

## **Instruction for the written report of thesis work at the bachelor level within chemistry, chemical biology or chemical engineering at Linköping University**

This instruction is provided by the Programme Board in Chemistry, Biology and Biotechnology, as a support during report writing, to everyone with a role in the bachelor level thesis work (Bachelor of Science) – the student, the supervisor(s) and the examining teacher. Importantly, in order for the report to be written in accordance with this instruction, it needs to be considered during the planning and implementation of the project. The planning should be detailed in a planning report, which can then form the basis for the final report. As an aid in the examination process there is also a checklist that you need to take into consideration when writing the report.

The formal requirements (i.e. learning objectives) and examination codes for an approved thesis are available in each course syllabus in the study guide (<http://www.lith.liu.se/sh/>). There you can also find a regulatory framework containing general regulations related to the thesis work.

An important starting point for the design of the thesis work, including reporting, is expressed in the course syllabus as “CDIO ingenjörsmässighet” (CDIO engineering abilities). It is as follows:

### Natural science students

The student should be able to:

- *make judgments with respect to relevant scientifically, ethical and societal aspects.*

### Engineering students

The student should be able to:

- *create, analyze and/or evaluate technical solutions.*
- *make judgments with respect to relevant scientifically, ethical and societal aspects.*

A sound knowledge of the subject matter is of course necessary to be able to make these judgments, and to create, analyze and evaluate technical solutions.

In order for the report to clearly show that the above learning objectives are met, it should:

- include a description of the project problem and purpose, and provide accurate scientific, technical and methodological background information based on relevant sources,
- include a description of the obtained results, as well as an analysis based on existing theories,
- demonstrate theoretical understanding, ethical awareness and understanding of social aspects.

For a thesis that will lead to an *engineering degree* the following is also required:

- a systematic description of how the student arrived at his/her conclusions and results (see also the sections marked with an asterisk (\*) later), including
  - a detailed chronological and methodological description of the original project design,

- a chronological description and analysis of the progress of the project, and a description of the decisions taken based on this analysis.

### **Language and presentation**

- Use scientifically correct language.
- Use the same tense throughout the report (past tense / passive voice). Some exceptions may apply, such as when referring to figures and tables in the Results section, or when discussing possible future development. A passive voice means writing “the sample was applied” and not “I applied the sample”.
- The level of the report should be such that another student at the same level of education is able to understand the content.
- Strive to describe the experimental methods clearly enough to allow for the experiments to be repeated by the reader.
- Use pictures, tables and figures in order to clarify descriptions of methodology and results. Be sure to refer clearly to these items in the text.
- Consider the outline of the report and think about paragraphs and sub-headings that make it more readable.
- Remember that all parts should be coherent and be linked to the aim. If supplementary material is provided as an appendix, this must be referred to in the text.

## REPORT INSTRUCTION

Title: XXXX

Name: YYYY

For these items there is a special template, to be completed with a thesis number. This information is obtained by the administrator. NOTE! Make sure that the title clearly reflects the contents of the thesis report.

### Abstract

This is a brief description of the aim and methodology, and the main results and conclusions. This should be written in a motivating manner and give the reader a clear overview of the most important parts of the report. Typically 150-200 words. If the report is written in Swedish, a complementary abstract in English should be included as well.

### Statement of Authorship

If the thesis was carried out together with another student a contribution report is given here. If the thesis work was performed individually, this section is omitted.

### Abbreviations

Here, recurring abbreviations are listed to assist the reader. NOTE! The first time the abbreviation is mentioned in the text it should be written in full as well.

### Contents

Start the page numbering at the same page as the section Introduction (see below). Most word processors offer automatic page numbering and a contents template. The use of these is recommended.

### Introduction

Should contain an extensive description of the background and the aim of the current study.

#### The following should be included

- a description of the current state of knowledge
- a description of the current level of technology (*engineering students*)
- a description of the purpose of the study, for example, desired new knowledge, a more developed product or a new/improved method through a clearly formulated problem
- a description of how the problem stated in the purpose has been previously studied/addressed and how it will be addressed in the present study

- a description of the relevant methods in a comprehensive manner: first, previously used methods which have given important information, secondly, methods not used in the past but of interest to explore within the thesis work. NOTE! A detailed description of the methods used in the study is provided in the Materials and Methods section.
- information about project boundaries (if necessary)
- a reflection upon any ethical issues linked to this knowledge/technology
- a brief description of the societal relevance (impact) of this field of knowledge/technology and how the project may make a contribution, for example, by being related to industrial production, environmental work, forensic analysis, drug discovery, disease diagnostics, etc.

All information must be supported by relevant scientific literature and references must be correctly given.

## **Process\***

This section should be included in a report that will form the basis for an *engineering degree* but can be provided as an appendix. If you do so, it is important to clearly refer to the appendix in the introductory part of the report. Use the planning report as the basis for this section.

The Process section describes the planning of the work flow and how the work progress will be followed up. It is recommended to start by setting up a timetable, for example as a GANTT chart. Start with an introductory sentence saying that a time plan was established when planning the work. There are several benefits with a time plan: By arranging all intended activities/sub-projects in chronological order and by estimating the time needed for each of them it will be possible to continuously and systematically analyze and evaluate the progress of the project.

### **1. Timetable**

The chronological timetable includes a detailed description of planned activities and the estimated time for each of them. When constructing the timetable, consider the goal and the activities required to achieve it. The plan should be written with several concrete milestones, to allow for continuous and systematic follow-up according to a documented plan.

### **2. Plan for systematic follow-up**

Contains a) plan and goal for the next activity, b) implementation of the activity c) analysis of results in relation to the plan and the goal of the activity, d) continue to the next planned activity or reschedule, e) repeat steps a-d until the work is complete.

## **Materials and Methods**

In this section, the methods used in the thesis work are described in detail.

### 1. Theory of methods

In most cases, it is justified to describe the theoretical principles of (one or several of) the methods used. It is often useful to illustrate with figures and, also, remember to comment on the limitations of the methods (if important). NOTE! If the thesis work is carried out in the area of Chemical Analysis Engineering/Kemisk analysteknik, it is customary to write a section on theory that will be presented under a separate heading called "Theory". The Theory section should be placed before the section of Materials and Methods, and it should include a description of the principles of the methods used. In Materials and methods on the other hand, the exact conditions use in the current study is specified, i.e. as is mentioned in paragraph 3 below.

### 2. Models

If mathematical models have been used, they should be described here. If a statistical analysis of results has been performed, the statistical method should be described as well.

### 3. Experimental

Here, materials, exact procedures and conditions are specified. The report should be brief but detailed and written so that the reader would be able to repeat the experiments. It may be appropriate to divide this section by method. If advanced instruments have been used, brand and model name should be stated. If non-standard chemicals have been used, it should be indicated which company supplied them.

## Results

All results that emerge during the process are described here. This section should contain two parts: final results and a process analysis\* (unless the latter is instead provided as an appendix, in which case the reader should be referred there).

### 1. Final results

Here are described, in text, tables and figures, results that have generated new knowledge or a new product. A 'product' should be understood in a broad sense and could be a chemical method, an organic molecule with certain properties, an enzyme with a new catalytic activity, a sensor that detects the level of something etc. Strive to construct self-explanatory figures and tables by letting the captions be as informative as possible. Be sure to refer to tables and figures correctly in the text. If a statistical analysis of data is appropriate, this must be done and reported.

### 2. Process analysis\*

This analysis of the process is related to the planning report and to the timetable specified in the Process section. The implemented process should be described stepwise and in chronological order, focusing on the planned milestones. A typical outline might be:

**Step 1** An intermediate result: Briefly describe the analysis made and indicate which decision was taken for the next step, either 1) to proceed according to the original plan, or 2) to change the plan. If the latter was chosen, the change must be clearly described.

**Step 2** As above, etc.

## Discussion

The discussion can be divided into several parts and a possible outline is given below.

**i) Analysis of the main results**

What new knowledge has been generated from the results? Have all the results been commented upon? Has the study given the basis to solve the task? If only some of the goals have been achieved, what is missing and how can we move on? Are the results relevant and are there limitations to consider? Are there any alternative methods that could have given a more accurate result? Are the results statistically significant or are there uncertainties? Are there any weaknesses or errors? NOTE! Be sure to refer to the aim of the project!

**ii) Comprehensive analysis of the process\***

How well was the original plan followed? What important changes were done? How effective was the process for achieving the desired goals? This part may result in a recommendation of what an effective process should look like.

**iii) Impact in a broad sense**

Can society benefit from the results in any way? This should be discussed regardless of whether the work was focused on generating fundamental knowledge or developing a process, method, or product. The results may give the public a better understanding of natural phenomena or provide new conditions for today's rapid high-tech development, they may be useful in the industrial development or testing of a product or process, or they may be relevant for ecological and social sustainability development as tools for disease diagnostics, forensic analyses and so on.

**iv) Ethical implications in a broad sense**

Are there any ethical considerations that should be discussed? Are there any safety or environmental regulations that are important to take into account? Can the results obtained in the study be abused and used for a different purpose? Have people who have provided samples (if any) agreed to them being used in the study? Was animal testing necessary or are there alternative models? What values should we stand up for – is there any risk to the environment or anybody's health? Any other issues?

Finish the section with some **future perspectives** where the further development of the project is discussed. Another section, **Conclusions**, where the main results are listed might be added.

## Acknowledgments

Thank those people who helped and supported you during the project work. Are there any companies or funding bodies who made the study possible and should be mentioned?

## **References**

References in the text are listed here. Use the system that is common in the field. NOTE! Ensure that the work is related to current research and development by choosing relevant scientific sources. This means original articles and review articles in scientific journals. Unreviewed Internet material may not be used – make sure to refer to primary sources. The university library can assist in finding relevant sources. Manuals etc may only be referred to occasionally, and not without citing scientific papers in the field as well. For more information on citation and referencing, visit the library website:

<http://www.bibl.liu.se/citera-och-referera?l=en&sc=true>

## **Appendix**

This section can include raw data and detailed descriptions of the results and other observations that may be of interest to a specialized audience, but that should not be a part of the report. The description and analysis of the process can also be provided here. In that case, there must be references to the Appendix section in the Introduction and Results sections.