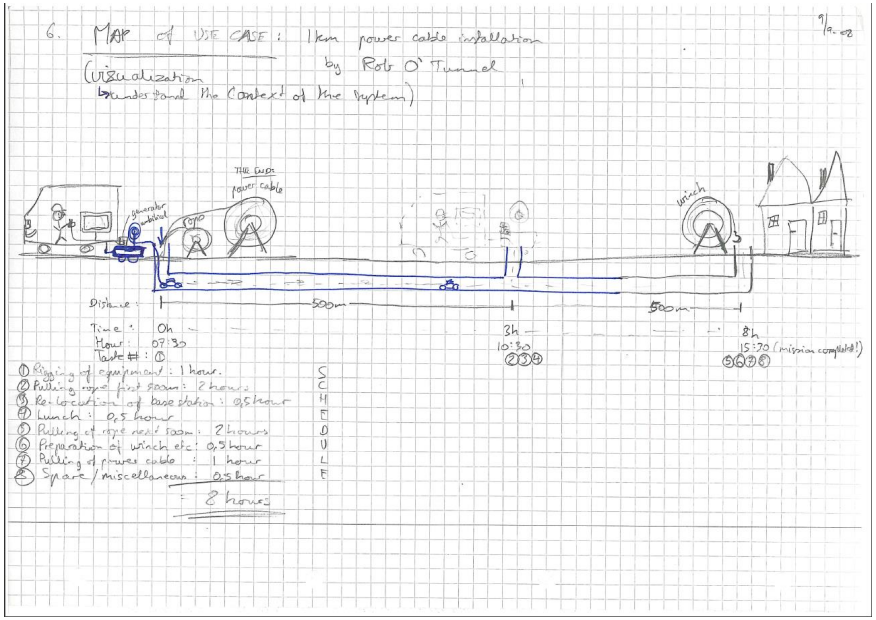


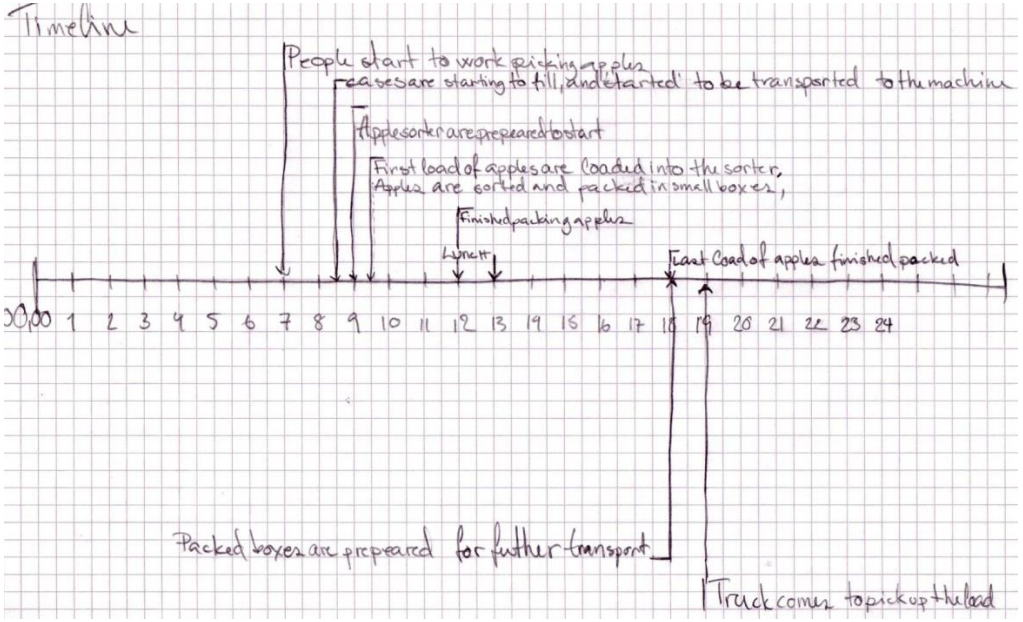


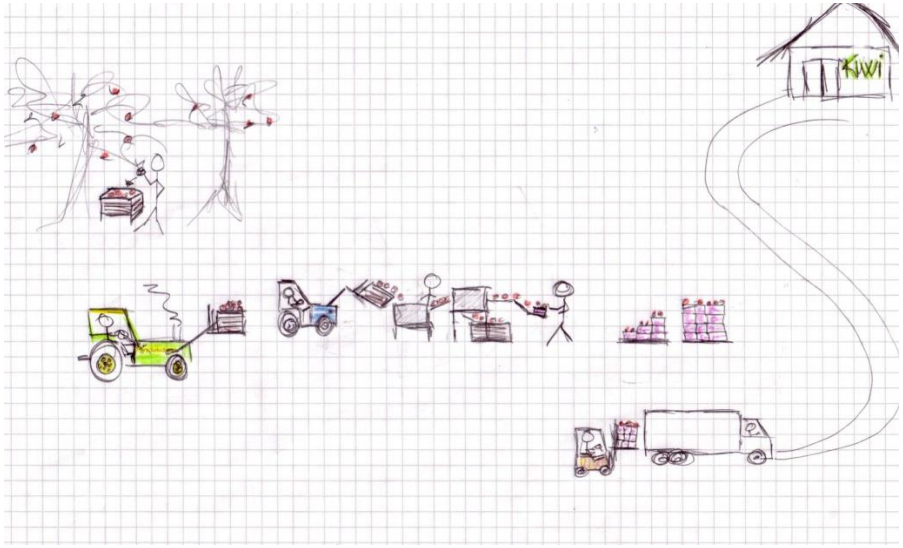


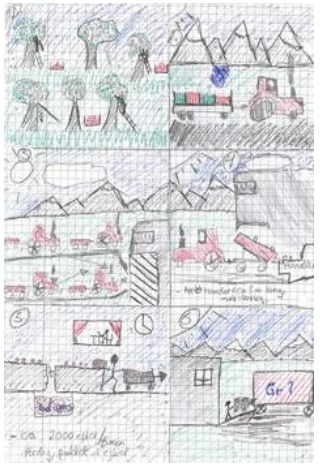


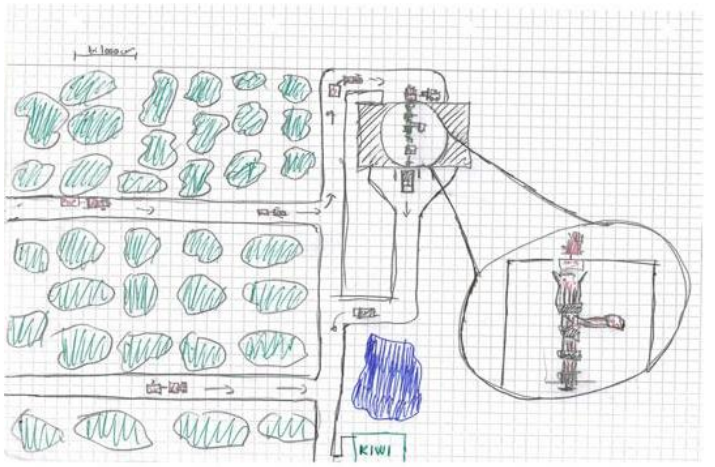
Example Stories of Apple Plucking Robot





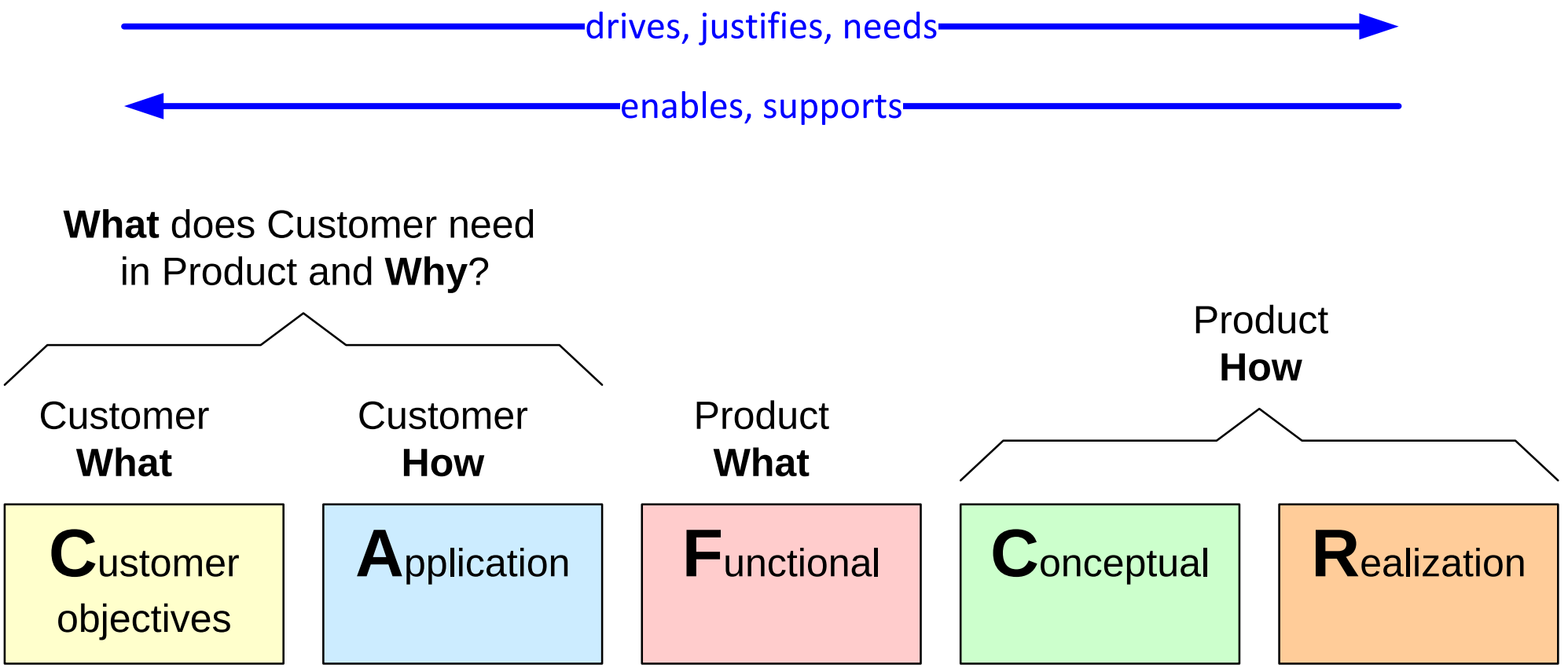




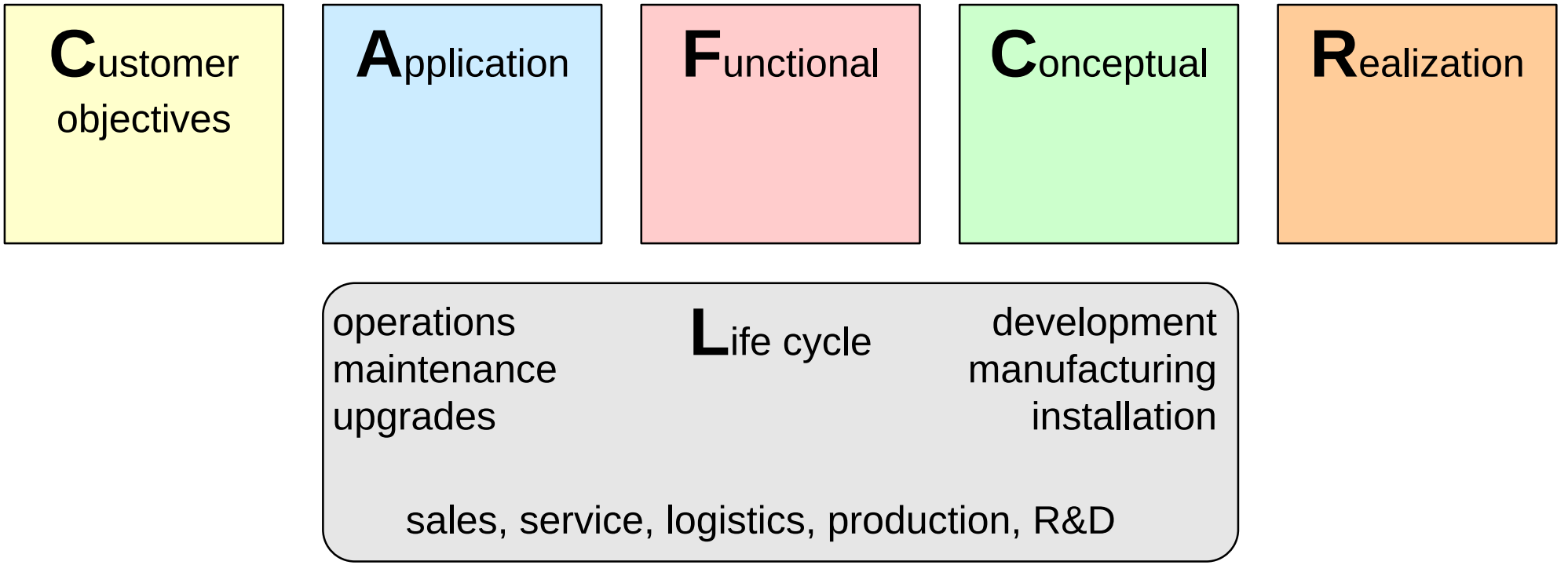


Class Room Fills itselfs with Flip Charts

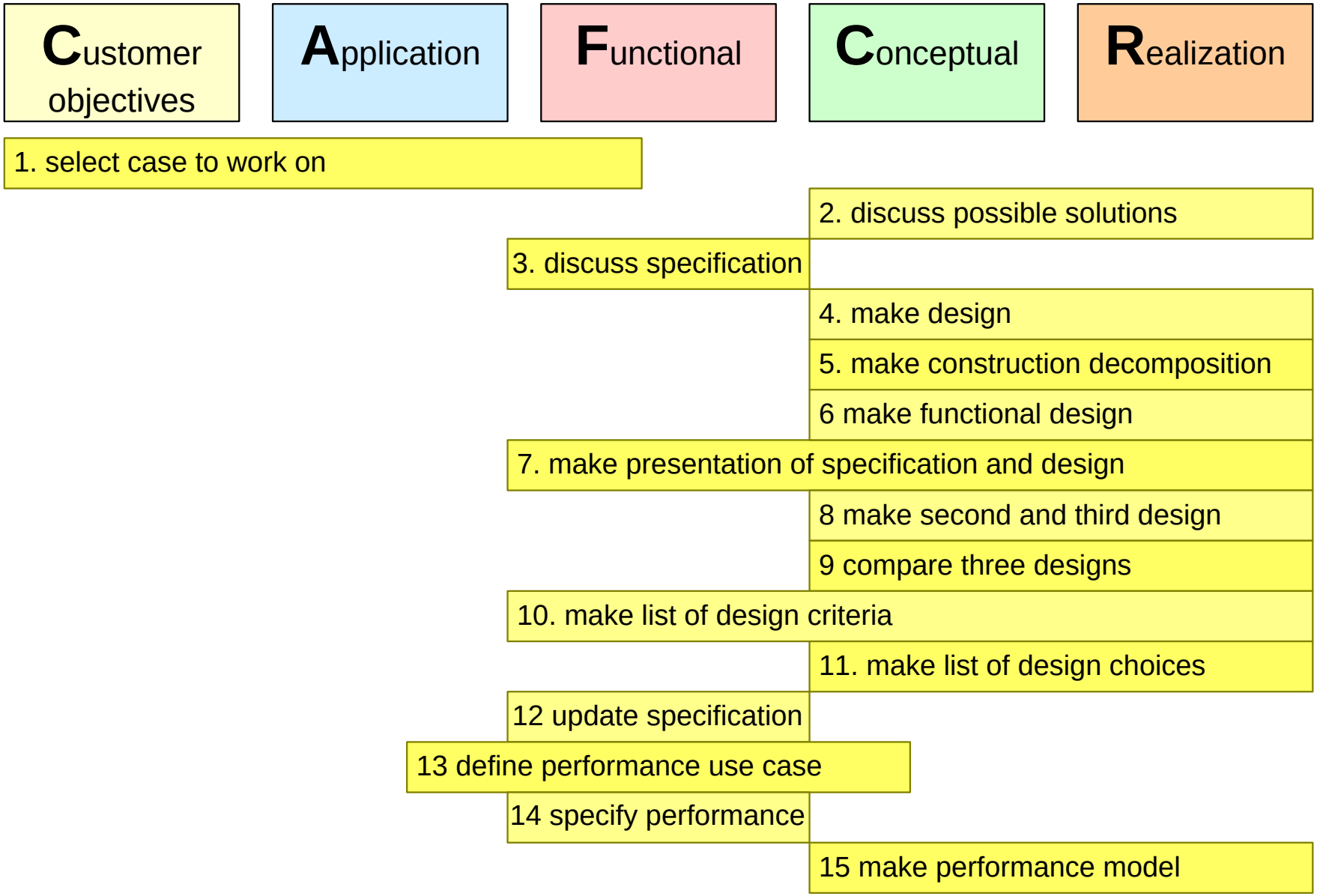
Material for Design is Based on CAFCR+



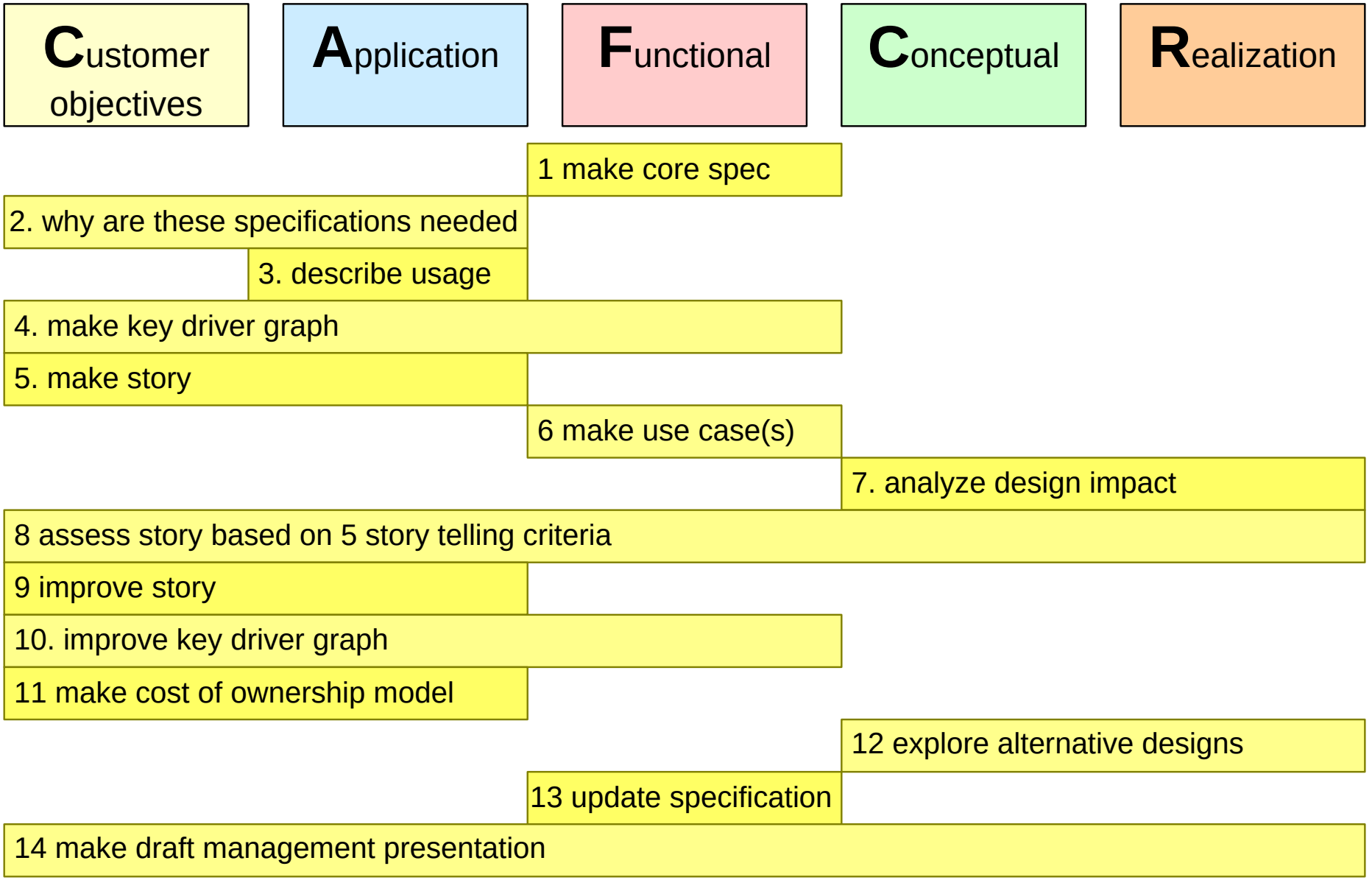
CAFCR+ Model


Customer objectives
Application
Functional
Conceptual
Realization
operations
maintenance
upgrades
Life cycle
development
manufacturing
installation
sales, service, logistics, production, R&D

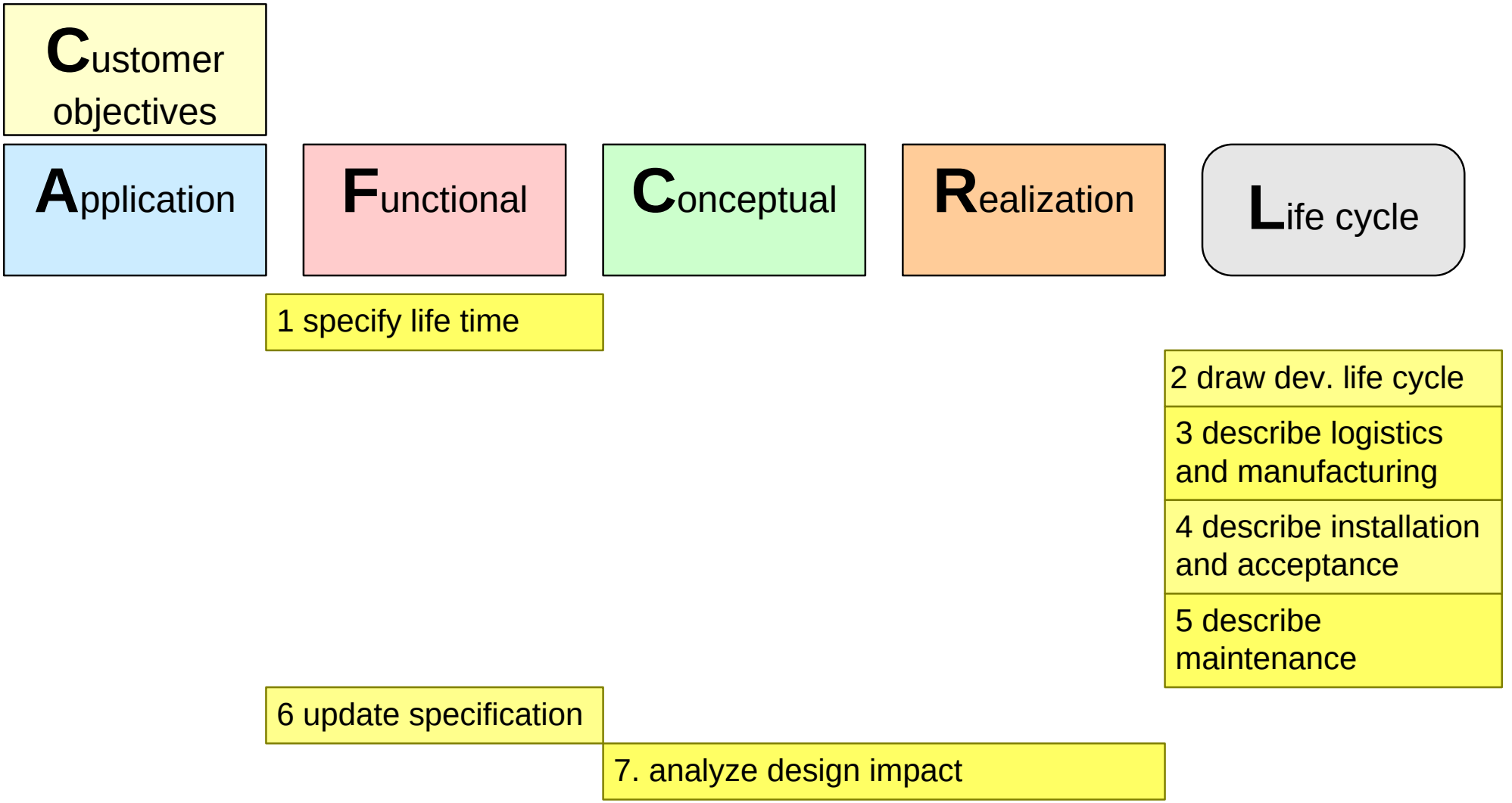
Steps for First 2 Sessions



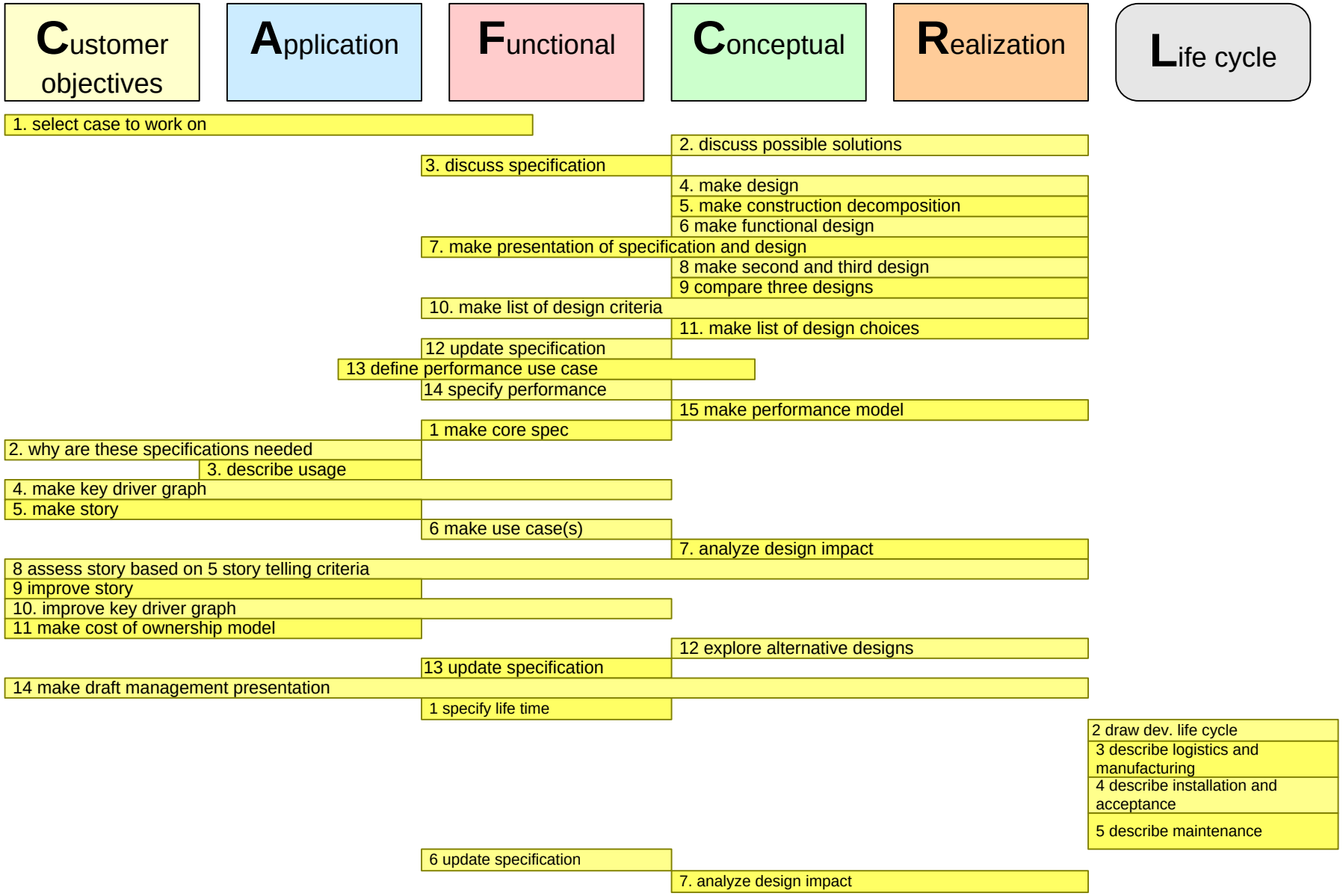
Steps for Second 2 Sessions



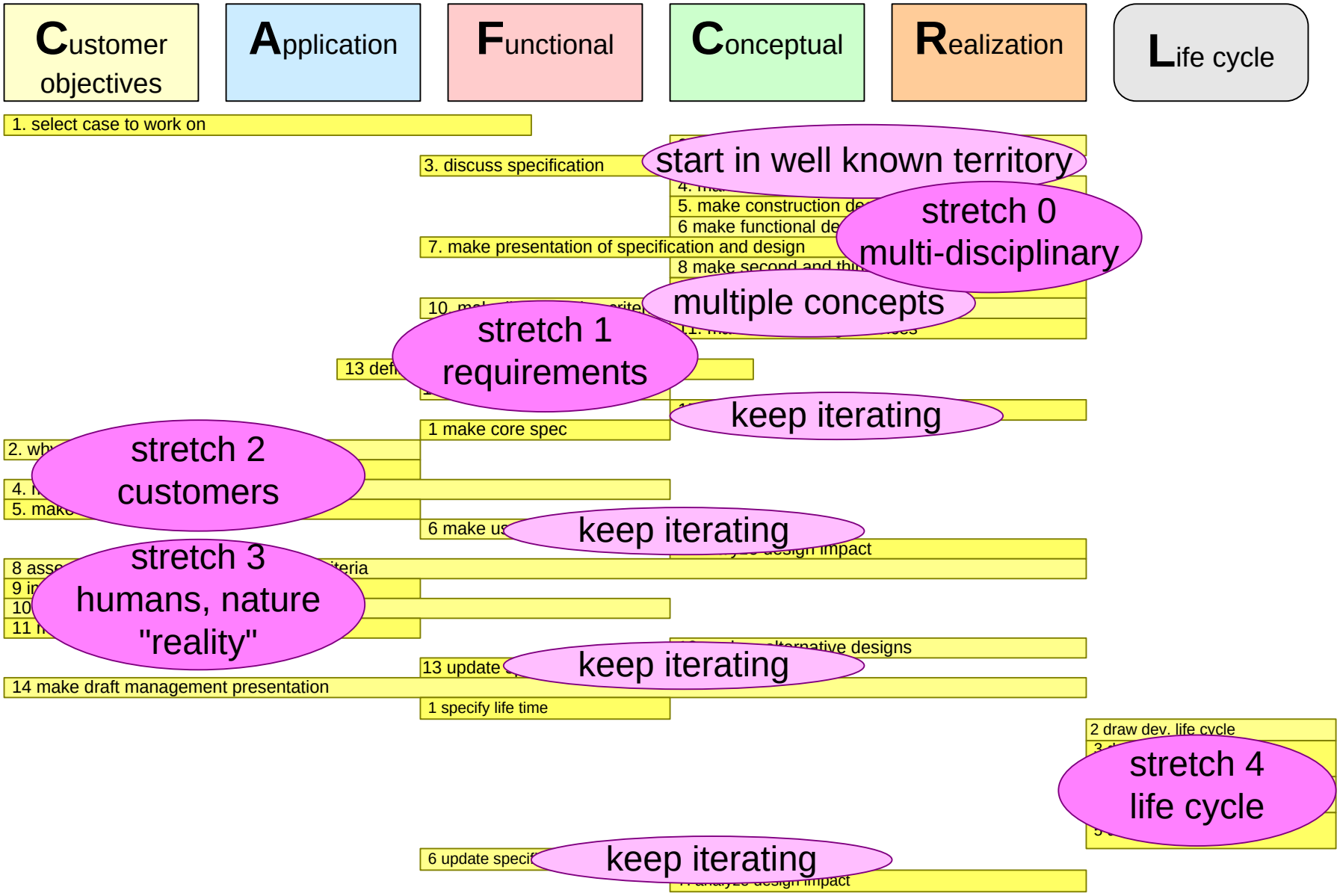
Last Session



Summary of all Steps



Stretching from Comfort Zone into Unknowns



Role of the Teacher

Guides the students through a journey.

Stretches students one step at a time.

Regularly forces students out of their comfort zone.

Provides feedback on their intermediate deliverables.

Helps students to reflect on their experience.

Provides theory JIT (Just In Time: appreciation and application).

Illustrates theory with examples from practice.

Keeps the pace high.

Initiates frequent breaks (this approach costs lots of mental energy).

Unfreeze students: let them sketch, stimulate creativity and imagination

Experiences of Teaching in this Way

The sessions can be a lot of fun for students and teacher.

Some interesting concepts pop-up.

The increase of awareness can be observed.

Some nice visualizations or animations are shown.

Time-boxes can vary from 5 to 20 minutes.

Sometimes a few steps have to be skipped.

Too funny concepts or stories distract.

Teams that get stuck in unrealistic proposal.

Students that miss sessions; participation is mandatory.

Teams that stick to the initial solution

Links

Course slides:

http://www.gaudisite.nl/BachelorSDallSlides.pdf

Background CAFCR model:

http://www.gaudisite.nl/ArchitecturalReasoningBook.pdf

Short introduction course in Systems engineering:

http://www.gaudisite.nl/ShortIntroCourseSESlides.pdf