

Systems Engineering Course Research Methods; Assignments

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Abstract

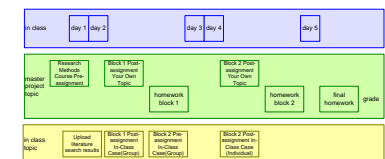
This course teaches research methods for systems engineering and related disciplines, such as industrial economy, engineering management, innovation, and technology management. This field of research needs research methods combining the traditional scientific methods ("hard") and methods from social sciences ("soft").

The course prepares students for their master thesis.

Distribution

This article or presentation is written as part of the Gaudí project. The Gaudí project philosophy is to improve by obtaining frequent feedback. Frequent feedback is pursued by an open creation process. This document is published as intermediate or nearly mature version to get feedback. Further distribution is allowed as long as the document remains complete and unchanged.

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This course is a joint development of

Kristin Falk

Satya Kokkula

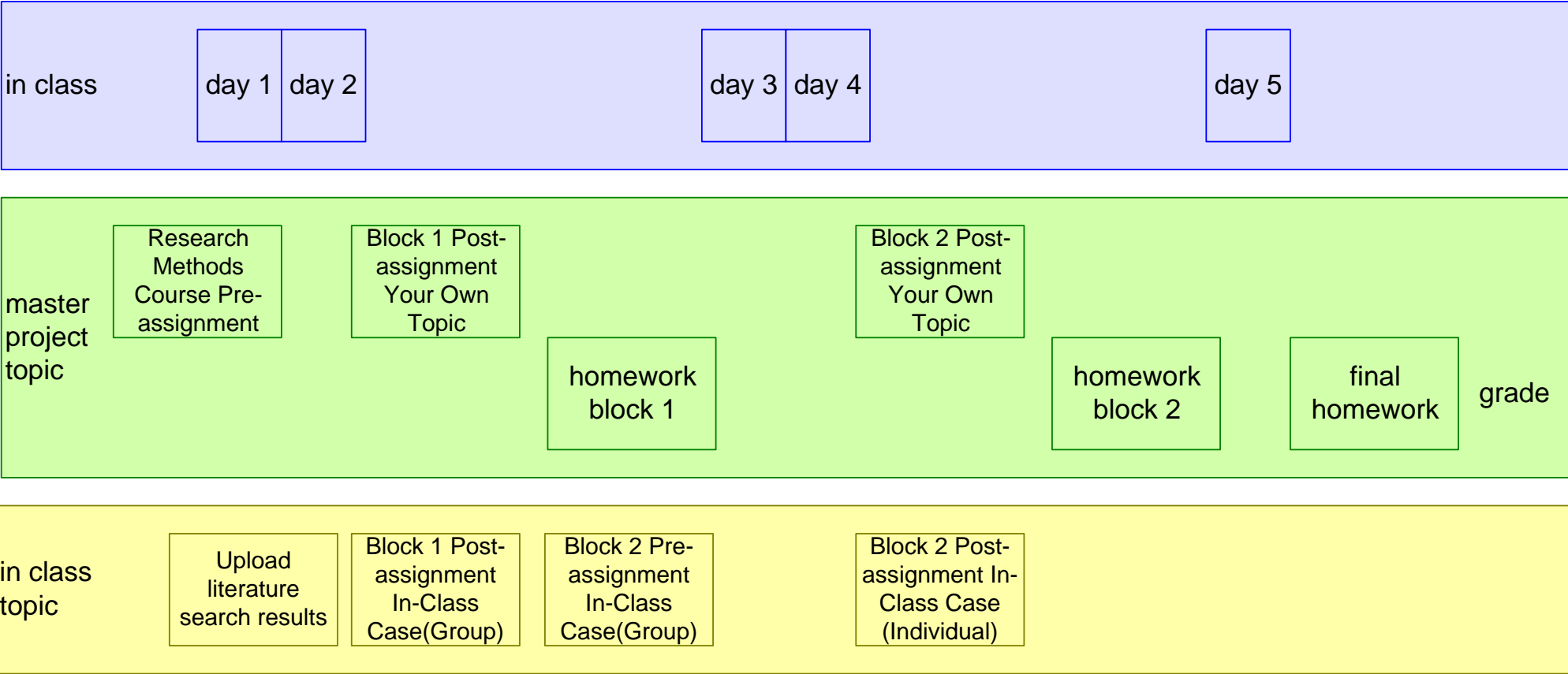
Elisabet Syverud

and Gerrit Muller

Research Methods Course Pre-assignment

- Determine a topic for the master project
- Position the topic in its context (e.g. in your company, in ongoing projects)
- Discuss the topic with its stakeholders
- Try to formulate the line of reasoning:
 - problem, goal, envisioned solution, rationale, open research questions

Flow of Assignments



What Specific Problem Triggers this Research?

- Describe what problem triggers your research
- Be as specific as possible, for instance asking:
 - Why, what, how, who, when, where
- If you find it difficult to describe the problem, then start with listing symptoms and challenges, or identifying dilemmas

- Who are the stakeholders related to this problem
- What can you ask them to explore the problem
- What can you tell them to introduce your research
- Transform the answers into a script for interviews of stakeholders

Apply the Same Steps on Your Own Topic

- What specific problem triggers your master project topic?
 - What are the symptoms, challenges, or dilemmas?
- Who are the stakeholders related to this problem
 - How can you introduce the problem to them to explore it?

Formulate an Initial Set of Research Questions

- Transform the **problem statement** into a **Line of Reasoning** including a main **research question**
- What sub-questions will help you to answer the main research question?

Good research questions are **open questions**, e.g. allowing an answer in terms of how well, how much, etc.

You typically need one main question and **3 to 5** sub-questions.

Make all questions as **specific** as possible. The main question may invite some generalization.

Feasibility of this Study

- Make an A3 with your current idea for the master topic
 - What is your current idea about the context, system of project of interest, and the Line of Reasoning
 - What scope of the research is fitting in the available time and effort
 - What do you need (e.g. information, contacts, access to people, tools, ...) to perform the study?
 - What risks do you see for the research?

- Attach your A3 on the wall
- Half of the students stay at their A3, the other half visit their colleagues
- As a host, discuss the content with visiting staff and colleagues to gather feedback and comments to clarify your own ideas (ca 30 minutes)
- repeat with the other half of the students (ca 30 minutes)

- Use the research questions to determine 5 to 10 key words or phrases
- Search for relevant literature
- Identify ~3 potentially interesting papers
- Make an initial assessment of these 3 papers

Keep notes on all papers you find

Refine Literature Search

- Refine the 5 to 10 key words or phrases
- Look for literature reviews
- Look for founding papers
- Use these to search for relevant papers
- Order on relevancy based on abstract

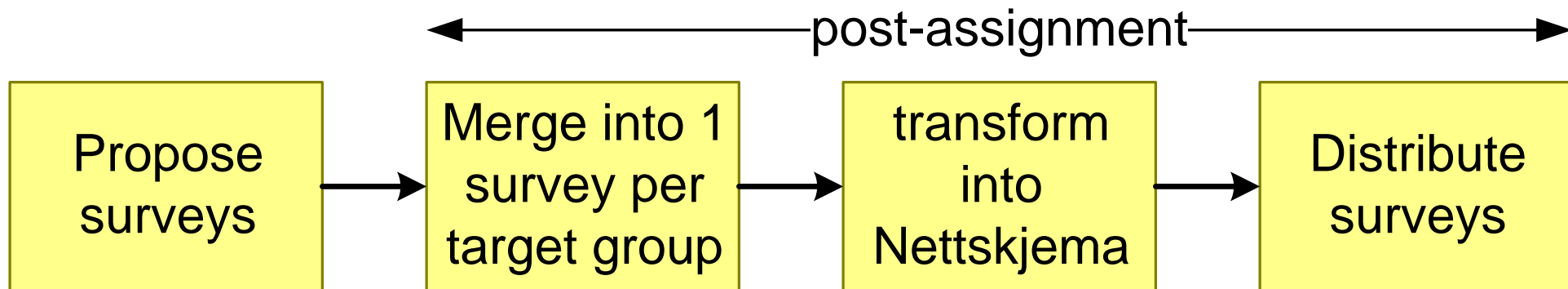
Keep notes on all papers you find

Upload Literature search results

- Submit your literature search results, including links.

Propose Survey Approach

- Define the target groups
- For each target group
 - Formulate survey questions
 - Propose format per question, e.g. free text, range, Likert scale



Make an Initial Research Design

- What will you do, when and where with who?
- What will you look for and look at?
- How can you analyse what you did and observed?
- How will this help you to answer the research questions?

Block 1 Post-assignment In-Class Case(Group)

- Finish the survey
- Distribute the survey to enough people to get a response of at least 10 respondents

Block 1 Post-assignment Your Own Topic

- Refine the topic for the master project
- Position the topic in its context (e.g. in your company, in ongoing projects)
- Discuss the topic with its stakeholders
- Reformulate the line of reasoning:
 - problem, goal, envisioned solution, rationale, open research questions

Block 2 Pre-assignment In-Class Case(Group)

- collect the survey results
- transform them into a well readable form

Homework Block 1

For the individual master project topic:

- initial interview and/or survey
- initial problem analysis
- literature review at least 10 articles
- search secondary data sources
- read Research Methods paper
https://www.gaudisite.nl/CSER2013_Muller_SEresearchMethods.pdf
- elaborate research design

effort

30%

60%

10%

use the paper template

Submit a 5 to 10 page report with the above content; **maintain a detailed logbook!**

Refresh your statistics, for instance <https://towardsdatascience.com/the-5-basic-statistics-concepts-data-scientists-need-to-know-2c96740377ae>

Analysis of the Survey Data

- Download the Excel spreadsheets with survey data
- Discuss what you can do with this data for analysis
- Discuss how you can use this data

Relate the Data and the Research Questions

- Take the research questions that you defined in the post-assignment.
- Does the survey give you any new insights in the research questions?
- Do you want to adapt the research questions?
- Do you want to run another survey? If so, what are the questions for the new survey?

Revisit Individual Master Project

- Revisit your research design
- What data do you need?
- How can you collect that data?
- What are the main challenges for your master project?

Assess your Current Project Definition

- How good is your scope [1 = very poorly defined.. 5 = very well defined]
- How good are your research questions [same 1 to 5]
- How confident are you that you can execute the project [1 to 5]
- What are the main hurdles?

- Analyze the data statistically
- Look for overall distribution and for correlations
- Capture results on a PowerPoint slide

Upload the PowerPoint file to Canvas

Re-iterate the Research Questions

- Classify your research questions according to the meta-levels and their scope
- Are the research questions specific enough?
- Do you have a logical build-up of the research questions?
- Do you have a way to find answers?

Discuss the validity of your results

- First, only from statistical perspective
- Second, including the survey process
- Capture results on a PowerPoint slide

Upload the PowerPoint file to Canvas

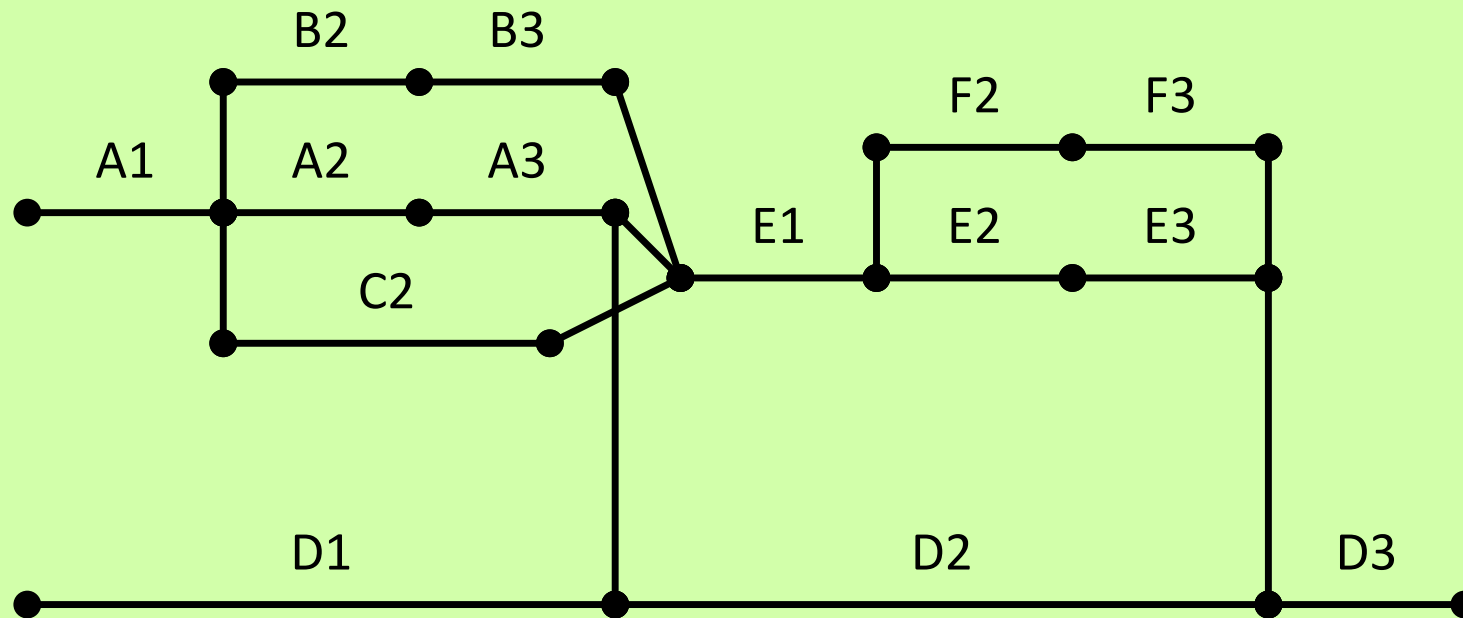
Context Assignment

Make the following steps for the as-is situation as far as time allows

- Sketch the workflow at micro level in 10..20 steps
- Sketch the workflow at meso level in 10..20 steps
- List stakeholders
- List the 3..5 concerns for each stakeholder
- Indicate what stakeholder performs what step of the workflow
- List the incoming and outgoing artifacts for each step of the workflow
- Make an information model of the artifacts
- Identify the main characteristics per step, e.g. effort, time, quality, ...
- Quantify these characteristics

Make a PERT plan for Master Project Execution

- Strive for >20 activities
- Show dependencies



- How many activities did you define so far?
- How concrete are the activities? [1 = highly generic, 5 is very specific (e.g. system, phase, stakeholder, properties, etc. defined)]

Make a Book Plan for your Course Paper

- Define the sections
- Define the subsections
- Define the content per (sub)section in keywords
- Define the size of subsections in #pages (e.g. $\frac{1}{4}$ page, 3 pages)

How many pages do you plan for:

- Line of reasoning
- Literature survey
- Research design
- Expected results

Block 2 Post-assignment In-Class Case (Individual)

- Write a brief reflection on the in-class assignment:
 - What are the main findings?
 - How did you get to these findings?
 - What did you learn from doing the in-class assignment?

max 2 A4s

Maximum two A4 pages in total

- Update the line of reasoning for your master project topic, including the research questions, according to your current understanding.
- Write down your research plan, include
 - Research design
 - Research method(s)
 - Explain how to collect what data
 - Explain how to analyze data

Homework Block 2

For the individual master project topic:

- | | effort |
|--|--------|
| <ul style="list-style-type: none">• improve and extend the articles (from HW1)• elaborate 2 .. 3 of them as critics | 50% |
| <ul style="list-style-type: none">• identify challenges and risks in problem definition | 15% |
| <ul style="list-style-type: none">• make research design more concrete | 30% |
| <ul style="list-style-type: none">• make book plan for the course paper | 5% |

Submit a 10 to 15 page report with the above content

use the template, maintain a detailed logbook!

Write an Abstract of your Course Paper

Write an abstract

in 3 paragraphs

use 2 sentences per paragraph

max 300 words in total, less is better

annotate the book plan of the Research Methods paper with keywords for

- content
- scope

Make a Diagram Visualizing the Research Design

Make a diagram to visualize the research design, e.g.

- the research actions
- the collected data
- the results from the analysis

for instance in the form of a flow diagram

Assess your Project Status

- How clear is your **problem**, **goal**, and **envisioned solution**? [1 = very poorly defined.. 5 = very well defined]
- How good are your **research questions** [same 1 to 5]
- How **confident** are you that you **can execute the project** [1 to 5]
- What are **your main concerns**?

use the template: [ITM4400](#) and [ITM5000-SE-Template-2025.docx](#)

write a course paper, as an academic paper of ca 15 pages, containing:

- title
- abstract (max 300 words, less is better)
- introduction (context, line of reasoning)
- literature survey (of at least 10 publications, 2..3 as critics)
- research design
- discussion (risks, expected results)
- conclusion

and add appendices (which do not count for the 15 pages):

- an execution (PERT) plan
- a book plan for the final paper of the master project