TDDD89 - Scientific Method

Lecture 1
Introduction

Christoph Kessler

2026

LINKÖPINGS UNIVERSITET

Part I: General Information

- Course format
- Activities
- Examination

Part II: Towards a great thesis

- What is a *good* thesis project?
- Overall thesis structure
- Thesis project types

Continued in first part of Lecture 2 (tomorrow afternoon)

Part I: General Information

Learning Goals

- Compare and evaluate **scientific and engineering methods** in the topic area selected by each student.
- Find, summarize and reference **related work** and **background literature**.
- Critically **evaluate** scientific works.
- Learn about **requirements, structure, format of a master thesis**
  - By reading *guidelines* and *best-practices papers*.
  - By reading a *sample master thesis*.
  - By writing an *extended thesis project plan* for a real or fictitious master thesis project.
- Formulate a **scientific text** using generally accepted standards
  - Write, and critically review, a ***project plan*** for an academic study, including method, tasks, time plan, risk analysis.
  - Practice **writing**, and critically **reviewing**, text for thesis sections on *Introduction* (research questions), *Background* and *Related work*.
  - Learn about proper use of **academic English**.
- Assess and manage **ethical issues** and **societal aspects** of science and engineering in their topic area.
- Insight into **different forms, fields and career paths** for **professional work in computer science and engineering** related areas, especially in **research and development** in an **international** context, in both industry, research organizations and academic institutions.

COURSE CONTENTS/LITERATURE IS SPECIFIC TO COMPUTER SCIENCE AND ENGINEERING esp. D, IT, U

Organization

- Practice scientific work, writing, and project planning *before* starting the master's thesis project
  - If you happen to already know your *real* master thesis project, you *can* work with it in the course,
  - otherwise, find *some* thesis topic of interest to work with during the *course*.
  - Seminar group work is mostly topic-area specific
- Focus on formulating research questions, literature review and survey of background and related work, and an initial description of a research method.
- 6 lectures
  - Thesis structure; Literature search and analysis; Research methods; Topic selection and career paths in R&D; Academic English; Stylistic advice, Thesis process, Outlook
- 6 seminars
  - Mandatory presence
  - Guiding questions with hand-in preparation before each seminar
  - Group work, with feedback by group peers and by group leader
- Hybrid course: All seminars (on Thursdays 08:15) and some lectures are **on distance**!
  - Since 2020: zoom breakout rooms worked **better** for the document-centric group work than the noisy on-campus seminar rooms

Course format and staff

- 6 x 2h **Lectures**
- 6 x 2h **Seminars**
  - Theme-specific groups
  - Group leaders 2026:
    - **Adrian Pop** (Group **A**)
    - **Zeeshan Afzal** (Group **B**)
    - **Federica Uccello** (Group **C**)
    - **Sebastian Litzinger** (Group **D**)
    - **Joakim Argillander** (Group **E**)
    - **Szilvia Varro-Gyapay** (Group **F**)
    - **Buse Atli** (Group **G**)
    - **Willem Meijer** (Group **H**)
    - **Roland Plaka** (Group **I)**
    - **Leran “Loki” Li** (Group **J**)
    - Backup: Christoph Kessler

- **Feedback**
  - Feedback on drafts during seminars by group members
  - Feedback on submitted introductions (research questions, academic English) by seminar leaders
    - Feedback seminar (fourth week)

Lectures

1. Introduction (Christoph Kessler)
2. Introduction (cont.): (C.K. and guest speakers)
   Common thesis types.
   Panel: Outlook to working and career paths in academic and industry R&D
   (and what the thesis topic selection may have to do with it…)
3. Literature search and evaluation (C.K.)
4. Introduction to academic writing in English (Shelley Torgnyson)
5. Scientific methods (C.K.)
6. Final hints on academic writing;
   Outlook to the master thesis process (C.K.)

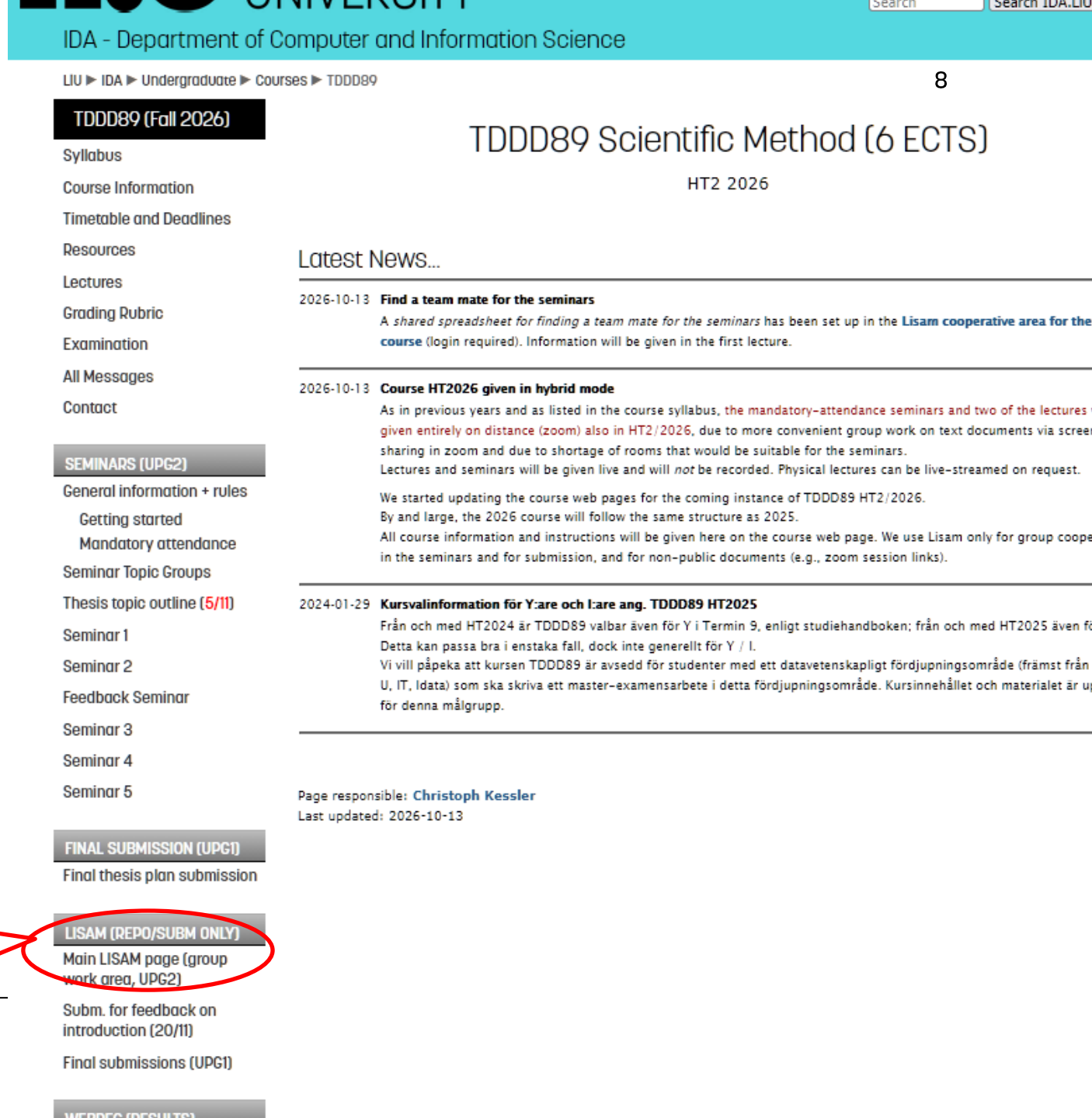
Lectures 2 and 6 are given on zoom, find the lectures zoom link on Lisam for TDDD89.
Other lectures can be live-streamed on request. We do not record lectures.

Course Web Page

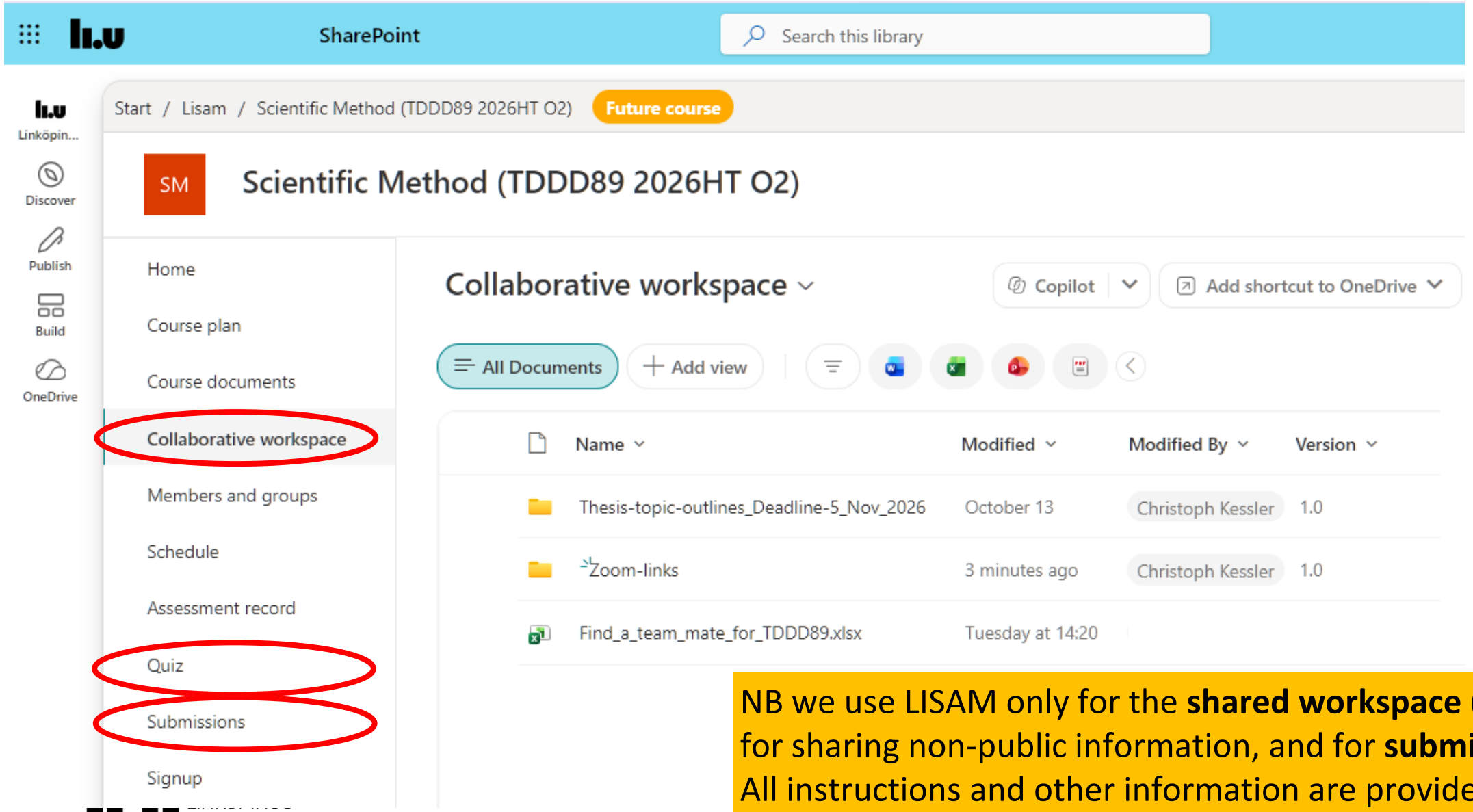
for all course information and instructions

https://www.ida.liu.se/~TDDD89/

Lisam page
only used for: shared workspace (weekly preparations, group work), submissions for examination, and sharing non-public information such as zoom links



LISAM - Shared workspace and document submission



NB we use LISAM only for the **shared workspace (seminars)**, for sharing non-public information, and for **submissions**. All instructions and other information are provided on the course web page.

Resources

LINKÖPING UNIVERSITY

IDA - Department of Computer and Information Science

Search | Search IDA.LiU.se | Search | A – Z

LiU ▶ IDA ▶ Undergraduate ▶ Courses ▶ TDDD89 ▶ Info ▶ Resources

TDDD89 (Fall 2026)

- Syllabus
- Course Information
- Timetable and Deadlines
- Resources
- Lectures
- Grading Rubric
- Examination
- All Messages
- Contact

SEMINARS (UPG2)

- General information + rules
  - Getting started
  - Mandatory attendance
- Seminar Topic Groups
- Thesis topic outline (5/11)
- Seminar 1
- Seminar 2
- Feedback Seminar
- Seminar 3
- Seminar 4
- Seminar 5

FINAL SUBMISSION (UPG1)

- Final thesis plan submission

LISAM (REPO/SUBM ONLY)

- Main LISAM page (group work area, UPG2)

TDDD89 Scientific Method

Resources

- **Degree projects (Master theses 30hp) at IDA** (valid since 15/8/2024, new page on Liunet, requires LiU login)
  - **Instructions for students regarding thesis works (30hp) at IDA** (PDF, requires LiU login)
- **Degree projects at ISY**
- **exjobb.liu.se**, new exjobb-project database at LiU
- For further currently open internal thesis projects, check also **open thesis projects at IDA** (forthcoming on LiUnet) as well as thesis projects announced on the personal web pages of **IDA researchers** and **research labs/divisions**, and on the **ISY exjobb web page**. You can also talk to the teachers in relevant advanced-level courses that you are taking.
- **Template for an IDA thesis project specification**
  Such a project specification (including self-assessment of project-specific prerequisites and availability of resources) is required for the IDA wexupp registration, deadline 15 working days before the beginning of the lecturing period containing the desired project start date. You can possibly reuse text from the TDDD89 ETP (UPG1) if it was for the same project.
- **Template for an IDA master thesis project plan**
  The (real) thesis project plan is due 2 weeks after project start. This is the generic structure for IDA, i.e., minimum requirements; your thesis examinator might have further requirements. You can possibly reuse text from the TDDD89 ETP (UPG1) if it was for the same project.
- **Checklist for degree project at the second cycle (Master's) level**
- J. Åberg: **Introduction to scientific methods** (in Swedish)
- **ACM Code of Ethics and Professional Conduct** (see also the **PDF poster**),
- **IEEE Code of Ethics**

Writing a thesis

- J. Åberg (2015). *Instructions for final thesis reports.* (**English**, **Swedish**).
- C. Kessler: **Stylistic advice to my students for writing a thesis**
- N. Ramsey: **Learning Technical Writing Using The Engineering Method**, Tufts University, 2016
- **Academic English Support at LiU** (on LiUnet, requires login)
- **IEEE Editorial Style Manual**, official manual by the Institute of Electrical and Electronics Engineers, used by engineers in Computer Science and Electrical Engineering.
- The **Academic Phrasebank** from Manchester University, UK, may be used to find synonyms and useful phrases in academic writing.

Reading papers

- S. Keshav (2007). **How to read a paper.** *ACM SIGCOMM Computer Communication Review* 37(3): 83-84.
- T. Greenhalgh (1997). **How to read a paper. Statistics for the non-statistician. I: Different types of data need different statistical tests.** *British Medical Journal* 315(7104), 364ff.
- T. Greenhalgh (1997). **How to read a paper. Statistics for the non-statistician. II: "Significant" relations and their pitfalls.**

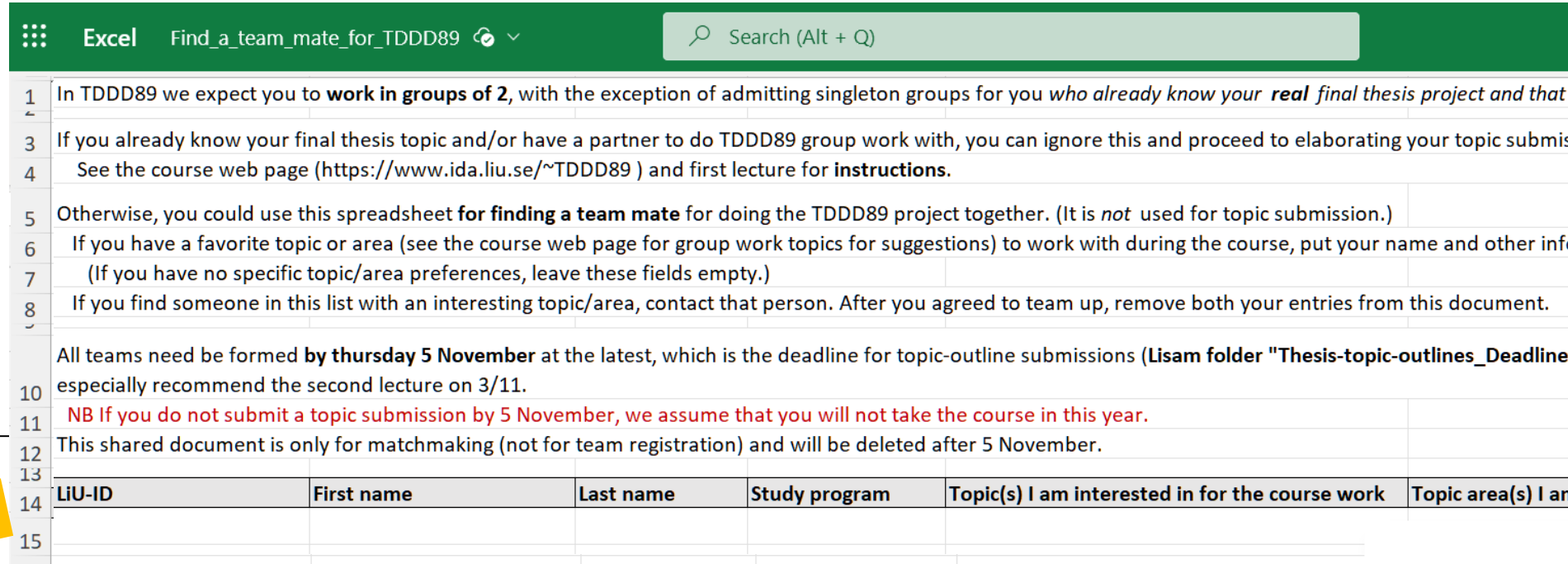
Working in pairs – Find a partner

Seminar work (such as extended thesis plan writing) is done in **pairs**.

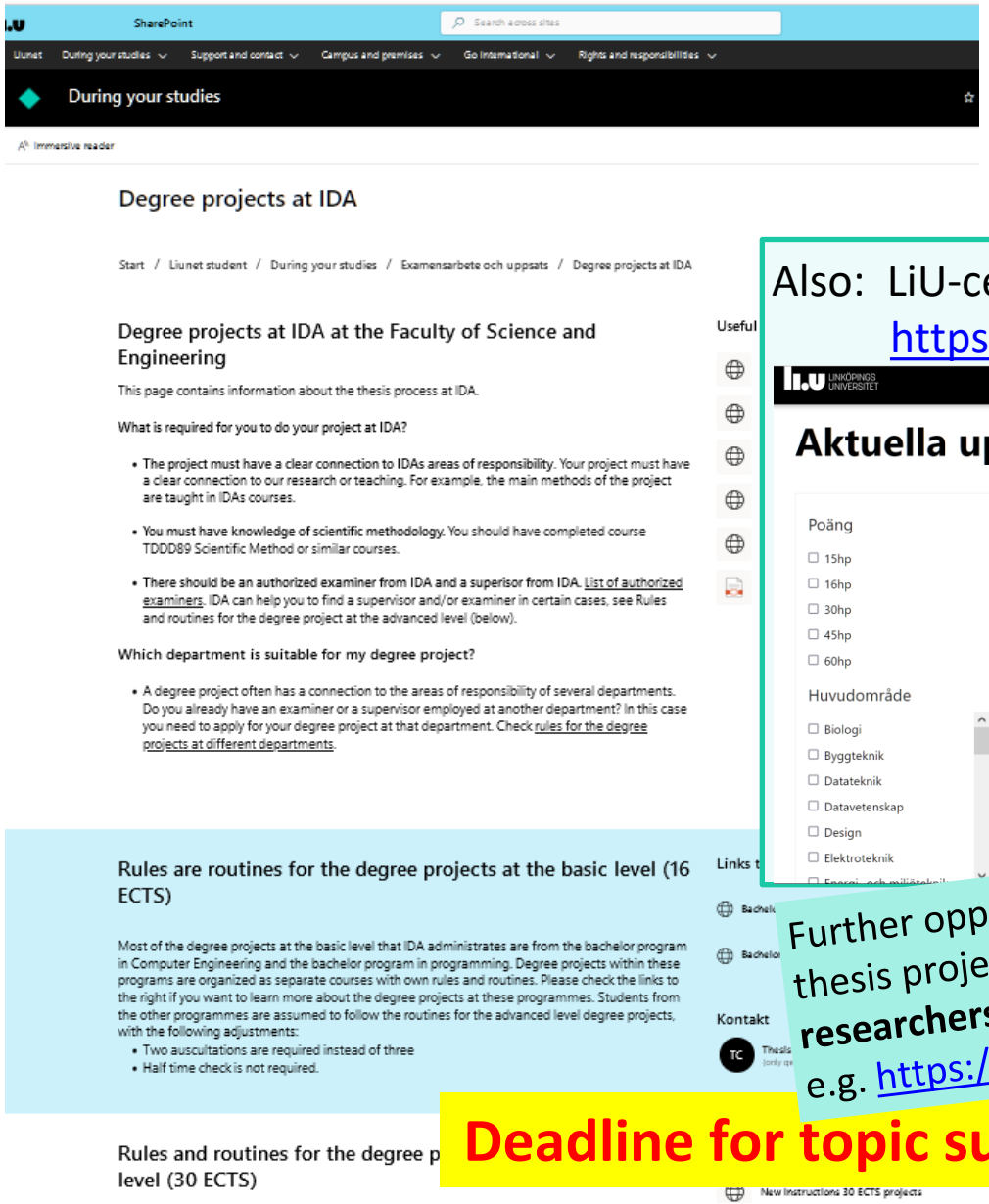
- Exception for those who already have been assigned their “real” thesis project and know they will do it alone.

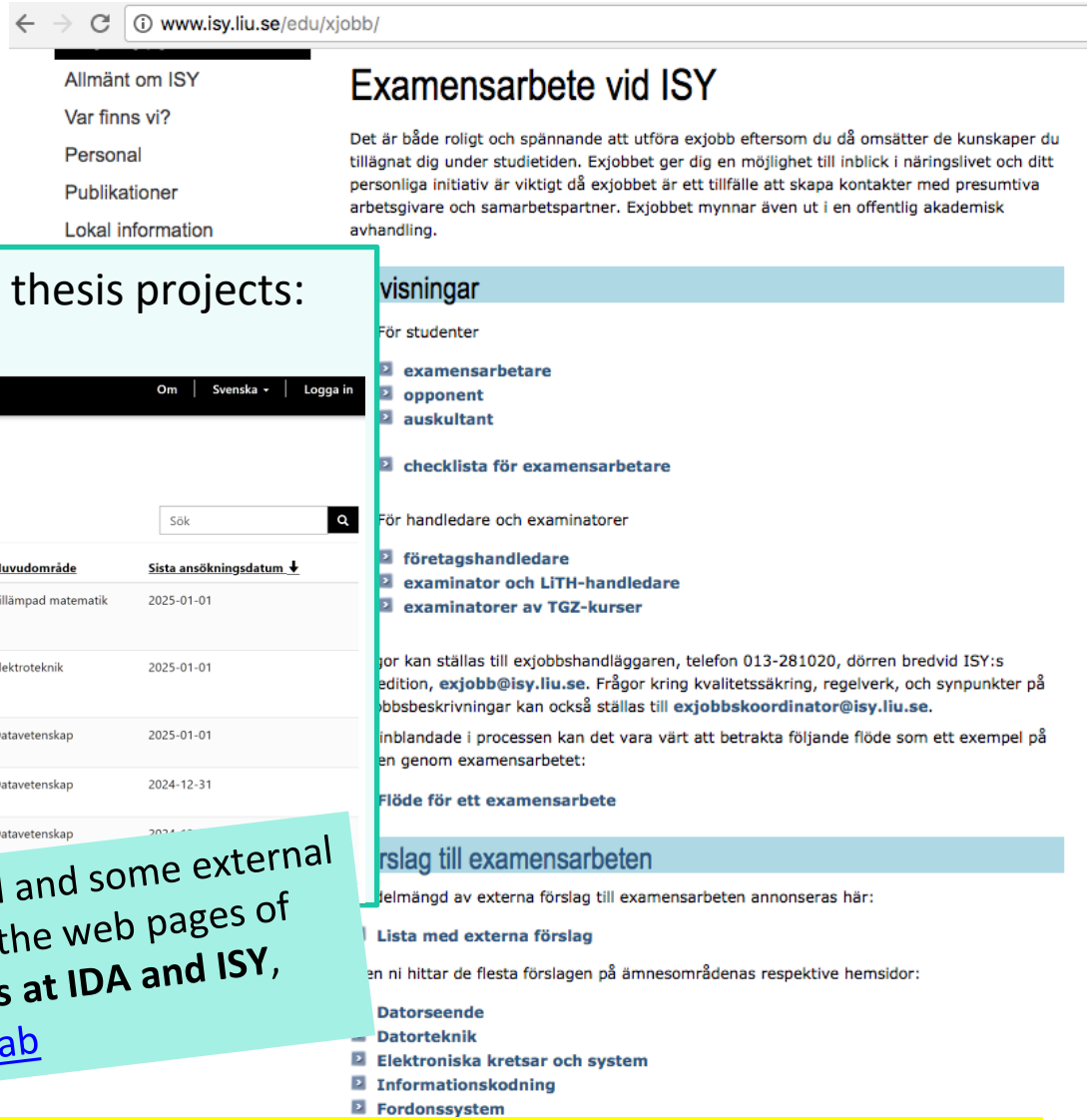
No partner for the course yet?

There is a **matchmaking spreadsheet** linked from the course web page

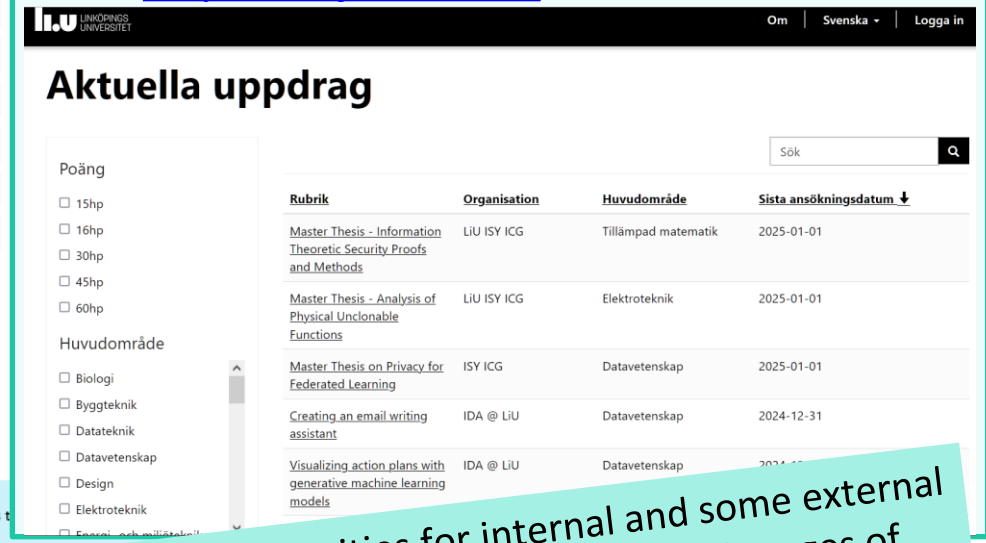


Selecting some thesis topic to work with in this course





Also: LiU-central database for thesis projects:
https://exjobb.liu.se



Further opportunities for internal and some external thesis projects may be found on the web pages of **researchers and research groups at IDA and ISY**, e.g. https://www.ida.liu.se/~pelab

Deadline for topic submission (like lab registration): **Thursday 5/11/2026**

Sample theses – define the group topic areas

Resources
Lectures
Grading Rubric
Examination, GenAI Policy
All Messages
Contact

SEMINARS (UPG2)
General information + rules
Getting started
Mandatory attendance
Seminar Topic Groups
Thesis topic outline (5/11)
Seminar 1
Seminar 2
Feedback Seminar
Seminar 3
Seminar 4
Seminar 5

FINAL SUBMISSION (UPG1)
Final thesis plan submission

Seminar Topic/Method Groups ("Themes") and Sample Master Theses

The following selected Masters' theses pertain to the different groups' topics and/or research method types. Each thesis has a numbe keywords describing it by topic area and method type, and seminar groups are formed based on the similarity of the thesis topic outl submitted by students in the first week.

- **Topic 1:** Software development processes, software quality - Case study:
  "Vertically Scaling Agile: A Multiple-Case Study" by Nicklas Östman and Rasmus Lindström, Linköping University 2017.
- **Topic 2:** Programming framework, parallel systems, compilers, metaprogramming, performance - Design, Prototype implementation:
  "Skeleton Programming with SkePU and MLIR: Accelerating Embedded Domain Specific Languages using Multi-Level Intermediate Representations", by Axel Sundelin, Linköping University 2026.
- **Topic 3:** Business software, services, software contracts - Usability study, iterative development:
  "Usability of a Business Software Solution for Financial Follow-up Information of Service Contracts" by Therese Borg, Linköping University 2018.
- **Topic 4:** Deep learning, machine learning, image processing, computer vision - Experimentation:
  "3D reconstruction from satellite imagery using deep learning" by Tim Yngesjö, Linköping University 2021.
- **Topic 5:** NLP, LLMs, machine learning, data mining, databases - Experimentation:
  Bridging Language and Data: Optimizing Text-to-SQL Generation in Large Language Models by Niklas Wretblad and Fre Gordh Riseby, Linköping University 2024
- **Topic 6:** Security and Computer Networks - Evaluation:
  "Certificate Transparency in Theory and Practice" by Josef Gustafsson, Linköping University 2016.
- **Topic 7:** Security and Computer Architecture - Experimentation:
  Detection of side-channel attacks targeting Intel SGX by David Lantz, Linköping University 2021
- **Topic 8:** Algorithms, scheduling, embedded realtime systems, metaheuristics - Improvement, optimization,
  "Performance Optimizing Priority Assignment in Embedded Soft Real-time Applications" by Fredri Edqvist, Linköping University 2018.

Absolutely no idea for a topic? Take one of these as a placeholder, so you have something to work with for Seminar 1 (+ 4).

Choosing a closest thesis topic area / method type

from the list of sample master's theses

1. **Software development processes, software quality / Case study (1)**
2. **Programming framework, parallel systems, compilers, performance / Design, prototype implementation (2)**
3. **Business software, services, software contracts / Usability study, iterative development (3)**
4. **Machine learning, data mining, image processing / Experimentation (4)**
5. **NLP, LLMs, machine learning, data mining, databases / Experimentation**
6. **Security and computer networks / Evaluation (6)**
7. **Security and computer architecture / Experimentation**
8. **Algorithms, scheduling, embedded / realtime systems, metaheuristics / Improvement, optimization, analysis (8)**

https://www.ida.liu.se/~TDDD89/seminars/topicgroups.shtml

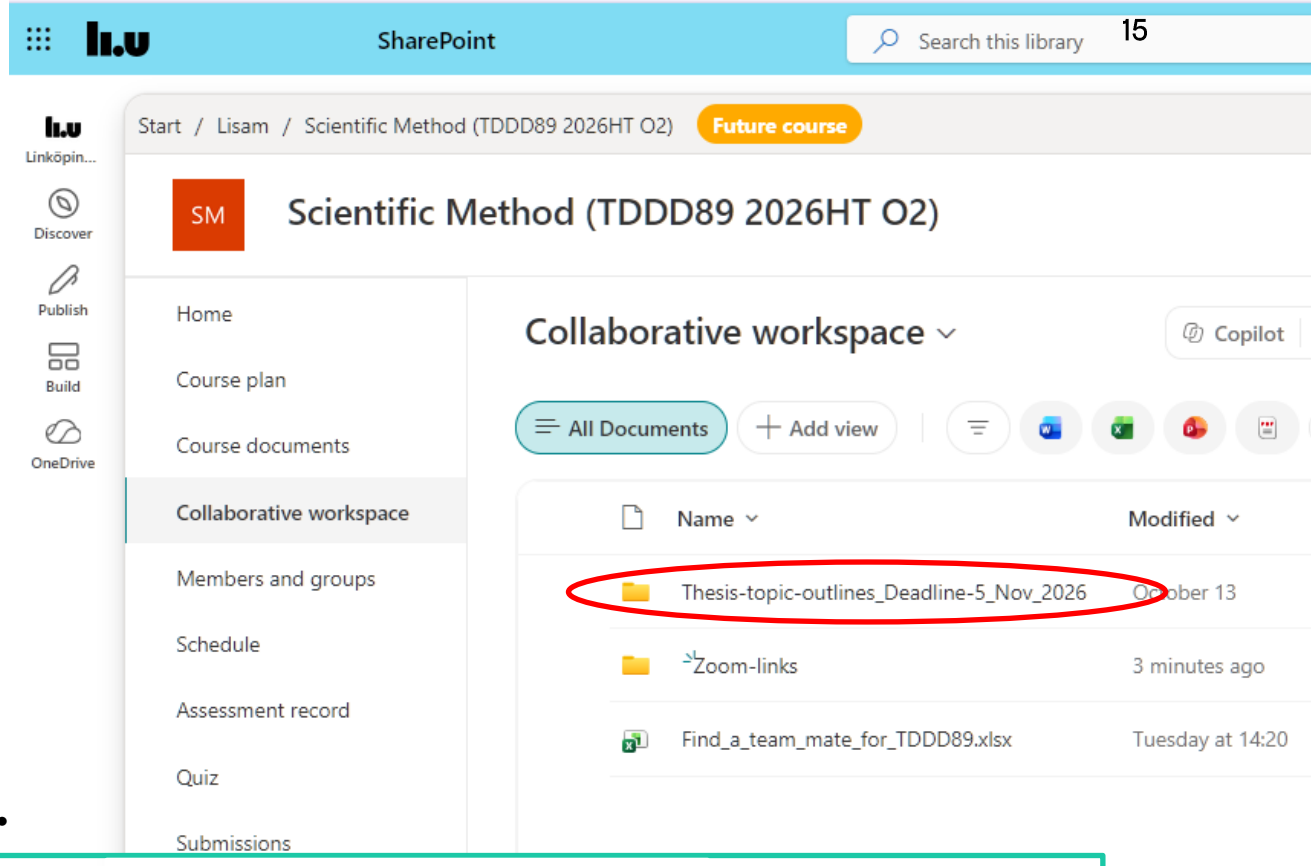
Getting started: An early deadline

- **By Thursday 5/11 (this week!)**:
  - Find a **partner** to work with
  - Find a **topic** to work with
  - Find the **closest topic area** (1-8)
  - Find the **closest method type** (1-8)
  - **Submit** a ***thesis topic outline*** (**max. 1 page**)

    File (.pdf, .txt), named "***liuid001_liuid002.***

    - Tentative **title** and short **abstract**
    - **Self-classification**: Closest topic area(s), closest method type(s) (most relevant first)
    - **Additional information**: IDA vs. ISY affinity (if known); assigned real-thesis topic or not

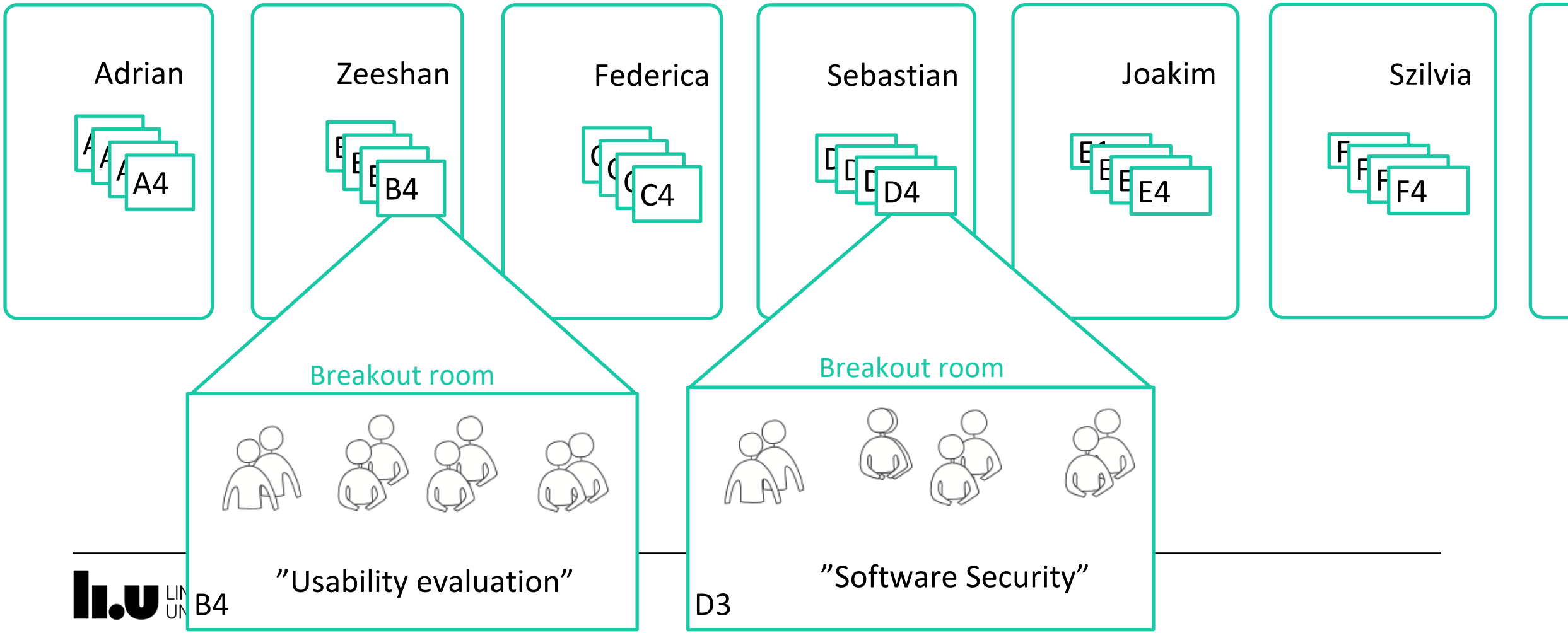
    Put it in LISAM collaborative workspace folder "**Thesis_topic_outlines_Deadline-5_Nov_2026**"



- By **Monday** next week, you will be divided into **seminar groups** based on this information
- We will then sign you up in a webreg group (A-J, see TimeEdit schedule; seminar zoom link on Lisam) for UPG2

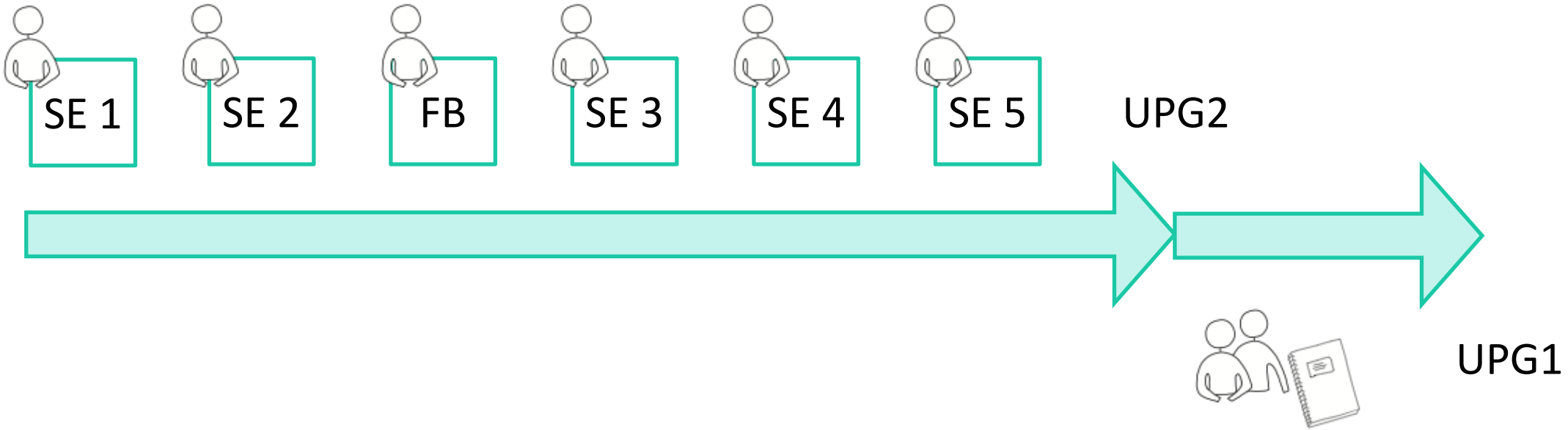
Up to 40 Seminar topic groups: {A,…,J} x {1,…,4}

(mapping to be announced early on Monday 9/11)



TDDD89 Scientific Method
Examination

- **UPG2 (2hp)**: Preparation and participation in *seminars* during the course (**weekly deadlines**)
  - partly individually, partly per team
- **UPG1 (4hp)**: *Extended thesis plan*, to be finished at the end of the course (deadline **11 January**)
  - per team (pair) of students



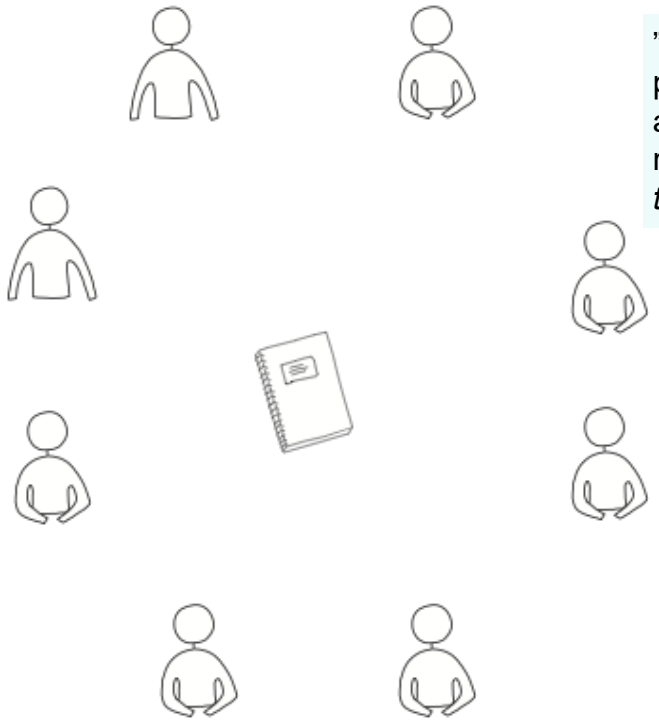
Seminars

Seminar	Read in sample thesis	Write extended thesis plan
1	Introduction, Background+Related work / Theory	
2		Introduction incl. research questions → ca. 2 pages + references
FB	*Feedback seminar on introduction, esp. the research questions*	
3		Introduction incl. res. questions, Background, Related work → ca. 5 pages + references
4	Method, Results, Discussion, Conclusion	
5		Introduction incl. res. questions, Background, Related work, Project plan → ca. 8 pages + references

20/11 Submission of introductions for feedback
from your group supervisor esp. on the research questions and on academic English

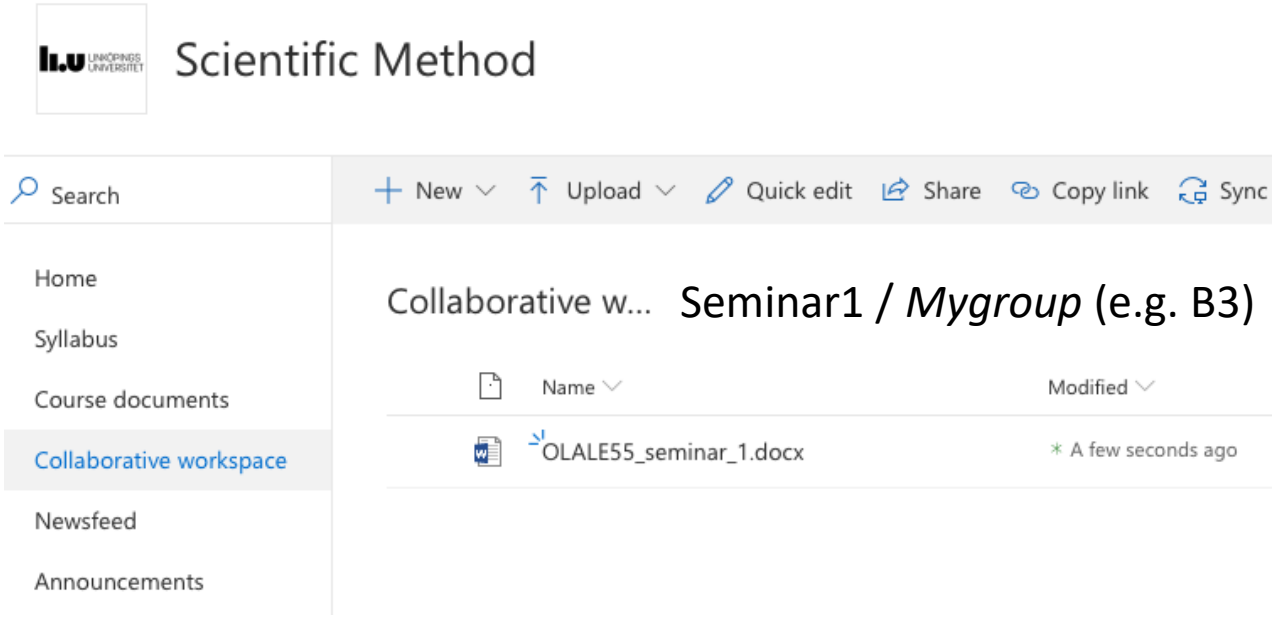
then revise for UPG1 submission

Seminars 1 and 4: Reading the sample thesis



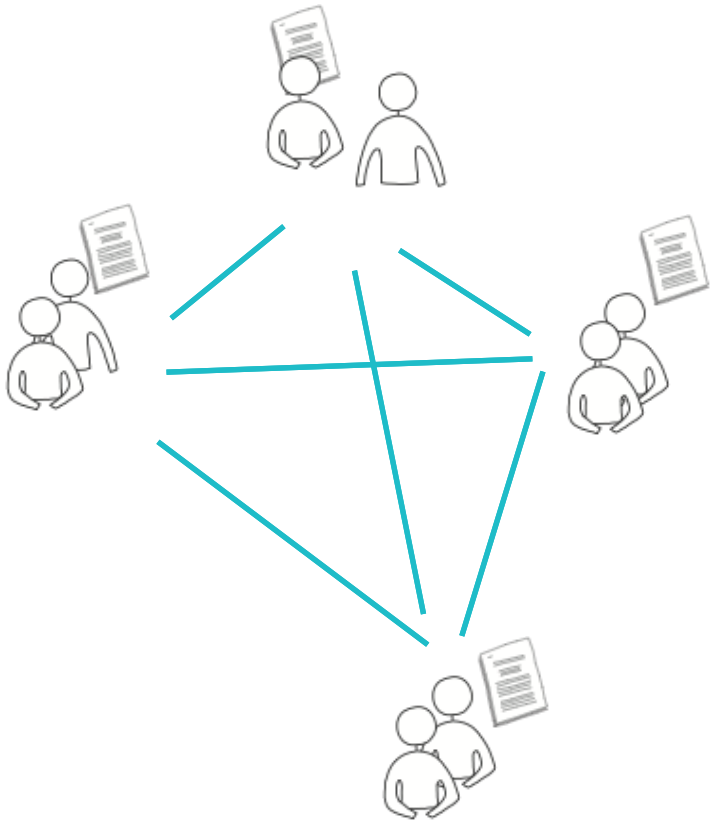
”Are the research questions in the published thesis easy to find, clear and with a reasonable scope, as required by the *instructions for final thesis reports* ?” …





- Individual written preparation (in Lisam folder) due before the seminar.
- Instructions on the course web page.

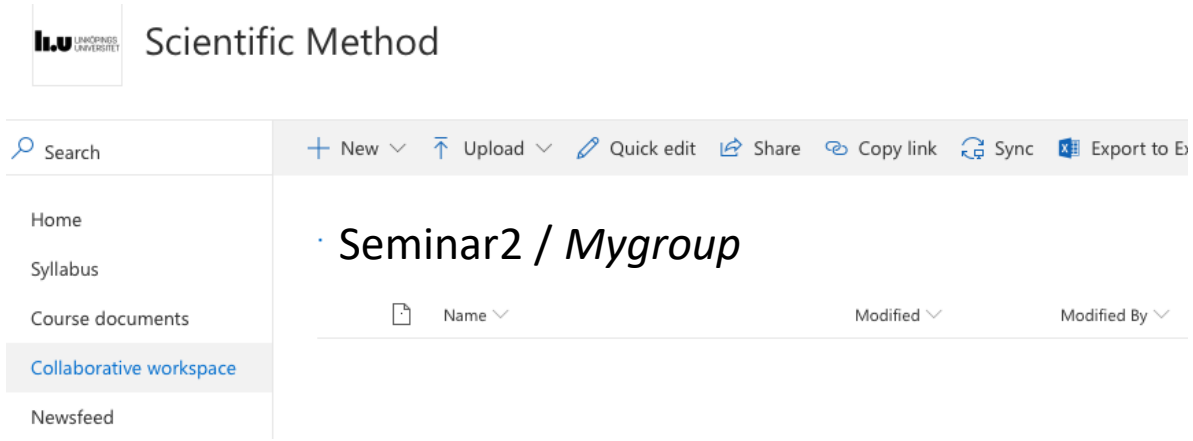
Seminars 2, 3, 5: Writing an extended thesis plan + feedback



1

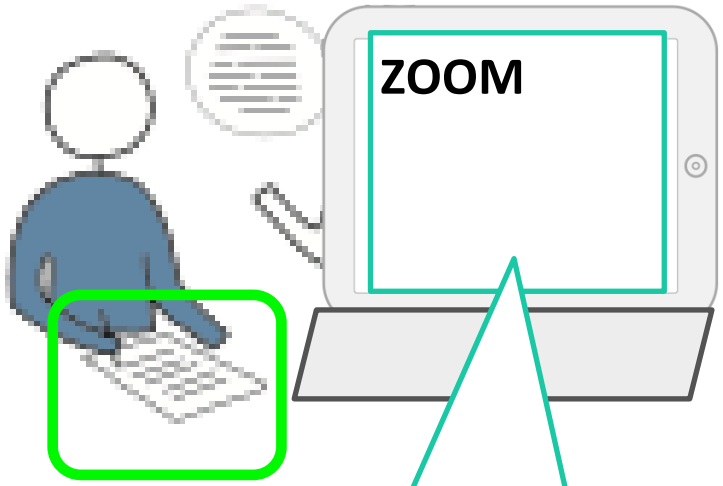


2



- Draft submission (Lisam folder) deadline on **Tuesdays 12:00**
- Written peer review by every other group member (due (Lisam folder) ***before* the seminar**)
- Instructions on the course web page.

Seminars



Make sure you have an updated zoom client installation on your laptop and on your mobile phone (as backup). Feel free to test it beforehand. Zoom login with LiU SSO (LiU-ID).



Avoid distractions.

Have your preparation/solution ready in Lisam.

Use screensharing.

Take notes!

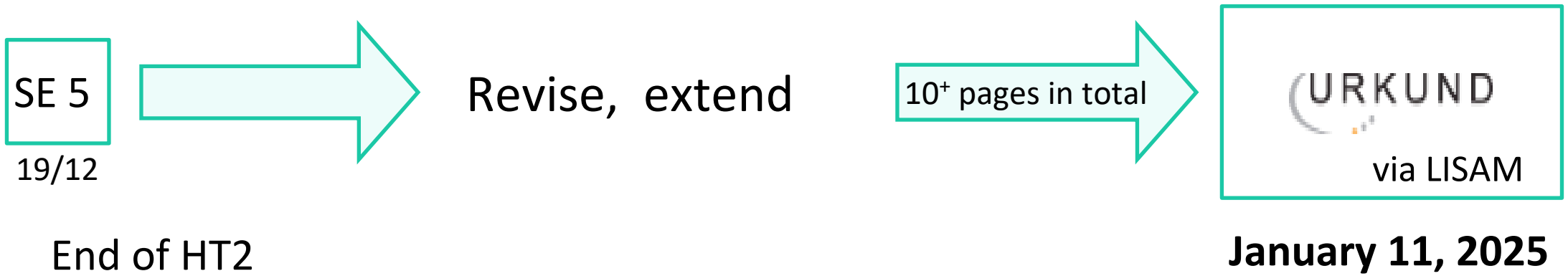
Webcam on during seminar group work

Recording is not permitted

General rules for group work – Group Contract

- Participation is documented by zoom login with LiU-ID.
- Webcam is on for everyone. No recording.
- All material needs to be available during discussions (in group folder on Lisam).
  Use screen sharing in zoom. The group chairperson is responsible for the screen-sharing.
- Use English, at least if a non-Swedish speaking participant or seminar leader is present.
- All need to actively participate.
  - Aim for equal participation.
  - The group chairperson keeps track of the time.
  - Shuffle the role of the group chairperson over the seminars.
- Give clear and constructive feedback to your group peers.
  Be polite. Criticize the draft / answer given, not the person(s) behind.
- Take notes!
- If anything is unclear: collect these issues and ask the seminar leader when visiting your room.
- Individually, submit 4-5 lines of discussion outcome to your seminar leader at the end (email).

Final submissions



End of HT2

January 11, 2025

Generative AI tools?

- Not permitted in TDDD89 for any moment, for obvious reasons.

Workload distribution

160h total:

Plan your time and
read the seminar instructions
thoroughly

Seminar	Work %
1	20
2	15
3	20
4	20
5	15
Final submission	10

Background and Related Work: Often perceived as the most difficult part. You have almost 2 weeks time, but start early, don't wait until after the Feedback seminar

Recent changes based on course evaluation feedback

- 2026: Academic English feedback on submitted introductions (20/11) is now given directly by the seminar leaders.
- 2026: Deadline for writing seminars (2, 3, 5) moved from Mondays to **Tuesday noon**
  → more time for preparing, while still leaving 1.5 days for peer-reviewing.
- 2023: The *panel discussion* was introduced and kept in its early position (Lecture 2) to possibly help with the course topic selection before the topic deadline (5/11)
- 2023: Compensation assignment for missed seminars and late preparation hand-in has been updated/clarified
- 2022: Seminars moved from Tuesdays to Thursdays / submission deadlines moved from Sundays to Tuesdays / Mondays
- 2021: Reading *Method* chapter of the sample thesis moved from Seminar 1 to Seminar 4 to reduce time pressure before Seminar 1 deadline
- We admit singleton groups if you already have been assigned your *real* thesis topic and will do it alone.
- Widely appreciated and kept since the pandemic: the **hybrid** format
  - *Seminars* in zoom breakout rooms
    - Was perceived by many as better than physical seminars in the C-house rooms (screensharing is convenient, less background noise, no need to move tables around)
      - provided that one can *see* each other during discussions and microphones are working properly.
  - Some *lectures* remain virtual, too – helps to reduce schedule conflicts, as LiU does not have enough large lecture halls

Part 2: Getting Started

Towards a Great Thesis

What is a great thesis?

Thesis = project results + written presentation

Example:

- *A working, interesting application with proven and general value*
  - A well-described *application*
  - of general *interest*
  - and with a clear description of ”*proven*” and ”*value*”

What is a great thesis?

Thesis = project results + written presentation

- Includes an **evaluation** with
  - **general** and
  - **interesting** results
  - that others can **use**
  - that others will **believe**

What is a great thesis?

Thesis = project results + written presentation

- An authoritative report
  with a good **focus** (→ research questions!)
  and **results** that answer the questions
  through a transparent, thorough **description of the process**

Getting started: Elaborate the requirements → find the research problem / research questions

Precise requirement – finding *relevance* more important

Why?

”Evaluate algorithms to be used for image clustering”

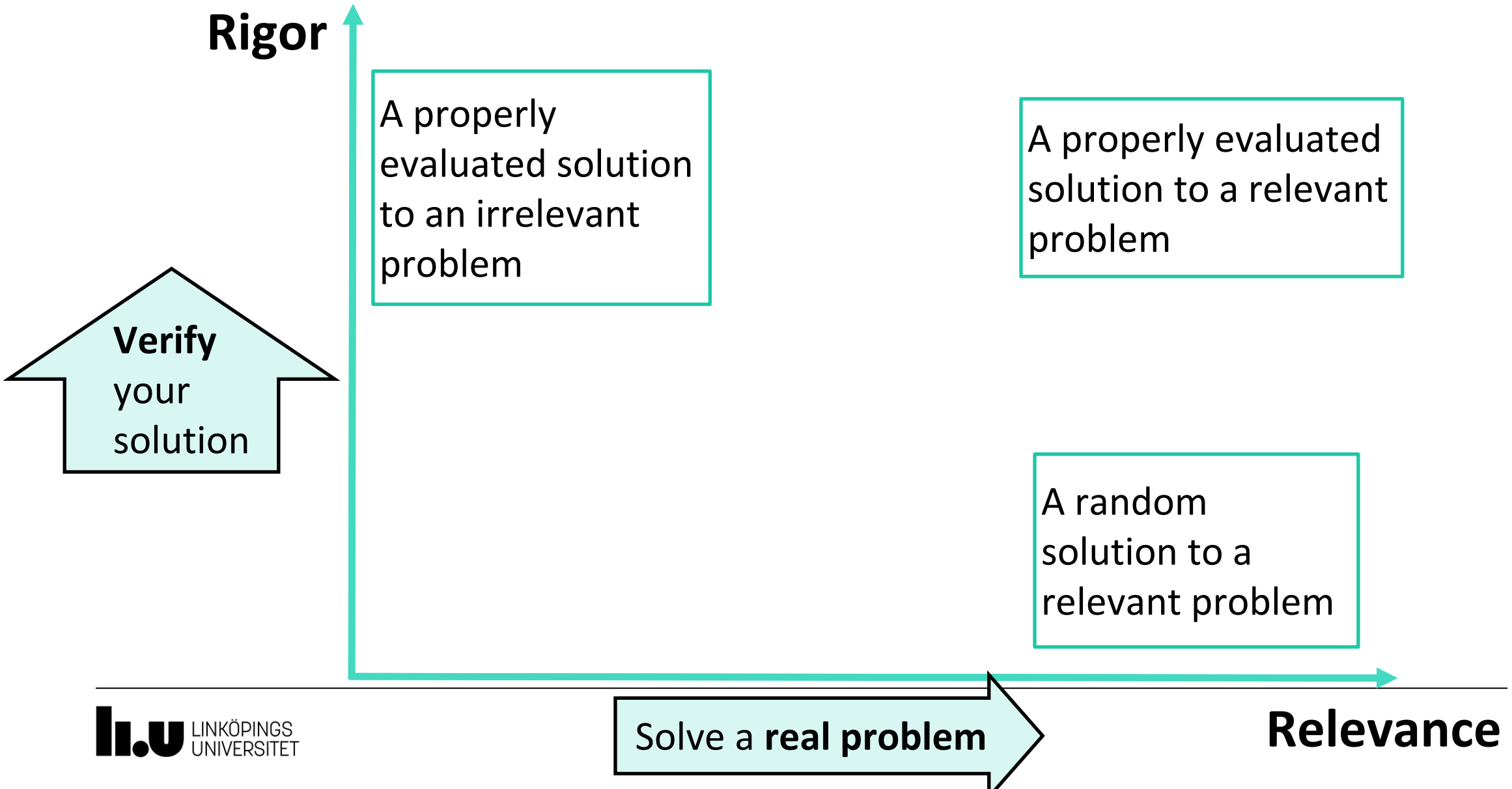
”Determine whether clustering algorithms can be used to detect activities in sets of images”

Vague requirements – finding *focus* and *rigor* more important than *relevance*

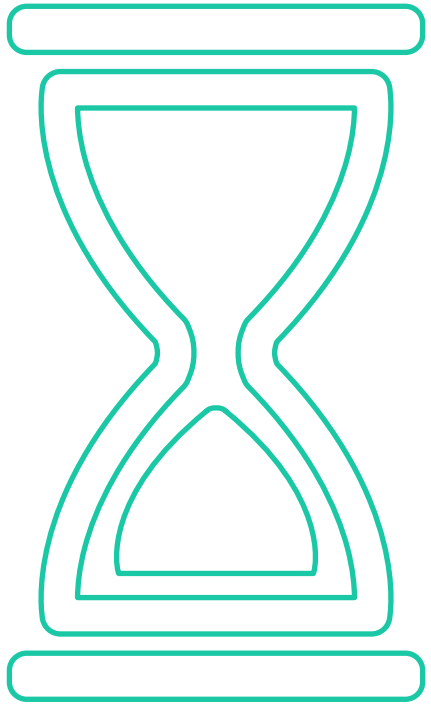
How?

”Find activities in sets of images”

Relevance vs. Rigor



Thesis outline



Hourglass model for technical reports:
Usually, most specific in the middle
(details, technicalities)

Why should I even read this thesis?

What have you studied here?

What does this relate to?

Can I trust you?

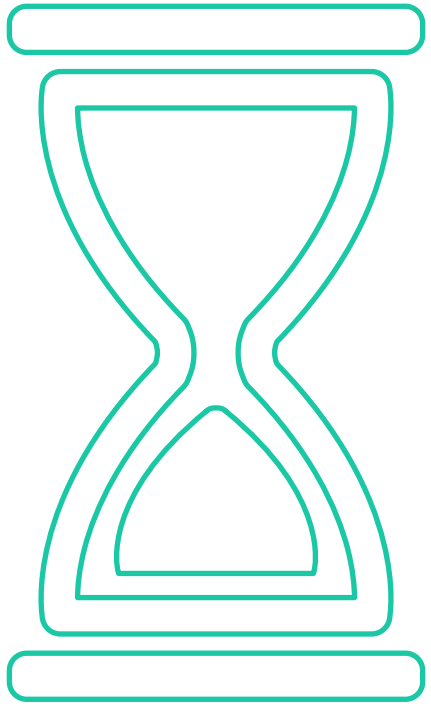
What is built?

What have you found?

How can we explain the results?

How can I use these results in my work?

Thesis outline



Hourglass model for technical reports:
Usually, most specific in the middle
(details, technicalities)

- Abstract
- Research Questions
- Background and Related Work / Theory
- Method
- Implementation
- Results
- Discussion
- Conclusion

Thesis outline

Remark: This very **generic thesis structure**, which we use in this course, is **not necessarily the best choice for the *chapter* structure and -titles** of **your** thesis.
For your final thesis, you might find a **more specific chapter structure and titles**, but make sure to duly cover all these ***aspects*** somewhere.

- Abstract
- Research Questions
- Background and Related Work / Theory
- Method
- Implementation
- Results
- Discussion
- Conclusion

More specific thesis outlines may fit better …

- Abstract
- Introduction with Research Questions
- Background
- Related Work
- Design and Implementation
- Evaluation of Aspect 1: Method, Results, Discussion
- Evaluation of Aspect 2: Method, Results, Discussion
- Conclusion and Future Work

What is a good research question in Computer Science?

Question type	Example question	Type of answer

Different research questions in Software Engineering, adapted from: Mary Shaw: Writing Good Software Engineering Research Papers: Minitutorial. Proc. 25th International Conference on Software Engineering, ICSE '03, pages 726-736, 2003. IEEE Computer Society.

What is a good research question in Computer Science?

Question type	Example question	Type of answer
Means of development	What is the most efficient software testing method for a small team developing a mobile application?	Procedure
General method for analysis	How can one verify conformance to real-time constraints in a multi-threaded embedded system?	Analysis method
Specific evaluation of systems	When is PhoneGap more economical to use than NativeGoo for cross-platform mobile development?	Empirical predictive model based on data
Generalization or characterisation	Given recent results in tuning deep neural networks, which meta-heuristics should be used for exploring the parameter space?	Classification, taxonomy
Feasibility study	Can one automate (driving) a car?	Specific implementation, empirical observations

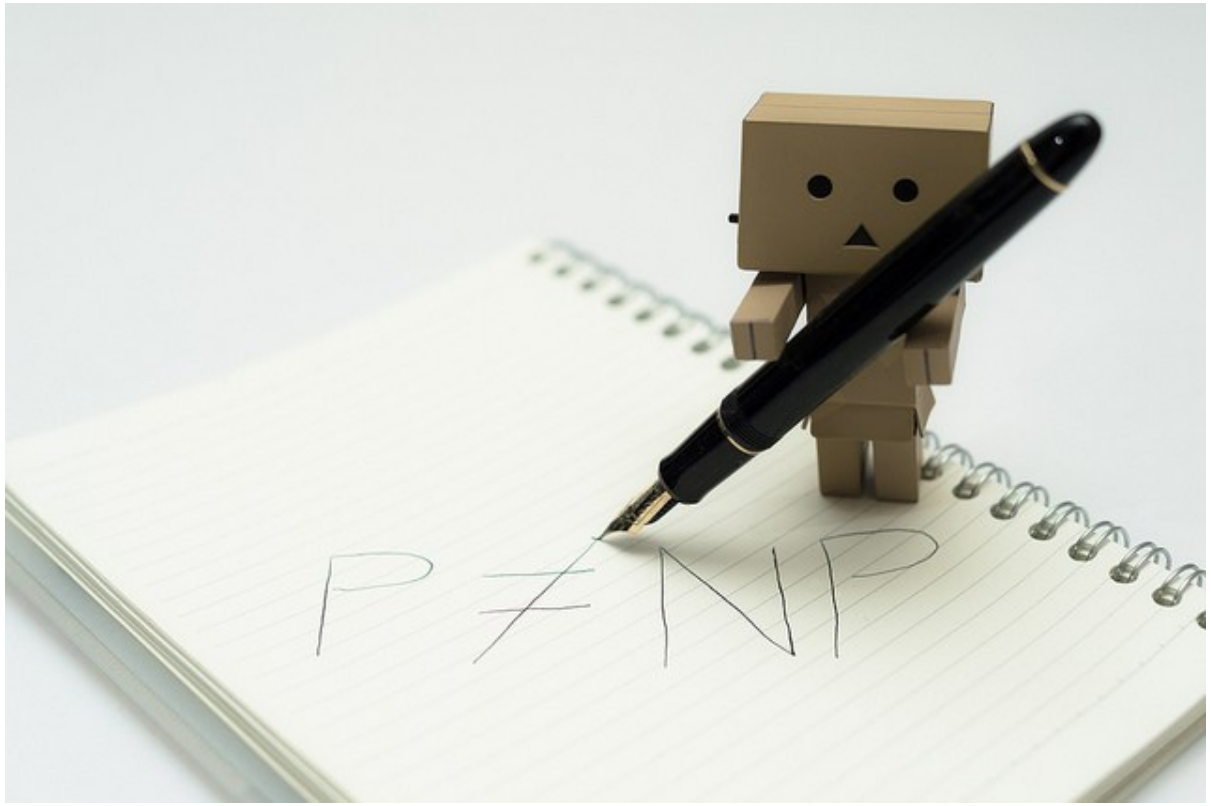
Different research questions in Software Engineering, adapted from: Mary Shaw: Writing Good Software Engineering Research Papers: Minitutorial. Proc. 25th International Conference on Software Engineering, ICSE '03, pages 726-736, 2003. IEEE Computer Society.

Towards A Great Thesis

I - The Problem

Start from a problem that people may be interested in (at least a few more than those who gave you your task)

→ Motivation and Aims
→ Formulate explicit research questions



Evaluating a research question

- ”How can one construct a web application?”
- ”Is it possible to construct a mobile application for functionality X?”
- ”How can one create a usable website?”

Is the answer any of the following?

By writing what has already been written many times before

Yes, there is no reason to believe it could not be done.

By adhering to published design guideline Y

Then come up with a better question…

Arriving at interesting research questions

- Start exploring a field:
  - ”How can fuzz testing be used to find bugs in concurrent embedded software?”

- Then, use existing technical approaches and theoretical models:
  - ”Combining with dynamic and static analysis of schedulability of embedded real-time systems”
  - ”What is the efficiency of AFL at finding timing-related errors in concurrent software?”

The journey to a better question

Question	Approach	Objection
How can we automate testing?	Applying automatic generation of test cases	We end up with 10^7 test cases, only some of which are necessary...

The journey to a better question

Question	Approach	Objection
How can we automate testing?	Applying automatic generation of test cases	We end up with 10^7 test cases, only some of which are necessary...
How can we select *relevant* test cases?	Applying statistical/ML clustering techniques	Black-box solution with no known accuracy, we need traceability
How can we *automatically prioritize* test cases?	Optimize based on historical records to maximize *a*verage *p*ercentage *f*aults *d*etected (APFD)	No weight given to critical functionality
What do we really want to *optimize*?	Listen, observe, collect data	Requires an open mindset

2 - the Theory

“Theory”:
Rooting your work in your subject area’s scientific body of knowledge

→ create *trust* in your work

- **Background**
- **Formalization/Modeling**
- **Related Work**



“In God We Trust – All Others Must Bring Data!”

--- W. Edwards Deming

Convince the reader!

In many cases, you will produce some code as part of your thesis project.
This is not enough for your thesis work, though.

- Is this a *relevant* problem?
- Is this work based on the *state-of-the-art techniques* in the field?
- Does it *improve* or *generalize* over previous work? And how?
- Are all claims made *proven* in the thesis, or based on *trustworthy sources*?

You need to convince your (critical) audience
that you have done a great job!

By anchoring your work in the scientific body of knowledge of your field

Theory

Compare these two claims:

”There are seven dimensions of usability”

”NP-hard problems are at least as hard as the hardest NP problems”

Theory: Characterization of knowledge, accumulated through scientific studies, published in peer-reviewed journals and conferences

Criteria:

- Validation
- Does it describe the world?
- Is it proven?

More about literature search and analysis in Lecture 3

Modeling / Formalization

- **Isolate** and **abstract** the core problem
- **Models = abstractions**
  - Distill and formally describe the main relevant properties of a complex real system
  - Example: Models of computation, CPU performance / energy models
  - Formalization: Key parameters, set theory, equations, constraints, graphs, abstract data types, formal logic reasoning, …
- Empirical observations are based on expectations, informed by theoretical frameworks (models):
  - Example: When reading **power consumption** values of a modern CPU, we expect that it depends on the CPU's different **power states** (e.g., voltage/frequency level)
- Based on observations, you can **test claims** made by your theory

→ **Generalizability** of your result beyond the concrete problem instance

“There is Nothing so Practical as a Good Theory”

--- Kurt Lewin, 1890-1947, social psychologist

How to convince the reader?
By using a solid, state-of-the-art method to answer the RQs

In industry as well as in academia,
well-presented working solutions
based on widely trusted state-of-the-art techniques
are the best means of convincing the reader.

In the scientific community, we also require
claims about solutions to be **sound**,
so others can rely on them in their work.

Type of Method used to obtain and validate results	**Example scenario**

Type of Method used to obtain and validate results	**Example scenario**
Analysis	I have conducted a formal analysis of my algorithm, and have proved that it solves the TSP in $O(N^2)$, thus proving that P=NP
Evaluation	I have compared code review results with interviews and surveys, and found that if you test software, you are more likely to find faults than if you do not
Experience	I report on experience with aligning software architecture with code based on 20 years of software development for Swedish Social Security and have found that software architectures are essentially useless
Example/Prototype	This tool can recognize location and pose, so when you enter a bathroom it will give you valuable advertisements on Facebook while sitting down.

Method



For theses that involve creating a product / prototype, you need to **assess the external or internal qualities** of what you produce (e.g. usability, correctness, or scalability), using **qualitative** or **quantitative methods**.

Other types of theses that do not involve creating products/prototypes (e.g., systematic literature reviews) have their own established criteria for assessment.

You want to ensure that what you are studying does represent reality.
This is called ***external validity***.

Reproducible Results

All details about your **assessment method** need be carefully documented in the thesis

- e.g., test data sets, benchmarks, code, system, experimental setup

Allows others to follow the same setup to obtain the same data

→ **Reproducibility** increases **trust** in your work.

Algorithms	Implementations	Number of runs	Hyper-parameters
nearest centroid classifier	NearestCentroid	3	metric∈{"l1";"l2";"cosine"}
naive Bayes classifier (multinomial distribution)	MultinomialNB	22	alpha∈np.linspace(0,1,11) fit_prior∈{True;False}
Linear SVM	LinearSVC	20	C∈np.logspace(-4, 4, 10) loss∈{"squared_hinge";"hinge"} class_weight="balanced"
Logistic Regression	LogisticRegression	40	dual=False C∈np.logspace(-4, 4, 10) class_weight="balanced" solver∈{"newton-cg";"sag";"lbfgs"} multi_class="multinomial" dual=True C∈np.logspace(-4, 4, 10) class_weight="balanced" solver="liblinear" multi_class="ovr"
Perceptron	Perceptron	13	penalty∈{"l2";"elasticnet"} alpha∈10.0**-np.arange(1,7) class_weight = "balanced" penalty=None class_weight="balanced"
Stochastic gradient descent	SGDClassifier	120	loss∈{"hinge";"log";"modified_huber"; "squared_hinge";"perceptron"} penalty∈{"l2";"elasticnet"} alpha∈10.0**-np.arange(1,7) class_weight="balanced" average∈{True;False}

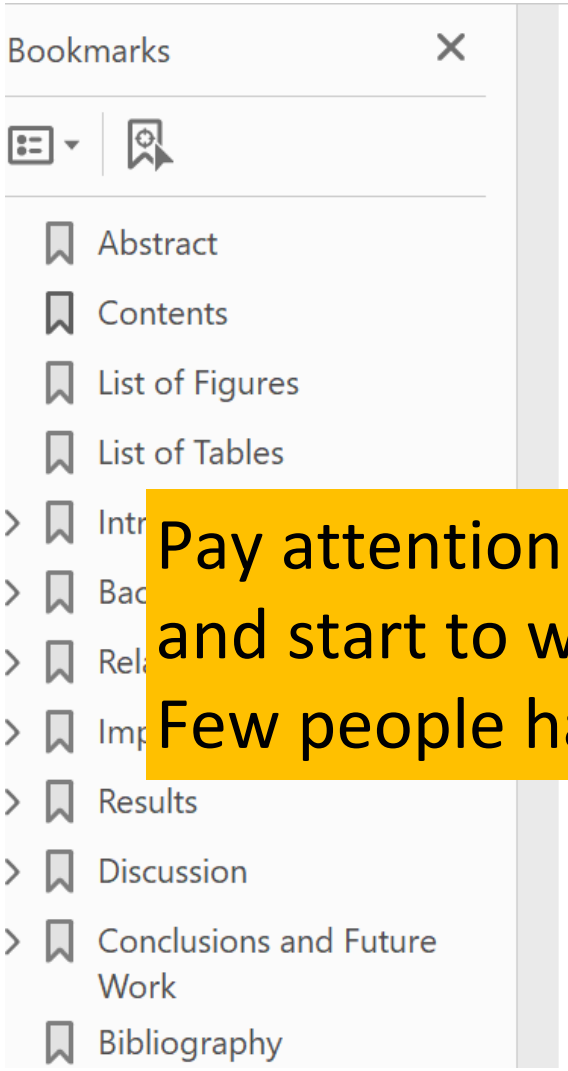
Table 3.8: The different configurations of the experiment 4

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More about Research Methods in Lecture 4 ...

Thesis structure and format

For theses in mathematics, computer science and engineering I recommend using LaTeX.



List of Tables

1 Introduction
1.1 Motivation
1.2 Aim
1.3 Research Questions
1.4 Delimitations
1.5 Thesis Overview 3

2 Background 4
2.1 Data Plane Development Kit 4
2.2 Encryption 7

Pay attention to the structure, formatting and typesetting of your thesis, and start to write early.
Few people have accurate estimates of how long it takes to write a thesis.

3 Related Work 15
3.1 Exploiting Integrated GPUs for Network Packet Processing Workloads 15
3.2 Processing data streams with hard real-time constraints on heterogeneous systems 16
3.3 Machine Learning-Based Runtime Scheduler for Mobile Offloading Framework 16
3.4 Machine learning based online performance prediction for runtime parallelization and task scheduling. 17
3.5 Delay-Optimal Computation Task Scheduling for Mobile-Edge Computing Systems 17
ning Strategy for Task Scheduling of WSNs with Mobile Nodes 17
l Packet Classification on FPGA, Multi-core General Purpose 18

[45] B. Le Gal and C. Jego. "High-Throughput LDPC Decoder on Low-Power Embedded Processors". In: *IEEE Communications Letters* 19.11 (Nov. 2015), pp. 1861–1864. ISSN: 1089-7798. DOI: 10.1109/LCOMM.2015.2477081.

Summary so far:

A great thesis:

- An interesting problem
  with clear research questions
- Well positioned with respect to the state of the art (related work)
- A reliable method
- A working solution
- Established effects that answer the RQs
- Great presentation

To be continued in the next lecture …

On zoom, **tomorrow Tuesday 15:15** – zoom link see Lisam cooperative area

- **Common thesis types at IDA/ISY**

- Also:
  Panel discussion (starting at 16:00 sharp):
  What comes after graduation?
  Outlook to professional career paths in industrial or academic R&D
  (and what the thesis topic selection may have to do with it…)
  – Important for answering preparatory questions before Seminar 1