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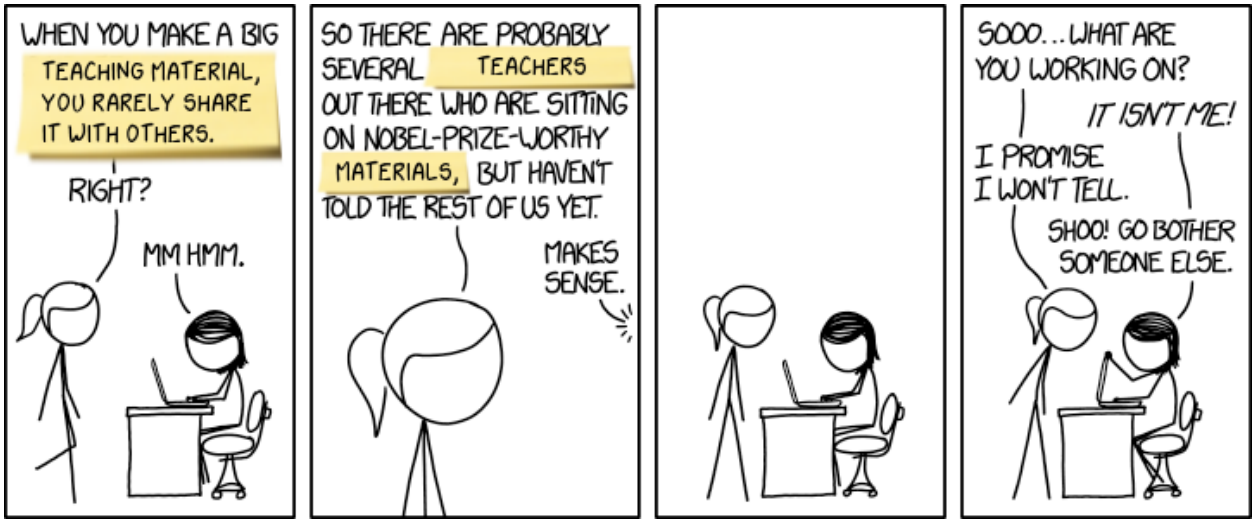


# Accessibility of Teaching Materials

## Exploring Obtainability and Testing Usability in Design of Shareable Teaching Materials

Master of Science thesis in Learning and Leadership

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SEBASTIAN EVERETT ERIKSSON

Department of Communication and Learning in Science
CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover: The comic strip is an adapted version of the *xkcd* webcomic strip called *Unpublished Discoveries* and aims to illustrate a teacher's unwillingness to share teaching material. In this study it is suggested one should instead request feedback from others during the design process, as a means to improve the end result.



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# Abstract

In an age where open-source and creative commons flourish, this report proposes a framework for creators of teaching materials to share and develop these collectively.

For shareable teaching materials to work as intended, they need to be accessible to possible recipients. In this study, accessibility is defined as being obtainable and usable. The recipients have been delimited to only include teachers.

This study aims to find out how design of teaching materials can affect their accessibility. This is mainly done through usability testing the teaching materials with the help of teachers and teacher students. Data collected through these tests are used to identify shortcomings in accessibility. The teaching materials are then revised with regards to these shortcomings. The teaching materials in this study had been created in advance on a triannual workshop called Kleindagarna.

A new methodology was created in this study, pertaining to theories of project planning. This methodology was named KRUT and is based on Adaptive Software Development (ASD), a variant of agile project management, found in computer science and IT. This methodology has been presented as a deliverable. Connected to this deliverable is also a Swedish usability testing manuscript, inspired by a usability testing manuscript created by Steve Krug. These deliverables enable teachers and others to implement usability testing in their own work. It is recommended that any creator of teaching materials, not only teachers, implement usability testing (for example the KRUT-methodology) to improve their materials.

The results of this study indicate that teaching materials can be placed on a scale between abstract and concrete. The concrete teaching materials are generally more appreciated by teachers and are easier to understand. One way to make a teaching material more concrete is to design it around one or more student handouts. Based on this study, recommendations can also be made to try to make many small revisions, rather than a few large. One reason for this is that each new revision can be usability tested as soon as it is finished, which raises its potential.

Keywords: usability, obtainability, teaching materials, accessibility, Kleindagarna.

# Acknowledgements

Firstly, we want to thank every teacher and teacher student who usability tested teaching materials for this study.

We owe Samuel Bengmark, our examiner at Chalmers as well as our closest contact to Kleindagarna, some very special gratitude. He was the one suggesting the teaching material from Kleindagarna as a viable resource for our study.

We want to thank Torbjörn Lundh for giving us some valuable insight regarding Kleindagarna, its history and the challenges of designing specific teaching materials.

We also had the enormous pleasure of having Mats Ander as our supervisor at Chalmers, something we are incredibly grateful for. He introduced perspectives we had not thought of and pointed out where we should aim our effort.

Our near and dear get our final thanks, for supporting us through this unique part of our lives. And for continuing to support us in our future endeavours.

Sebastian Everett Eriksson & Håkan Andersson, Gothenburg, August 2018

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# 1

# Introduction

Teachers often design their own teaching materials. Many problems may appear when sharing these materials with each other, including: misunderstood abbreviations, unclear purpose and structure, and lack of adaptability that require time and resources for reworking the material.

## 1.1 Definitions

The title of this study is "Accessibility of Teaching Materials". It is therefore important to start defining what the words *accessibility* and *teaching material* mean in this study. There will also be a definition and short introduction of the phrase *usability testing*, an important part of this study.

### 1.1.1 Defining *accessibility*

This study focuses on how design of teaching materials affect their *accessibility* from a teacher perspective. This is important to remember, as the study has not collected any data from students. Assumptions are however made that the teachers involved in the study have their students' interests in mind, and that improvements on teaching material accessibility for teachers will trickle down as improvements on for example student learning. Accessibility in this study is further defined via one of its definitions in the Oxford dictionary (Oxford Dictionaries | English, 2018):

> "The quality of being easy to obtain or use."

Based on this quote we can write accessibility as:

> ***accessibility = obtainability + usability***

### 1.1.2 Defining *teaching material*

Further, we need to define the phrase *teaching material*. In the context of this study, they are materials that are used in a teaching situation with students, but chosen by the teacher, and that are shareable and reusable by many teachers. It's essentially a limitation of the concept of *OER*, or Open Educational Resources.

> "Open Educational Resources (OERs) are any type of educational materials that are in the public domain or introduced with an open license. The nature of these open materials means that anyone can legally and freely copy, use, adapt and re-share them. OERs range from textbooks to curricula, syllabi, lecture notes, assignments, tests, projects, audio, video and animation." (Unesco, 2012)

While OER can be used by students independently, this thesis limits its focus by defining teaching materials as such that are chosen and used directly by teachers. The reason for choosing this focus is because of the complex role a teacher plays in education. Although the Swedish education system consists of many other actors, such as students, principals, administrators, school curriculum writers, parents, and more, the teacher is often one who has to take into consideration the many different interests of these actors (Bengtsson & Selimovic, 2009). Thus, studying materials from a teacher's perspective brings many important organizational and leadership aspects, compared to only studying students' learning.

### 1.1.3 Defining *usability testing*

Usability testing is a method used in software development to discover usability problems in a cheap, efficient and easy-to-do manner. As the usability testing proponent Krug proposes, these tests can be used for other projects outside of software development (Krug, 2010a). This study explores the use of usability tests in the context of teaching materials, and how it can be done effectively, even by teachers without previous knowledge of usability design.

## 1.2 Background

Below is some background information about how teaching materials are used in schools, and about the specific materials that were used and tested in this study.

### 1.2.1 Teaching materials in different schools

Sharing materials between teachers can happen in many different ways, or not at all, in Swedish schools. In some schools, teachers prefer to work individually and do their

own thing. In others, they might have a shared hard drive on an internal network, or a school-wide computer system that every teacher uses. It is also possible for separate teacher groups to collaborate in different ways over different subjects.

Together with schoolbooks, and other external solutions, shared teaching materials comprise a system that can both help and limit a teacher's work process.

### 1.2.2 Kleindagarna

For this study, all the teaching materials tested were created by a triannual three-day workshop called Kleindagarna. Kleindagarna is organized by the Swedish Committee for Mathematics Education (SKM), the Swedish National Committee for Mathematics (KVA), the Institute Mittag-Leffler and is funded by Brummer & Partners. (Kleindagarna, 2018a)

At this workshop, maths teachers from upper secondary school meet up with professors and maths teachers from universities and colleges at the Mittag-Leffler Institute outside Stockholm. During the workshop they collaborate to produce teaching materials in mathematics. These teaching materials are meant to be used for teaching upper secondary school, and often touch subjects that are not typically found in course literature.

### 1.2.3 The 5E Instructional Model

At Kleindagarna, teachers are encouraged to use the 5E when designing teaching materials. 5E is basically a way of structuring lessons, created by The Biological Science Curriculum Study (BSCS) on a foundation based on constructivist pedagogy. (NASA, 2018)

The different phases of the 5E model are:

> "*ENGAGE*: The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.
>
> [...]
>
> *EXPLORE*: The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.
>
> [...]
>
> *EXPLAIN*: The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means.

> [...]
>
> *EXTEND*: The purpose for the EXTEND stage is to allow students to use their new knowledge and continue to explore its implications.
>
> [...]
>
> *EVALUATE*: The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place."
> (NASA, 2018)

Note that the phase *EXTEND* is often called *ELABORATE* instead.

## 1.3 Delimitations

This study focuses on how design of teaching materials can improve their accessibility for teachers, hopefully improving education on many levels. The aim of this study is however not to explore these levels further. This is similar to how improving accessibility (usability and/or obtainability) of a website is good practice. For websites, positive effects of improved accessibility can be improved functionality, increased sales, improved first impression, etc. For teaching materials, these effects include increased student learning, improved lesson planning, and more. As mentioned earlier, measuring these effects are not a the focus of this study. This report does not put considerable effort in researching or testing sustainability aspects, for example what impacts shareable teaching materials have on schools in exposed areas and the environment.

## 1.4 Relevance

Teachers all over the world create and rework materials usable in teaching situations. Some are shared but most are presumably part of its creator's personal collection of *materials usable when needed*. This suggests there is potential gains both in time and quality, provided there is a suitable platform for efficient sharing of teaching materials. With a platform for sharing teaching materials, obtainability of these materials are greatly improved. However, the teaching materials on this platform could have been created only to be used by the original creator, and can therefore lack when it comes to usability. To improve on the usability aspect, this study suggest usability testing as a means to give designers the feedback needed to improve the materials most efficiently. Creators of teaching materials act in different environments; some are teacher, others are authors of non-fiction, etc. This report delivers a method as a way to advocate incorporating usability testing in their field.

## 1.5 Research Questions

More specifically, this study aims to answer the research questions below:

1. What results are produced when applying Krug's usability testing method on teaching materials?
2. What challenges might teachers run into when attempting to perform usability testing on teaching materials, and how might they deal with these challenges?
3. What factors do teachers consider when deciding on how to use a teaching material?
4. From the perspective of a technological system, how can usability design for teaching materials be used to help teachers?

# 2

# Theory

## 2.1 Project types

When working on a project, it can be advantageous to identify what kind of project it starts off as. One model put forward by Obeng (1996) describes four project types. This is roughly the same model presented by Dombkins (1997), both of which are revised versions of a model made by Turner & Cochrane (1993). Instead of labeling them Type 1-4 or Type A-D, Obeng made the labels descriptive.

The project types each answer yes or no to the two questions: *Is the project objective clear?* (or *Is it known WHAT the project is?*) and *Are the project methods clear?* (or *Is it known HOW the project will be done?*).

**Table 2.1:** Turner & Cochrane, Dombkins and Obeng described the same type of project differently.

| What | How | Turner & Cochrane | Dombkins | Obeng | Example project |
|---|---|---|---|---|---|
| yes | yes | Type 1 | Type A | Painting by NUMBERS | Engineering |
| yes | no | Type 2 | Type B | Going on a QUEST | Product development |
| no | yes | Type 3 | Type C | Making a MOVIE | Application development |
| no | no | Type 4 | Type D | Lost in a FOG | Research |

Obeng visualized these projects with a 2-by-2 matrix. Although the types are categorical, the axes are continuous. This means that a project can be represented by a point somewhere within the matrix.

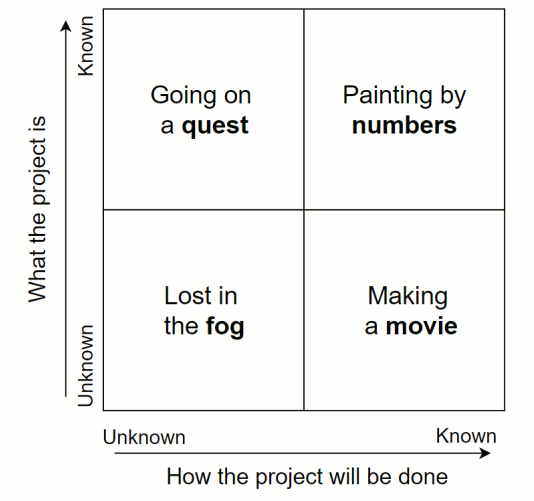



**Figure 2.1:** A redrawn illustration of Obeng's 4 project types. (Obeng, 1996)

Robert Buttrick (2009) took Obeng's matrix further, introducing arrows to visualize that projects can change type as they progress. This is done by defining previously unknown HOWs and/or WHATs.

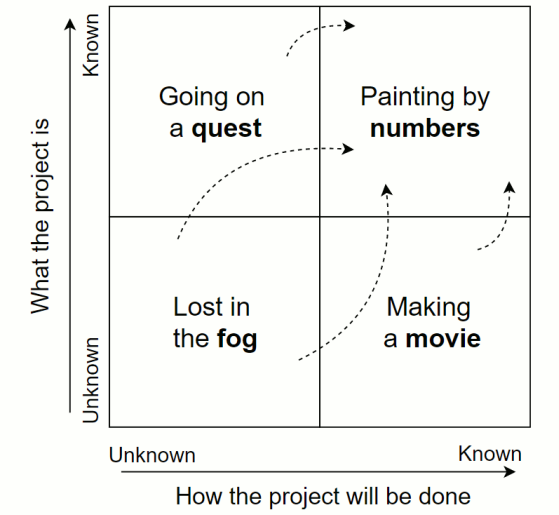



**Figure 2.2:** Projects usually resemble a NUMBERS-project more as they progress. (Buttrick, 2009)

Depending on the type of project, Obeng suggests different approaches to progressing them. If the WHATs and the HOWs are known, it gets easier to estimate the cost, time and result of a project. Conversely, a project with more unknowns requires work before it starts to look promising. The work required before projects with many unknowns show promise can vary, which is why Obeng recommends that at least the initial processes of these projects should follow an agile (iterative and/or parallell) methodology. Generally, projects closer to FOG benefit from agile methodology and projects closer to NUMBERS benefit from waterfall (linear) methodology.

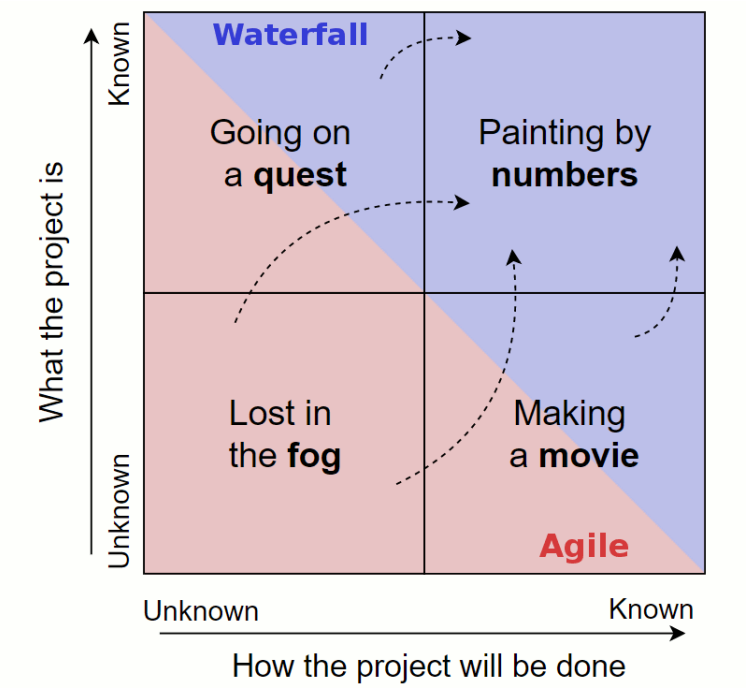



**Figure 2.3:** Projects closer to a NUMBERS-project benefit more from a waterfall methodology. Projects farther from a NUMBERS-project benefit more from agile methodology. (Obeng, 1996; Buttrick, 2009)

### 2.1.1 Types of teaching material projects

It can be argued that designing teaching materials can start off as any type of project.

One project may for example start with a set of inspirational resources, and the designer knows exactly what to add and what to remove to finish the project. The designer has a clear vision both concerning the WHATs and the HOWs of the project, making it a NUMBERS-project.

Another project may stem from a forced need of new teaching materials, because of a govermental decision to introduce programming in mathematics. The WHATs are somewhat known but if it is unknown how to reach these objectives, the project start off as a QUEST-project. If this project would be riddled with more question marks, for example if it would be unclear what programming language (if any) should be used and on what level the programming should to be taught, then the WHATs are less known and the problem would therefore start as a FOG-project.

Designing a teaching material as a MOVIE-project would be if the designer had all the skills (pedagogical, technological etc.) needed to create the teaching material, but did not know at the start of the project what content the teaching material should include or what objectives should be met.

### 2.1.2 Types when revising teaching material projects

When a teaching material has been created, more or less successfully, the teaching material can be used in a new project aiming to improve it. The teaching materials may not only change HOW the previous objectives are met, because it may sometimes prove beneficial to also change WHAT the objectives are. These projects therefore start as FOG-projects.

## 2.2 Franklin's theory: Technology as a system

Since it is not obvious what the implications of shared teaching materials could be, it is important to stay critical and discuss the effects of certain material designs during the study. A certain perspective that can be used is one by U. Franklin, in the book and lecture series The Real World of Technology (Franklin, 1990). In it, she discusses technology as a complex system:

> "Technology is not the sum of the artifacts, of the wheels and gears, of the rails and electronic transmitters. Technology is a system. It entails far more than its individual material components. Technology involves organization, procedures, symbols, new words, equations, and, most of all, a mindset. [...] Personally, I much prefer to think in terms not of systems but of a web of interactions. This allows me to see how stresses on one thread affect all others. The image also acknowledges the inherent strength of a web and recognizes the existence of patterns and designs." (Franklin, 1990, p.16 & 95)

Since teaching materials encompass both a way of working and artifacts, they can be viewed as a technology, as defined by Franklin. As such, they affect how a teacher does their work in complex ways. For example, as Franklin also notes, materials can be used both to assist teachers in their lesson design, or to make them comply to certain standards and control structures. Therefore, it becomes important to consider effects on the teacher's work as a whole, instead of limiting the analysis to a specific lesson.

An important aspect of these systems of technology that Franklin defines is the difference between *holistic* and *prescriptive* technologies. In short, these can be described as the difference between an early industrial factory worker and an artisan: While the artisan maintains control over how they do their work throughout the whole production process, the factory worker works only on a specific task in a process controlled through strict social structures. The artisan relates to the holistic technology, while the factory worker relates to the prescriptive technology. Franklin further comments that, while prescriptive technology can be efficient and productive, it comes with a big social mortgage of a culture of compliance, and there only being one way of doing something.

## 2.3 Krug's theory: What is usability, and how do you test it?

Steve Krug is a usability consultant who wrote books about usability. His usability books are mainly focused on websites, but as he writes himself, his methods are applicable on other things as well.

Krug defines his first law of usability as *"Don't make me think!"*, implying that users should understand what a website is and how to use it without expending any effort thinking about it:

> "A person of average (or even below average) ability and experience can figure out how to use the thing to accomplish something without it being more trouble than it's worth." (Krug, 2014, p.9)

Aside from a few principles of usability, Krug puts a lot of effort into describing the usefulness of usability testing and how to do such testing in a cheap and easy manner. In his book specifically about usability testing, he defines such tests as:

> "Watching people try to use what you're creating/designing/building (or something you've already created/desgined/built), with the intention of (a) making it easier for people to use or (b) proving that it is easy to use."

Or, in simpler terms:

> "A facilitator sits in a room with the participant, gives him[/her] some tasks to do, and asks him[/her] to think out loud while he[/she] does them."

### 2.3.1 Making usability testing scientific

One important difference between Krug's method and the method used in this thesis is that Krug's focus is not to be scientific, but to merely improve what one is building (Krug, 2010a). Thus, certain parts of his method have been adapted to make it easier to analyze:

1. In contrast to Krug's method, the tasks in the tests are not altered mid-test. This makes them more comparable.

2. There is more data gathering involved in the form of recordings and notes, rather than having a group of observers watching the test, to make analysis and comparison easier long after the tests have been conducted.

### 2.3.2 Connecting usability theory for websites to teaching materials

One can argue that there is a large difference between teaching materials and websites. While in some cases these can be the same, such as online materials shared through a blog post, a teaching material can sometimes take the form of a book, a single PDF file, and more. All the materials have in common is that they are used to facilitate and/or empower a teacher's work. However, usability testing is still clearly applicable in the sense that it consists of observing someone using what you are testing.

Since teaching materials can be used in many different ways, the use case had to be narrowed down. Thus, in this thesis, the use case that the usability tests cover consist mainly of how teachers use teaching materials to plan their lessons. This does not mean that other use cases are ignored, such as a teacher simply using a material to learn more about a subject. However, the lesson planning is the main focus of the usability testing in this thesis.

## 2.4 Adaptive Software Development

The main method of collecting data for this study consisted of a process inspired by Adaptive Software Development (ASD). This method involves iterative development with strengths that fit this study, such as being flexible and low risk. This can for example mean that new information can be easily adopted in future tests and that results can be delivered even if test subjects decide to terminate involvement in this study early. (Sommerville, 2016)

ASD is an antecedent to Agile Software Development, paving the way for popular project management methodologies such as Scrum and Kanban. The methodology for this study has no need of being as complex as Scrum or Kanban, one of the main reasons being the relative small size of the development team (i.e. the two authors of this paper), whereas for example the Scrum model is generally used by splitting a larger workforce in teams of 3 to 9. (Schwaber, 2004)

As can be seen in Figure 2.4 ASD consists of three stages with a feedback loop, enabling developers to perform multiple iterations of improvement based on what they learn from users. This model is similar to the methodology that was developed in this study to collect data on usability of teaching materials. (Highsmith, 2000, p.84)

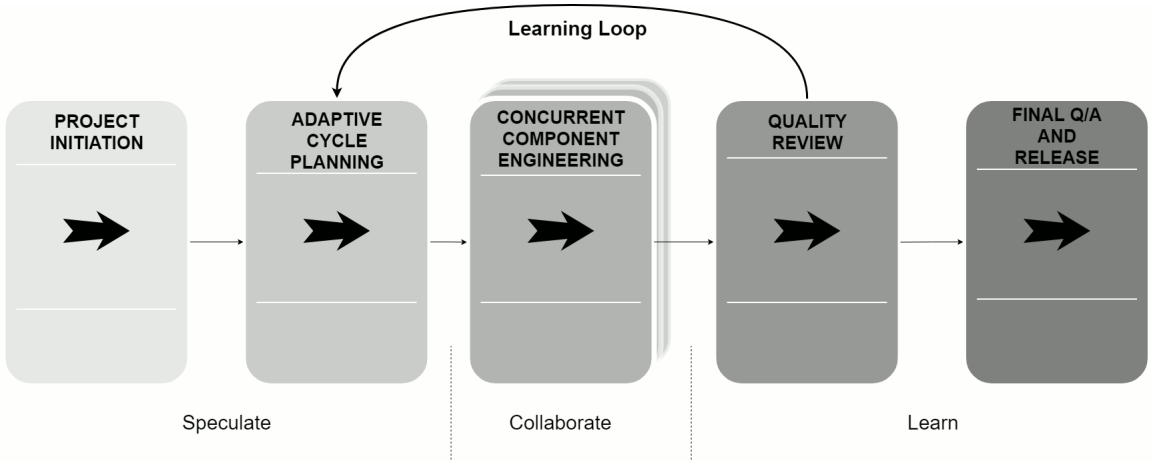



**Figure 2.4:** A redrawn illustration of the ASD model

# 3

# Methods

One goal of this thesis is to study how usability tests can be done on teaching materials for teachers, and not just for research studies like this. Therefore, a more generalized methodology was created during the planning of the thesis, and was refined in the same way the methodology describes as the methodology was applied during the study. Thus, the methodology was both part of the results and part of the method. Because of this, the methods chapter is divided into two parts: First, the methodology is presented, and then the more specific methods used in this thesis are described more in detail.

## 3.1 The KRUT-methodology

In the planning phase of this study, a new methodology was developed for usability testing. The methodology was named KRUT, from the processes involved; **K**ick-off meeting, **R**evising material, **U**sability **T**esting. Developing KRUT helped clarify what the study did and did not aim to investigate and how that was expected to play out. As with ASD, KRUT includes a learning loop. The main purpose of KRUT is to use data collected by usability testing a teaching material to revise said material. Usability testing fills two roles; ***identifying satisfactory usability*** as well as ***identifying potential gains in usability***. KRUT also describes the roles of the different actors, based on the current stage of the testing phase. It is designed with a team of two and a single subject group in mind. The KRUT-methodology is described in figure 3.1.

### Comparing ASD to KRUT

There are both similarities and differences when comparing ASD to the KRUT methodology presented in figure 2.4 and figure 3.1. To compare more easily, KRUT-processes are written in in bold and ASD-processes are bold-italics.

The **Kick Off Meeting** used to introduce one or more teachers to the study, as well as deciding on a teaching material to work on and a date for the first usability test, is comparable to the ***Project Initiation*** of ASD, being prior to the steps contained inside the ***Learning Loop***.

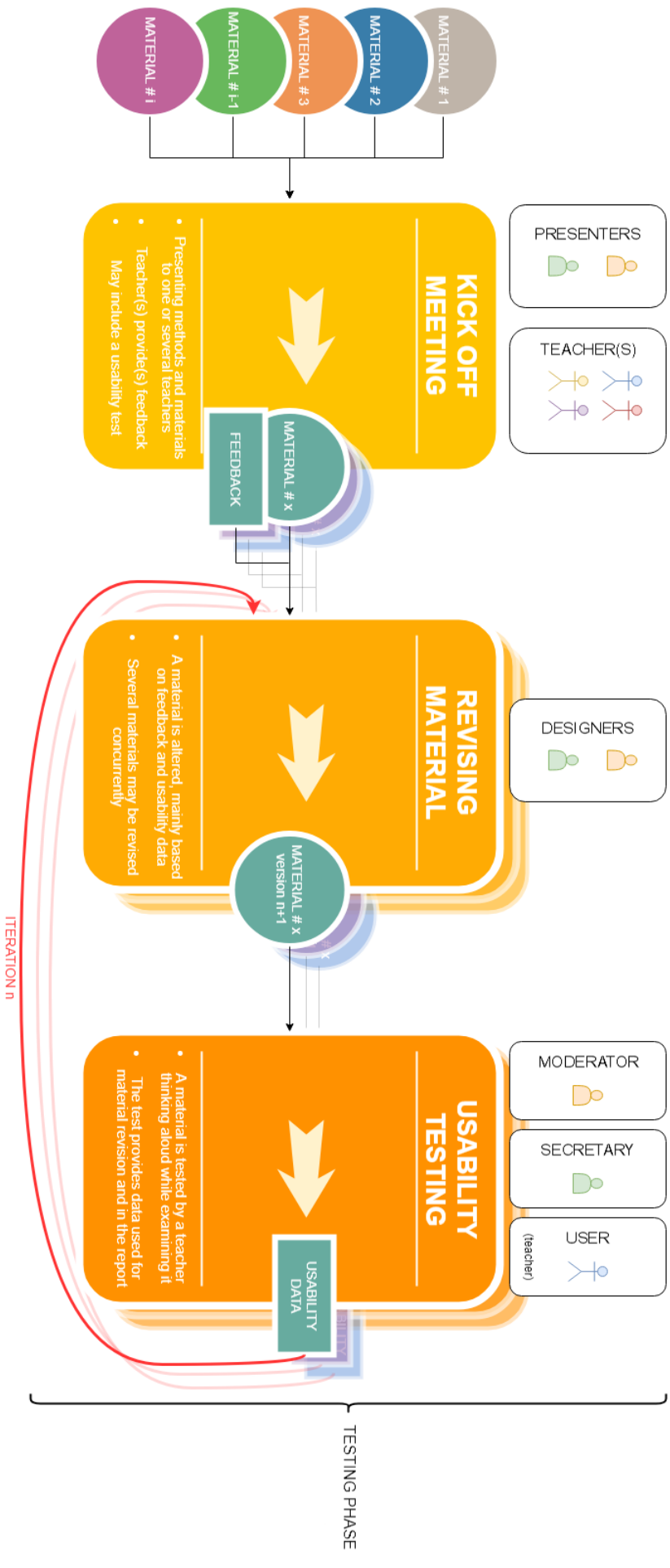



**Figure 3.1:** The custom KRUT-methodology, created for usability testing teaching materials

What in the ASD methodology is called ***Adaptive Cycle Planning*** is the initial step of the **Revising Material** stage, deciding on how to rework the teaching material based on the data collected from a **Kick Off Meeting** or previous **Usability Test**. This is inevitably one of the stages where collected data is summarized and analyzed, even if just as a thought process.

The ***Concurrent Component Engineering*** part of ASD is practically the same as the **Revising Material** stage. This is where a coder would revise the code of the program and this is likewise where the product, the teaching material, is being worked on with the intent of improving its usability.

What is called ***Quality Review*** in ASD is the **Usability Testing** part of KRUT. This is where the teaching material is tested on a teacher and the data needed to improve the usability of the teaching material is collected. The method used to test usability is based on Krug's script for usability testing websites (Krug, 2010b). Because a teaching material is quite different from a website, oftentimes focusing on interactivity, the script could not be used without some changes. There is however some important aspects of Steve Krug's script, e.g. not asking leading questions, that is of great importance to the quality of the data and thereby the quality of future revisions of the teaching material.

The end goal of ASD is called ***Final QA and Release***. In the case of KRUT, this step has been reduced. Its original intent is to finalize a product, whereas KRUT defines every revision as an equally valid product, even though the latest revision would theoretically be the most desired.

## 3.2 Implementation of the KRUT methodology in this thesis

The specific method used in the study differed in certain ways from the metholodogy, for multiple reasons. One of these reasons was that the metholodogy was designed with practical testing in mind rather than scientific testing. Another important reason was that the thesis also studied *obtainability*, while KRUT was mainly designed to test *usability*. Following is a list of details on how specific parts of KRUT were implemented.

- Obtainability was tested by adding a list of a materials to the test. The test subject picked the teaching material to be tested from the list of materials, which also acted like a usability test of the list itself. The results from this part of the test served as a basis for answering research question 3, about how teachers choose materials.

  The list of materials was developed from a list on Kleindagarna's website, which was remade and revised continuously as feedback was collected from the tests.

- Test subjects consisted of individual teachers and teacher students, instead of a team of teachers. This was mainly due to practical reasons: Individual teachers were easier to find and coordinate than whole teams. This also meant that the Kick Off Meeting was much shorter and done instantly before the test itself.
- To simplify coordinating the tests, many tests had a single person act as both moderator and secretary during the Usability Testing phase of KRUT. This meant that tests could be done more spontaneously and according to the test subject's needs.
- A usability testing script was created, see Appendix B.2, inspired by Krug's script (Krug, 2010b).
- Two tests were recorded with video and audio, and nine tests were recorded with written notes. No tests were transcribed through written notes. Information about the test subject was written down in a template in the test script. More information was recorded than what is recommended when using KRUT for non-scientific reasons, since recorded results are more important in science to make the research more reliable.
- The revisions of the teaching materials were done in between the tests, but not strictly directly after every test. This is because more revisions were required as the teachers had many different materials to pick from. Doing tests was instead prioritized over doing revisions, and revisions were sometimes postponed in favour of tests. In total, five teaching materials were revised.

  Another reason for prioritizing tests over revisions was due to revisions initially taking longer than expected. This led to a decision on prioritizing shorter changes and preserving as much of the original material as possible, which shortened time spent per revision significantly.

### 3.2.1 Result analysis methods

Analysis of the test results was in two phases: Continuously during every material revision, and once after all tests were finished for the final report. The continuous analysis was done ad-hoc according to the needs of every revision, mostly consisting of summarizing the changes to be done while reading through the usability test notes. The final analysis was done by reading through all the usability test notes and summarizing the findings in a single document, including categorizing similar findings and counting in how many tests they appeared.

Since the tests were not transcribed, there was also some analysis done during each test whenever notes were written. This analysis consisted mostly of interpreting what the test subject said and how they reacted, for example if they reacted confusingly at the material's structure. However, no design decisions were made during this live analysis. Instead, the analysis in the written test notes consisted at most

of describing usability problems in the material, rather than coming up with a solution to the problems. For example, the following line, translated from Swedish, was written in the notes for test aD (see table 4.1):

> ”Becomes confused about how the material is structured. Part C, is that part of lesson 2?”

This line is a mix of what the test subject said and how they reacted. It is likely that they asked themselves whether "Part C" is part of "Lesson 2." When revising the material, this helped the person who revised the material to know that the document structure was unclear around Part C, and specifically that it was unclear what lesson Part C was part of.

### 3.2.2 Test subject anonymity

In this study some personal details were disclosed and some were held anonymous. What is disclosed and examples of what is held anonymous are listed below.

#### Disclosed information

- Age – rounded to nearest 5 years.
- Current status – if the test subject is currently working as a teacher and if so on what stage of education, or if they are e.g. studying to become a teacher.
- Years in teaching – nearest year if under 10 years, can otherwise be rounded to nearest 5 years. No regard to the age of students taught. No regard to full-time or part-time employment.
- Subjects – what school subjects is the test subject certified to teach or studying to teach?

#### Anonymous information

- Sex/Gender – the risk of a reader finding false correlations from the data is assumed to be greater if the test subject's sex and/or gender is disclosed.
- Name – the name of the test subjects will not be disclosed, and because the sex/gender will not either, the label of the test subjects will also be as gender free as possible.
- Name of school – with this information, it would be too easy to identify the test subject.
- Place of school – all subjects studied will live and work in close proximity to Gothenburg, Sweden, as it has been decided to delimit the tests to personal meetings.

# 4

# Results

Results can be presented in different ways. One way would be to describe the usability tests in detail, and another way would be to only summarize the results in table. By describing all usability tests in detail, it would be hard to get a good overall view of the findings. Focusing more on something also means focusing less on something else, and there are other parts of the documentation that deserve that attention more. It would therefore not be ideal to do lengthy elaborations on each teaching material. On the flip side, only giving a summary on the findings would leave out describing the crucial process. The process mainly includes:

1. Performing a usability test
2. Identifying what can be learned from the data
3. Figuring out how the particular teaching material can be improved from the data
4. Revising the teaching material (preferably in an effective manner)

The ideal way of delivering the results should entail a compromise between these two extremes. The finding has therefore been divided into a sample case and a summary. The sample case describes a teaching material thoroughly, delving into details of the process and findings, exemplifying the usability testing process.

## 4.1 Summary of usability tests

Seen in table 4.1 is a summary of all the usability tests. Each test has a codename containing one lower case letter, referring to the material that was tested, and an uppercase letter, referring to the test subject. For example, test "nB" tested material "Nätverk - insamling av data" on test subject B.

Every test subject also has a longer codename containing their age, profession and teaching experience. This is according to section 3.2.2, about what information is disclosed about the test subjects. The format of this codename is as follows:

- A letter in alphabetical order chosen chronologically. For example, test subject

"B" was done earlier than test "D" but later than test "A".

- The age of the test subject, rounded to the nearest 25 years.
- The letter "T" if they worked or had worked as a teacher, or "S" if they were studying teaching.
- The total number of years they worked as a teacher, rounded up if less than 10, otherwise rounded to the nearest 5 years.

Thus, "A30T2" means test subject A is approximately 30 years old, has worked as a teacher, and has approximately two years of teaching experience.

**Table 4.1:** Summary of all usability tests of the study

| Test codename | Date for test | Material that was tested | Test subject |
|---|---|---|---|
| mA | 2018-04-24 | Mönster och talföljder - Pascals triangel ur slantsingling | A30T2 |
| nB | 2018-04-30 | Nätverk - insamling av data | B25S |
| lC | 2018-05-03 | Vad ska lotten kosta? | C35T3 |
| aD | 2018-05-09 | Konsten att bestämma arean | D35T6 |
| sE | 2018-05-09 | Område statistik | E40T4 |
| oF | 2018-05-14 | Modellering | F50T30 |
| nF | 2018-05-14 | Nätverk - insamling av data | F50T30 |
| mG | 2018-05-24 | Mönster och talföljder - Pascals triangel ur slantsingling | G25T2 |
| dG | 2018-05-24 | Den dolda och tvetydiga matematiken | G25T2 |
| dH | 2018-05-30 | Den dolda och tvetydiga matematiken | H25S |
| dI | 2018-06-12 | Den dolda och tvetydiga matematiken | I30T1 |

## 4.2 Preface to sample cases

Each teaching material tested has a different story to tell. Be aware that because these sample materials are described in detail, some of the content of the steps below are common to all teaching materials tested, while some are specific to the particular teaching material.

Every teaching material tested in this study were created at Kleindagarna. Unique teams for each teaching material, consisting of a handful of teachers, a subject expert and a Klein-representative are responsible for the version at the start of this study. When the workshop at Kleindagarna ends, the teaching materials are published on Kleindagarna's website.

## 4.3 Sample case 1. Kleinmaterial: Nätverk

Links to the material in its original and revised versions can be found in Appendix A.1. For an overview of the revised material, see Appendix A.2.

This teaching material dealt with networks and their applications in modern society.

### 4.3.1 Usability test I

The first usability test was performed by one of the authors of this report on the other author. As this was the second ever usability test performed, the intention was primarily to identify what to take into account for future usability testing and to identify the possibility of improving the usability testing methodology. The method consisted of following a script document on a computer including:

- A table made to be filled with personal information
- A list of keywords and questions (manuscript) inspired by the usability test script created by Steve Krug.

Results from this test included:

- Unclear if some tasks were meant to be executed by teacher or students.
- The material expected the teacher to be very familiar with the subject, tackling advanced areas of mathematics with mostly bullet points, expecting the teacher to provide the explanation.
- There was a concern on the material having too large scope. The material includes network theory, statistics, algorithms and data protection laws (GDPR), and aims to both explain and problematize all of these aspects.

### 4.3.2 Revision of methodology

After usability testing the teaching material, the authors identified that there was very limited information presented in the list of teaching materials on Kleindagarna's website. This made it difficult for the curious to know if the material was suitable for them. Because of that, a new list of teaching materials was compiled. This consisted of information not just what the subject of the material was, but also for what grade it was suited and a more detailed description of the teaching material. After the usability test, a discussion arose on what type of material the revisions would be. Two suggested possibilities were documents (i.e. pdf- or odt-files) and presentations (e.g. pptx-files). A document would have the strength of being easily skimmed and modified. A presentation would have the strength of being a ready-made lesson material, with the potential of not requiring as much planning time. The discussion culminated in the decision to choose type on a case-by-case basis. Some factors to take into account when deciding on the type would be: results from usability tests, perceived intent of original creators and what form would be most suited for the particular teaching material.

### 4.3.3 Watching the Klein-lecture

Before designing a teaching material, the participators on Kleindagarna receive a lecture by the subject-expert. This lecture was recorded and confidentially shared online. Before revising the material, it was decided that it would be beneficial to watch this lecture, to learn more about the theory the material was based upon and what the creators intended the students would learn.

### 4.3.4 Usability test II

The same revision was tested again. The test subject this time was a Klein-representative that had been involved in the creation of the original teaching material. Testing teaching materials on a subject that was not a teacher in upper-secondary-school or a teacher student aiming to teach at upper-secondary-school was not the norm. One purpose of this was to analyze how rewarding usability testing non-intended subject could be. The test subject also teaches mathematics on an upper-secondary school level, but to post-secondary school students (one additional difference is that the pace of the courses are comparably higher than in upper-secondary-school). These problems were found during testing:

- The teaching material was not considered complete by the creators. This was understood through the following quotes:

  > "This [material] can't be used [in a lecture], it's too vague."

  The target group for the material, in its current form, was not students.

  > "The way [the material] is written now, [it] was made for [the participants at Kleindagarna]."

- The biggest remaining problem of the material design lies in a the student activity (the *Explore*-phase of the lesson) where the class are to compile data to create a network. To be able to make the network and its analysis meaningful, it was suggested that the compiled data should be personal and able to lead to a finding. However this proved problematic.

  > "What was hard with this group was that they wanted to do something in the style of [the lecturer], something sociological. But this became so sensitive, almost every fun [study] we came up with became sensitive. [...] Social networks, when someone is an outsider, it's good for the teachers to know how it works, but to [show it to a class] is a different thing."

  Ultimately, the activity asks for generated data, instead of personal, more valuable data. The reason for this is because no conceivable alternative could eliminate the risk that personal data could result in undesirable findings. For example if the data collected answers what students had lunch together, outcasts are visible in the finding.

  > "[We ultimately decided] to randomize who played with whom, so that it became a made up network. [...] This was a way to create the same kind of graph, but harmless, which [unfortunately] makes it less interesting."

  The following quote supports both of the mentioned analysis results:

  > "[The study should be] something quite harmless, but [...] you want to see yourself in the network."

*Note:* the quotes have been translated from Swedish to English.

### 4.3.5 Revision of teaching material

From the data collected, the following revisions were made: A decision was made to revise the material in the form of a presentation, with the aim to offer a ready-made presentation with enough explanation of the required theory to be a desirable product. To realize this, changes were made to the structure and to content.

#### Structural changes

- The separation of information to the teacher and the main presentation was improved by implementing tabs similar to how many websites function (see figure 4.1). This also clarified the structure to the user, enabling the user to quickly get an overview of the structure.
- The presentation's first slides contain useful information targeted to a curious teacher including how to read the important presentation notes (as these consists of teacher instructions and explanations). Previously, the first slide contained information on who had created the presentation. As this information was deemed less important than what the presentation actually encompassed, this slide was moved to the end of the presentation instead.

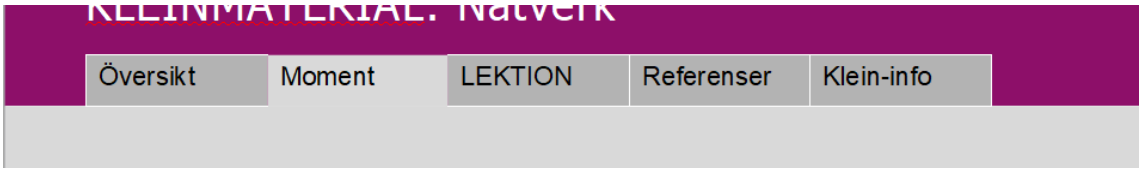



**Figure 4.1:** Tabs were introduced to give an overview of the material.

#### Content changes

- As mentioned previously, the presentation contains teacher instructions and explanations in the form of presentation notes. These can be printed or read in the presentation program, and also viewed while presenting (see figure 4.2). This was previously missing from the teacher material, or carelessly intertwined with content that seemed to be aimed to students.
- Activities were altered to be either less vague or more closely tied to what the students are expected to learn.
- The content was modified to be easily understood and conveyed. An example of this was replacing the headings so that they describe their respective slide, instead of being named after the current 5E-phase.

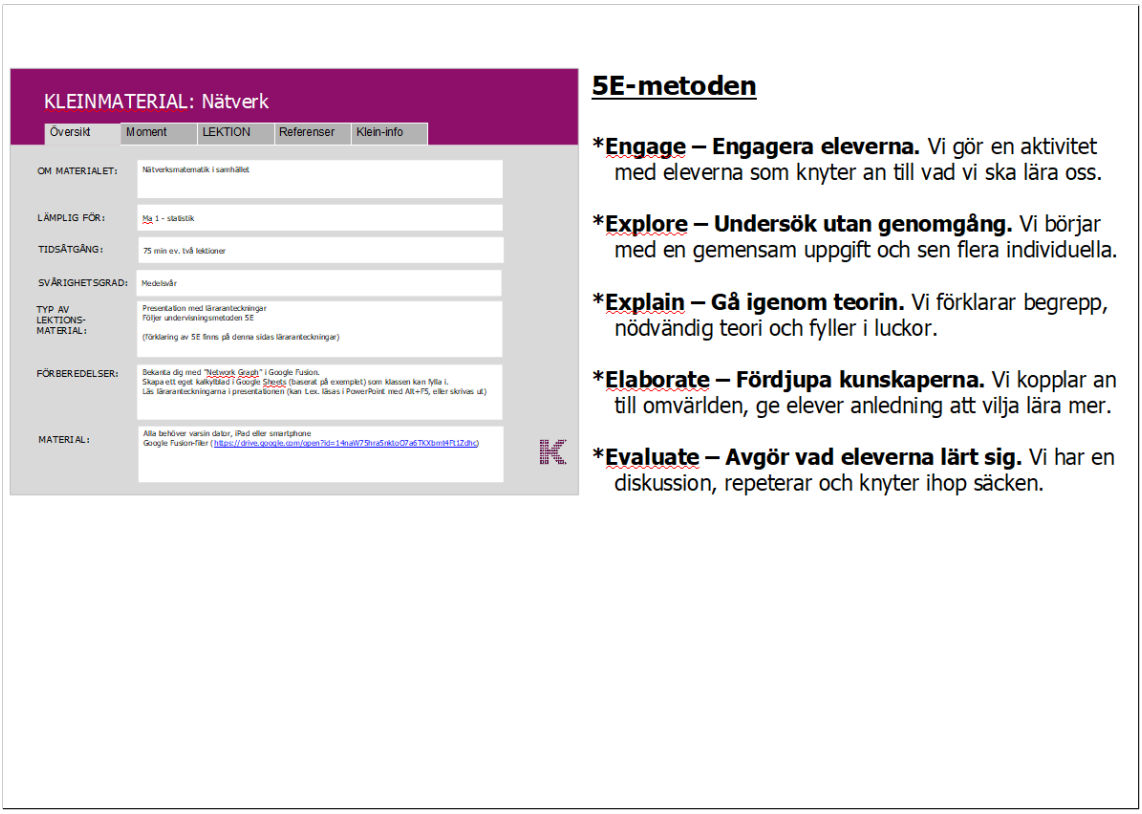



**Figure 4.2:** Presentation notes were introduced, to separate content aimed at teachers from content aimed at students.

### 4.3.6 What was learned from this case?

From this particular case, the following knowledge was obtained:

- Someone involved in the creation of a teaching material can have a very different experience and connection to the teaching material than what is conveyed to a reader. Maybe there is a part the creator is not satisfied with, but the reader might assume it is meant to be complete and only understand it as poorly made. This exemplifies the flaws of one-way communication.
- There needs to be a decision on how the teaching material is presented and what it aims to be. It can be everything from inspiring reading material to a documentary.

## 4.4 Sample case 2. Kleinmaterial: Vanliga missuppfattningar

Links to the material in its original and revised versions can be found in Appendix A.1. For an overview of the revised material, see Appendix A.3.

This teaching material concerned common misconceptions in mathematics. It had a list of exercises in the beginning and a list of correct answers in the end. In between these lists, it had a lesson plan. One of the main points of the material was to categorize different mathematical exercises as "beräkning" (calculation), "förenkling" (simplification), and "ekvationslösning" (equation solving).

### 4.4.1 Usability tests and problems found

There were three relatively similar usability tests done on this material. The tests revealed that the material had some problems with structure and explaining what the exercises were supposed to teach. All subjects understood the main points of the material eventually, but it took them a while to dos o. In order of the tests done, these problems were found:

- In test dG, see table 4.1, the meaning of the different categories were unclear at first. The test subject first thought the exercises were examples of solutions rather than exercises. They first expressed the following about the exercises:

  > "I think I understand what they're after, but it is a bit difficult to say if something is a simplification or a solution to an equation."

  Then they realized that it was a list of exercises rather than solutions:

  > "Oh, they mean that this [exercise] can be simplified, this can be solved as an equation, and this can be calculated."

  The subject also expressed that it took a lot of scrolling up and down to connect this first list of exercises with the lesson plan.

- The test subject in test dH expressed directly that they wanted a written purpose, connection to the curriculum, and time estimations. They expressed a need for more descriptions in general since the material was lacking an introduction or background, though they did not want too much text either. Furthermore, while they expressed a familiarity with the 5E model, they were clearly confused by how it was used in a part of the material:

  > "Oh, the 5E model! [...] 'Elaborate Calculate' [short pause] Uhm, what?"

  The text 'Elaborate' appeared in the beginning of a sentence as a sort of category or heading, but lacked any separation from the rest of the sentence. The text said "Elaborate Calculate, simplify and solve the equation [...]", but

it meant "Elaborate: Calculate, simplify, and solve the equation [...]". Similar patterns could be found in other parts of the material.

- In test dI, the test subject scanned the text up and down more compared to the previous tests, rather than reading it from top to bottom. This time, it took even longer for the subject to understand the material. This revealed a possible problem with the material's adaption to scanning. For example, the material had headings called things such as "Part A" and "B:2", which did not explain what the different parts were about. Furthermore, starting the material with a list might have meant that the subject did not know where to start reading, similarly to what happened in tests dG and dH.

*Note:* the quotes have been translated from Swedish to English.

### 4.4.2 Lessons learned

Since three test subjects chose to test this material and revision, it proved to be a good chance to study how different subjects react to the same material. According to Krug (2010a), testing the same thing several times tends to reveal the same problems, aside from a couple of differences. This was found to be the case with this material; the unclear structure and lack of introduction was prominent in all tests, but the subjects read the material differently. While in dG and dH the subjects read the material more in-depth, in dI they used more of a scanning approach. This likely affected their abilities to understand the material. The most important lesson gained from this, however, was that test subjects do read the same material in different ways, possibly due to different reading habits in general. This is further strengthened by another test, aD, in which the teacher tended to read everything top-to-bottom and in-depth directly, including the list of materials.

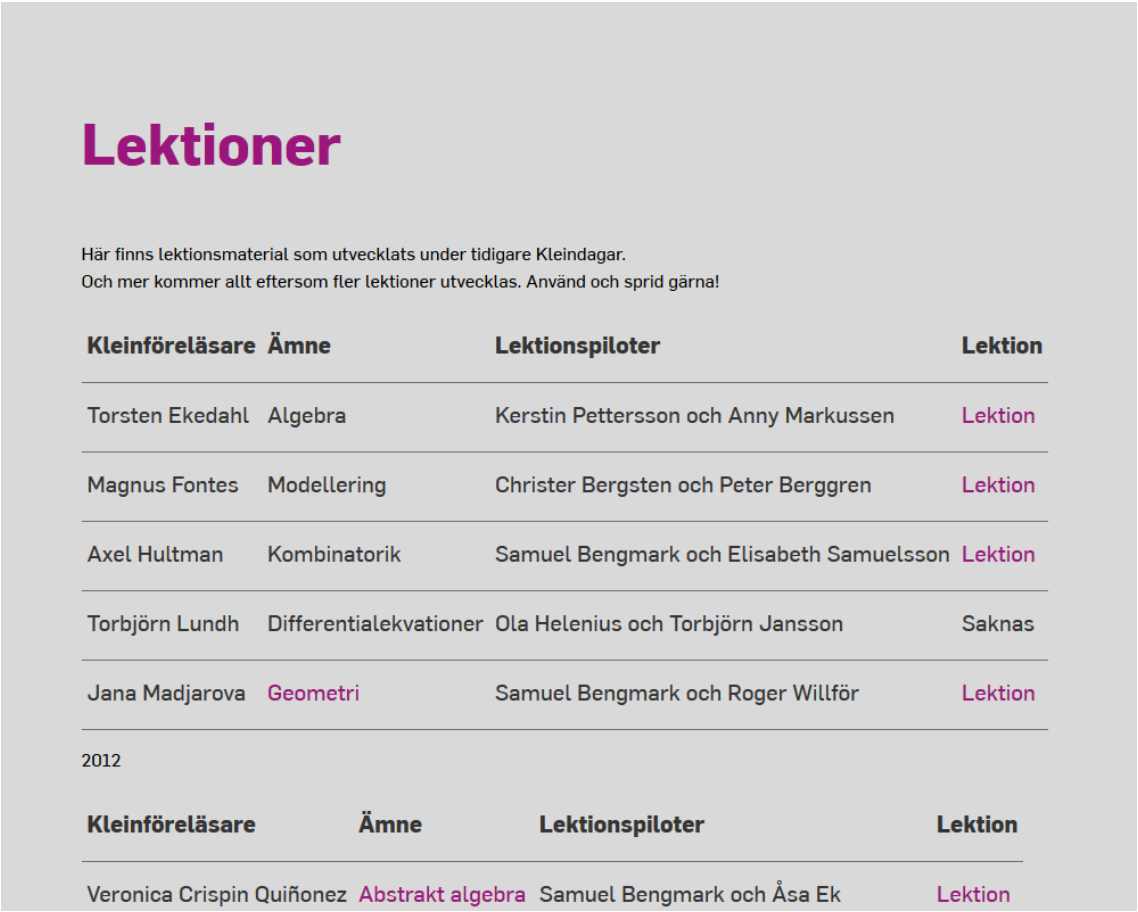
Interestingly, despite complaining about the material's clarity, all test subjects found a way that they could hypothetically use the material in a lesson, and two of them expressed positive thoughts about the material. More specifically, dH said that the material was "fun, with a lot of interactive parts" and "you can cut out [the exercises] and hold the lesson directly, which is good." In dG, the subject said that the material "feels very fun and doable", and "a fun way for the students to get a bit of a [habit]." This might point toward that a material which is difficult to understand still can be useful, if the rest of its content is good and relevant enough.

## 4.5 The materials list

The original list of materials was remade and revised continuously after feedback from the usability tests. It proved useful as a way to study how the teachers picked their materials, and what information they want when doing so. The original and revised lists, created by Kleindagarna and in this study respectively, are presented below.

### 4.5.1 The original materials list

The original list of materials was a part of Kleindagarna's website. This list contained information about the "Kleinföreläsare" (Klein lecturer), generic maths subject, who was testing the material, followed by a link to most of these materials in PDF-format. This information did not prove enough for the test subjects looking through the materials, which might be due to Kleindagarna's website being designed for a different target group. Note that the design of Kleindagarna's list seen in figure 4.3 was changed slightly during the thesis, and thus the revised list of materials was based on a slightly different design. However, the change only affected the color and font, and the information in the list remained unchanged. Thus, this change should have little to no effect on the comparability between these different lists.



# Lektioner

Här finns lektionsmaterial som utvecklats under tidigare Kleindagar.
Och mer kommer allt eftersom fler lektioner utvecklas. Använd och sprid gärna!

| Kleinföreläsare | Ämne | Lektionspiloter | Lektion |
|---|---|---|---|
| Torsten Ekedahl | Algebra | Kerstin Pettersson och Anny Markussen | Lektion |
| Magnus Fontes | Modellering | Christer Bergsten och Peter Berggren | Lektion |
| Axel Hultman | Kombinatorik | Samuel Bengmark och Elisabeth Samuelsson | Lektion |
| Torbjörn Lundh | Differentialekvationer | Ola Helenius och Torbjörn Jansson | Saknas |
| Jana Madjarova | Geometri | Samuel Bengmark och Roger Willför | Lektion |

2012

| Kleinföreläsare | Ämne | Lektionspiloter | Lektion |
|---|---|---|---|
| Veronica Crispin Quiñonez | Abstrakt algebra | Samuel Bengmark och Åsa Ek | Lektion |

**Figure 4.3:** The original list of materials on Kleindagarna's official website (Kleindagarna, 2018b).

### 4.5.2 Revisions of the materials list

Revisions of the list of materials were made continuously during the project, building on feedback from the usability tests. The list was remade from scratch in the form of a website, similar to the original list but containing other information, see figure 4.4. Comparing the original list with the revised list, a couple of things were changed:

- A tagline was added under the title: "Lektionsplaneringar med nya matteperspektiv" in Swedish, or "Lesson plans with new mathematical perspectives" in English. This was meant to change the expectations of the teachers looking through the list, so they knew the materials were about mathematics, and that they had innovative perspectives on mathematics rather than remaking typical maths lesson materials.
- A description was added for every material due to teachers expressing during the tests that they wanted to know more about the material they were going to choose. The descriptions were originally taken directly from the materials and slightly reworked, leading to some materials lacking a description due to not having one in the material itself. This further lead to teachers ignoring the materials that were lacking a description during some tests. Thus, descriptions were added to all the materials.
- The "Lektionspiloter" and "Kleinföreläsare" parts of the list were removed since few of the test subjects would understand what it was or know the people by name, and more space was needed for other information.
- "Relevant(a) gymnasiekurs(er)", in English "Revelant secondary school course(s)", were added due to them existing in most of the materials themselves, and thus easily added into the list. Likewise, "Koppling till ämnesplan", "Connection to the subject curriculum" in English, was added in the same way, also replacing "Ämne" in the original list..
- A title was added to every material in the list to make the materials more scannable instead of having to read the whole description to understand the general idea of the material.

A public version of the materials list, with links to all the materials created and tested during the thesis, can be found at the following address (last updated 2018-08-22):

`https://niwsters.github.io/teaching-materials-thesis/`

**Material från Kleindagarna**

**Lektionsplaneringar med nya matteperspektiv**

| Titel | Beskrivning | Relevant(a) gymnasiekurs(er) | Koppling till ämnesplan | Länk |
|---|---|---|---|---|
| Primtal och kryptering | Beskriver några metoder för att hitta primtal och hur de kan användas i kryptering. | Ma 1b, 1c och 5 | Taluppfattning, aritmetik och algebra: primtal, potenser med heltalsexponenter, strategier för användning av digitala verktyg. Innehåller övningsuppgifter. | PDF |
| Modellering | Eleverna får skapa en modell som mäter hur mycket som går åt av ett stift på en penna per millimeter streck som ritas. | Ma 1b, 1c och 2a | Matematisk modellering | PDF |
| Ramseytal | Eleverna får lära sig om begreppen permutation och kombination genom något som kallas Ramseytal. Innehåller blad som kan delas ut till eleverna. | Ma 5 | Permutation och kombination, grafer och grafteoretiska problem. | PDF |
| Geometri: Definition, sats och bevis | Eleverna får ställa upp sig på ett sätt så att de bildar en mittpunktsnormal. Sedan får de formulera hypotes och bevis, och fördjupa sig i ämnet med fler geometriska problem. | Ma 1b och 1c | | PDF |
| Operationer: Associativitet och kommutativitet | Undersöker ifall operationer är associativa och/eller kommutativa. | | | PDF |
| Område statistik | Går igenom statistiska begrepp genom att låta eleverna rita tsreck utan att prata med varandra, och efteråt analysera strecklängderna. | Ma 2b och 2c | Statistik, beräkning av lägesmått och spridningsmått mm., normalfördelning. | PDF |
| Randvinkelsatsen | Går igenom randvinkelsatsen laborativt. | Ma 2b och 2c | Geometri, randvinkelsatsen. | PDF |
| Den dolda och tvetydiga matematiken | Går igenom vanliga missuppfattningar i algebran och aritmetiken. | Ma 1 och 2 | Aritmetik och algebra. | PDF |
| | Utforskar hur en mäter längd, area och | | | |

**Figure 4.4:** The second revision of the list of materials, based on Kleindagarna's original seen in figure 4.3.

### 4.5.3 Results from studying how teachers choose materials

Studying how the teachers chose one material from the materials list generated a few findings that might point toward how teachers choose materials in general. This is relevant for discussing obtainability later in the report.

One common finding was that the teachers want to know what type of material they are picking. For example, they want to know whether the material is a practical lab kind of lesson, or if it is a more common combination of lecture and exercises. Information about the material's connection to the curriculum, and what courses it can be used in, was also appreciated by the test subjects.

Another finding was that teachers looked for materials that connected to what they were teaching at the moment. For example, in test sE, the teacher chose the statistics material to get some perspective on what they had taught recently. This is important to consider in the case of innovative or different materials, since teachers might ignore such materials in favor of those that connect more strongly to their teaching curriculum.

Important to note about these findings is that the teachers were told to choose one material per test, without opening it. Thus, they did not learn anything about the materials other than what was shown in the list of materials. This is different from reality, since if a teacher would visit a website containing several materials, they would be able to open each of them and look them over before picking one that they'd use in a lesson. However, the findings in this study might still be useful for getting some pointers in what teachers are looking for in a material, and what they want to know about it.

## 4.6 General perspective: Things that were learned from all the usability tests

The previous usability test cases in this chapter described how results were produced from a couple of specific tests. In a similar manner, more results were produced by going through the tests one by one and summarizing the findings, and comparing the tests next to each other. Below are some findings from this general analysis.

### 4.6.1 Comparisons between the teachers' typical lessons

Part of the usability test consisted of asking the teachers what their typical lesson looked like. The answers the teachers gave showed that most teachers work with a combination of lectures in group and individual student exercises, even if their lesson lengths and structures were different. For example, one teacher had three hour lessons with multiple 10 minute breaks, while another had one hour lessons. Other than that, tools such as Goegebra, calculators, computers, and online quiz tools were mentioned by some individual teachers.

### 4.6.2 Making the material intuitive for different behaviours is important

Because of the difference in how teachers read a material, where one might instantly read the material in-depth and the other might just scroll down while scanning it, having a material be intuitive at first glance is a good thing. Some materials took the teachers a while to understand, which could have been rectified through a more clear structure and by following typical patterns that the teachers are used to. One pattern that was asked for directly in two of the usability tests (dH and dI) was to have an introductory text, which was lacking for the specific material that was tested. At the same time, in one of the tests (mA), the teacher completely ignored the introduction at first to make sense of the material's content by itself. In either case, the material should ideally be clear to understand for both types of material reading behaviours.

### 4.6.3 Having student handouts as part of a material is appreciated

All materials did not have parts that could be handed out to students, such as a list of exercises. However, many teachers seemed to appreciate such "handouts", or ask for them when they were missing. For example, one teacher, in test aD, wanted a handout for the student that explained a difficult word that they hadn't encountered before. Another teacher said in test dI that they could use a list of exercises by itself without following the exact lesson plan. This shows that exercises as a part of a material can improve the adaptability of the material. In contrast to this, in test nB one teacher expressed that materials can also work as a source of inspiration rather than something concrete and finished as a handout or a finished lesson plan. An important aspect of both of these materials, the "concrete handout" and the "source of inspiration", is the amount of work that these different types require for adaption into a real lesson: The handout can be printed and handed out directly, while the inspiration has to be reworked into a new material.

### 4.6.4 Accounting for teachers' and students' previous knowledge

A common problem among many materials was the teacher's lack of previous knowledge about the subject that the material presented. The most common and concrete problem that appeared was when new vocabulary was used, such as RSA (tests lC and dH) and Dido's problem (dH). There was also an issue with one teacher not feeling competent enough to teach a subject that a material covers (sE). In contrast, another teacher expressed that a material could be explored together with the students when the teacher did not know everything about it either (lC). Similarly, some materials seemed too difficult for certain teachers to use due to their students' lack of previous knowledge (aD and sE).

### 4.6.5 Finding common usability problems

In every test, at least one unclear explanation or structure, unanswered question, or other smaller, easily rectified usability problem was found. Thus, the usability tests proved effective in finding these problems. Examples of the problems found include:

- No clear explanation about what part the student should do and what part the teacher should do during a lesson.
- A lack of description of the axes in a diagram.
- Mixed use of comma (,) and dot (.) as decimal separator.
- An undefined word that needed explanation (Galton board).

- Unclear use of the 5E-structure when it was not used as the teacher expected it to be used.
- Unclear whether "degrees" was referencing temperature, geometric angles, or "levels."
- Misunderstandings about what a list of exercises was, where the teacher described it simply as a "list" of unknown purpose.
- Instructions that required more explanation. In this case, the instructions merely showed a couple of numbers without describing what the numbers were for; "0,0,0,50...", where it was explaining a point system for gambling with dice.

Although many of these misconceptions were often understood by the test subject after a while, it often took a lot of time, and likely frustration, for them to figure it out.

# 5

# Discussion

## 5.1 Answers to RQ1: What results are produced when applying Krug's usability testing method on teaching materials?

Looking at what issues were found during the usability tests in this study, usability testing of teaching materials seemed to work similarly to how they work with websites, according to Krug's method. Both methods are effective in finding problems with misunderstandings and lack of clarity. However, when it comes to testing how the teachers would choose and use their material, the results are dependent on what is possible in a realistic teaching situation. For example, as described in section 4.6.4, some teachers evaluated a material according to their students' previous knowledge. Similar results were also found relating to how well a material connected to the school curriculum, see section 4.5.3. Without previous experience with working as a teacher, such things could be difficult to evaluate. That said, this study did not directly test and compare doing usability testing done with non-teachers, so specifying what difference having non-teachers as test subjects would make for the results is difficult to say. Studying what test subjects would be eligible for testing different aspects of teaching materials is an interesting subject for further study.

Aside from finding common usability problems, the usability tests also produced a few results that were unique for teaching materials, compared to testing websites or other things. For example, as seen in section 4.6.3, student handouts specifically seemed appreciated in many tests. This likely has several reasons:

- Student handouts require little preparation to use, since they often simply require printing, in contrast to for example having to write a slideshow from scratch.
- Student handouts are concrete and easy to understand, as long as the teacher understands that they are student handouts. This is because teachers know what student handouts are, and they know intuitively how they are supposed to be used, compared to more abstract materials.

Even if many materials could be improved with student handouts, it is likely not an all-encompassing solution. Similarly, future usability tests might find problems with student handouts that this study did not find. However, the result shows a strength in usability testing teaching materials, in that similar findings might be possible in more tests. Furthermore, the finding says something about the importance of being concrete: If a teaching material is to explain something abstract, having an example of what an explanation to a student would look like might make the explanation easier to understand for the teacher. Such realizations are a reason why the usability testing also makes the tester a better usability designer, aside from finding specific problems for specific materials.

Finally, testing the materials list as well as the materials in it showed an important distinction: The difference between making good content, and making the content easier to understand. While solving common usability problems is an important part of designing good teaching materials, it's also important to consider how useful a materials' theme or content is. For example, in sample case 2, section 4.4, it was revealed that the material was appreciated, despite big usability problems. The teacher expressed interest in the material's theme, which was common misconceptions in mathematics. The material also had student handouts. Usability testing can likely be used to find whether or not a teacher appreciates a specific theme, but figuring out what themes teachers are looking for, among other things, can be difficult to do by testing only one material. In other words, usability testing does not seem effective in testing whether a material asks the right questions, but it is effective in testing whether it answers its questions clearly.

## 5.2 Answers to RQ2: What challenges might teachers run into when attempting to perform usability testing on teaching materials, and how might they deal with these challenges?

While there are different forms of usability testing, the tests in this study were based on a method designed to be accessible to a wide audience, which is the one designed by Krug. To do similar tests, a material designer could use the usability test script supplied in this study (section B.2). This script is adapted from web development to teaching materials. However, due to the difference between doing a scientific study and a usability test meant for material development, there are some things that could be further simplified from the method used in this study.

To start with, the test subjects could consist of teacher colleagues. As this study found, it's a good thing if the test subjects have teaching experience due to being able to find problems with the curriculum, student experience, and similar issues. If the material that is to be tested is to be reused locally in a school, doing these tests could then be as simple as asking teacher colleagues to "have a look" at the material. This would save a lot of time and effort in looking for test subjects elsewhere.

Important to note when testing teaching materials is that there is a difference between simply asking a test subject "what they think", and to actually watch them try to use the material. The difference between these methods is less obvious in the method used in this study compared to when testing websites. This is due to the teachers actually not using the material in conjunction with real lesson planning, and thus the subjects end up thinking how it would be to use the tested material in an imaginary lesson. However, the main difference lies in watching the test subject read and/or analyze the material while they think out loud, instead of asking them what they think after they have read or scanned the material.

Finally, what seemed to help while making revisions in this study was to use short iterations. The idea behind this is that less time is spent guessing between different design decisions, and more time is spent gathering data that facilitates these decisions. Doing tests early and often also has the advantage of finding expensive problems early, where expensive means that redesigning the material late in the process would take significantly more time and effort than choosing the better design early in the process.

## 5.3 Answers to RQ3: What factors do teachers consider when deciding on how to use a teaching material?

Answers to this question can be found in the Results chapter, under section 4.5.3. Instead of reiterating these results, the results will be discussed here about what they say about the obtainability of teaching materials.

Obtainability, in terms of the ability for teachers to get access to a material, is difficult to measure. This study limited its obtainability research to a single materials list, and what the teachers looked for in that list. In reality, a teacher might not have access to a list. A school might for example have an internal network where they share files. Some teachers may also share their materials online through blogs. However, as long as the teacher has the ability to choose between materials, knowing what the teacher wants to know about a material before they pick it can be an important factor in making said material obtainable. If a material is accessible online, for example, but no teachers understand what it is, chances are that this material will never be looked at.

Designing systems that make teaching materials more obtainable is an important part of making teaching materials accessible, just like designing the materials themselves. What this study has shown is that understanding what the material is about can be an important part of making it obtainable, at least when said material is to be chosen among many other materials. Material designers should take this into consideration when sharing their materials.

## 5.4 Answers to RQ4: From the perspective of a technological system, how can usability design for teaching materials be used to help teachers?

Using usability testing to solve usability problems is a simpler problem than making sure that it is used in a way that helps teachers. This is an important consideration when, for example, employing usability testing in a larger organization, such as a school or a group of teachers. Analyzing the usefulness of approaches to usability testing requires a holistic perspective, for which this study applies the theory of Holistic Technology as described in section 2.2. Note that this part of the discussion will be more theoretical and based on literature, compared to the more concrete, results-based analysis of the usability tests themselves.

To begin with, *help* in this case is defined as improving how well teachers do their job, as well as their enjoyment of work. Enjoyment of work means, for example, to avoid overworking the teachers with too many responsibilities. Depending on how usability testing is applied in a teacher's worklife, it can have different effects on these aspects.

Usability testing as a technology can be divided into Franklin's holistic and prescriptive categories. As a prescriptive technology, usability testing could be delegated to a group of usability experts. In this case, a usability designer has to be educated and do a proper form of usability testing, conforming to usability testing standards. In such a system, a teacher's usability tests would be considered amateurish, and not following proper usability procedures. While teachers would be allowed to hire usability experts to do testing for them, this would take a lot of resources, and the teachers themselves would lose control over that part of the design process. As Franklin describes it, it creates a form of division of labour - the teachers teach, while the usability designers design. While it is hard to predict exactly how such a system would look like, it could be compared to how schoolbooks are used by many teachers in the current system. The schoolbooks are designed by specific material designers, over whom the teachers have no control.

In contrast to the prescriptive system, a holistic system would be characterized wth teachers having control over the whole material design process. Applying usability testing in such a system would mean that the teachers would do tests on the materials that they designed wanted to share with each other. This means less division of labour, and more power to the teachers over the design process. Usability testing would be considered common knowledge rather than something delegated to experts. While this could affect the quality of usability tests, the teachers would also likely understand the tests better, and thus become better usability designers.

Effects on the teachers' work and enjoyment of work in both systems could be various. While usability testing does take time, teachers sharing materials with

each other could also lower the workload for the individual teacher. Delegating material design to external parts, such as schoolbook designers, could also both increase and decrease workload: The teacher doesn't have to do a lot of material design themselves, but the material still has to be adapted, and the teacher loses control over part of their work process. Letting teachers control how they do their work, and avoiding division of labour, is important to avoid the social mortgage described by Franklin.

Another, slightly different finding from this study was that the teachers tended to look for materials that fit the requirements they had to follow in their teaching. This leads to an interesting conflict: Making teaching materials more accessible could lead to teachers learning new things, but usability tests might lead to design decisions that conform more to the school curriculum. Kleindagarna's materials are a clear example of this, since they are often meant to show new and innovative perspectives on mathematics. If these materials were to conform more to what teachers require, there's a risk that they could become less innovative. At the same time, if a material does not conform to what teachers want, it might not be used at all.

## 5.5 Similar studies

When conducting a literature study to find what similar studies have already been carried out, most focused on e-learning. This was not suprising, due to the similarities e-learning has with websites, the most common usage for usability testing. The methodology used in these studies did not vary from how websites are commonly usability tested. One main difference is that e-learning is aimed for students, whereas teaching materials are aimed to teachers. Some of the studies found are listed below:

- The importance of usability testing to allow e-Learning to reach its potential for medical education. (Sandars, 2010)
- Usability testing of e-learning content as used in two learning management systems. (Debevc & Bele, 2008)
- Usability testing of e-learning: an approach incorporating co-discovery and think-aloud. (Adebesin, de Villiers & Ssemugabi, 2009)

When it comes to usability testing more unorthodox types of materials, one particular study was found where functional documents were tested in a similar way to usability testing (Schriver, 1991). This study describes a procedure called *protocol-aided revision*: "It is a cyclical activity in which each cycle consists of readers responding to a text and a writer using readers' responses to guide revision". Differences in Shriver's study compared to this study on teaching materials include:

- *Functional documents* are not the exact same thing as *shareable teaching materials*, since teaching materials aim to be used to teach someone else than the one using the material.

- *Protocol-aided revisions* is, although similar, not *KRUT*. One big difference is that it does not suggest involving an initial meeting with a test subject group, which was inspired by the ASD-model, instead assuming for example that it is already decided on what materials should be tested.
- The study focuses on revising materials to only feature *plain text*, defined as "[...] clearly written and usable texts that suit the unique needs and purposes of both subject-matter novices and subject-matter experts.", instead of the focus to revise both content and structure to improve upon the obtainability and usability.

## 5.6 Limitations of the study

### 5.6.1 Homogeneity of usability test data

The study's focus could be different if the test data collected was more homogeneous. A good way to achieve this would have been to collaborate with teachers from a single school, as these teachers might then optimize the teaching materials with some respect to the same group of teachers and students. Regular testing with the same teachers could then be established, which better reflect the way this study's findings are proposed to be used. Interest was showed by representatives on schools contacted, but claims were made that the teachers' schedules did not allow for this kind of collaboration. Any effects exclusive to collaboration within a school's teacher base has therefore not been examined. Instead, teaching materials were limited to maths and test subjects were exclusively math teachers connected to upper secondary school and students nearly eligible to teach maths at upper secondary school. Even though the data is less homogeneous, it can be assumed that this has led to other findings that would not have been made when testing materials exclusively with teachers from a single school.

### 5.6.2 Control of usability test data

In this study, exploring accessibility has encompassed studying both obtainability and usability. To collect more data on obtainability, usability tests were preceded by the usability subjects choosing the teaching material they wanted to test. This reduced the authors' control of testing certain teaching materials. This removed the ability to focus on a particular teaching material and usually prevented the authors to get the desired familiarity with the teaching material ahead of time.

### 5.6.3 Balancing revision sizes

Usability testing makes it possible to revise the tested teaching material. Much of the data collected during the testing figuratively screams to be put to use in a revision. Adding alteration to a teaching material is in itself a project. When tackling a project, one should have a plan on how to reach the goal. Seeing that the development cycle in this study is iterative, adopting an iterative development process when making a revision is appropriate. That means that one should make many smaller changes, instead of trying to implement everything at once. A benefit of this is that one can have a new, albeit smaller, revision ready each time the teaching material is put down. This smaller revision is then ready to be usability tested on, if such an opportunity emerges.

### 5.6.4 Number of tests and statistical significance

The usability testing method used in this study was designed to be qualitative rather than quantitative. As a consequence, not that many tests were needed to find some interesting results. At the same time, these results might not be as statistically significant as that of a larger study. If similar usability tests are done on the same material in another study, some results will likely differ quite a lot due to test subjects reacting differently, among other variations. As Krug argues, the strength in his qualitative usability testing method is that similar problems tend to be rediscovered when more usability tests are done on the same website (Krug, 2010a). He also argues that websites should be designed to work for anyone, and thus any problems discovered are significant (Krug, 2014). Similar arguments can be said for this thesis. While the thesis did not aim to prove specific common usability problems, which would've required quantitative testing, it showed that usability testing is possible for certain teaching materials. Furthermore, it found patterns that might be useful for material designers to take into consideration when considering their own design decisions.

### 5.6.5 Validity of results

When describing the *protocol-aided revisions*-methodology, similar to *KRUT*, Schriver writes:

> "[...] keep in mind that the goal in recruiting participants is to gather a variety of responses to the text rather than to ensure statistical reliability. It is important not to confuse protocol-aided revision with an experimentit–its goal is neither hypothesis testing nor verification. Rather, it is aimed at debugging poorly-written text." (Schriver, 1991)

Furthermore, the revisions made in this study has aimed to find and patch the biggest obtainability and usability holes in a specific type of teaching material, but

the study as whole has aimed to inspire similar testing with other conditions. The KRUT-methodology rests on a foundation of tested theory including usability testing and ASD, giving it enough validity as a usable methodology.

## 5.7 Future work

### 5.7.1 For teachers

A suggestion is that teachers can use the methods presented in this thesis as activities in collaborative meetings, as a way to assess the accessibility of teacher materials. They could also discuss how they are affected by accessibility of teacher materials created by others. To assess accessibility on an institutional level, the following questions could be asked:

- In what ways might their economy deny better quality education (obtainability issue)?
- Is the quality of their education unreasonably dependent on the teachers finding teaching materials themselves (obtainability issue)?
- Do their teachers use teaching materials that can not be shared to others, e.g. substitute teachers, without a significant drop in educational quality (usability issue)?
- Do their teachers produce their own material with the sole intent of only using it themselves (obtainability and usability issue)?

### 5.7.2 For universities and colleges

Future theses could be made to e.g. verify, falsify, implement, expand and/or improve upon this thesis.

### 5.7.3 For others

Other fields of study could adopt a usability testing method, perhaps one inspired by the iterative method developed in this thesis, to identify the unknown in their particular field.

# 6

# Conclusions

A method called KRUT was developed and applied to do usability testing on teaching materials, following an iterative process inspired by ASD. Smaller iterations with incremental changes was shown to be useful to do more usability tests, and thus get more information to base design decisions on.

Usability testing was shown to work on teaching materials, with certain differences from web development. The main difference was that teaching materials often require experience with teaching to evaluate realistically. Questions asked during the test, such as, "how would you use this in a lesson?", might require an actual teaching situation to reference to. At the same time, more research is needed to identify the actual differences between testing on teachers and non-teachers.

An interesting usability aspect found from testing was the difference between abstract and concrete materials, and specifically how student handouts can be used to make a material more concrete. While a teaching material can be used as an abstract source of inspiration, materials that could be printed and used directly in a lesson seemed more appreciated and easier to understand.

While this study developed a method that is designed to be used by teachers themselves, it is possible, and recommended, for any creators of teaching materials to do usability testing. However, caution should be taken to not take away control over the teacher's work process through division of labour. Usability testing as a holistic technology can be applied by letting teachers create and share the material they use, and use usability testing to learn what other teachers want and need, thus becoming better usability designers themselves.

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# A

# Revised Materials

## A.1 Links to teaching materials

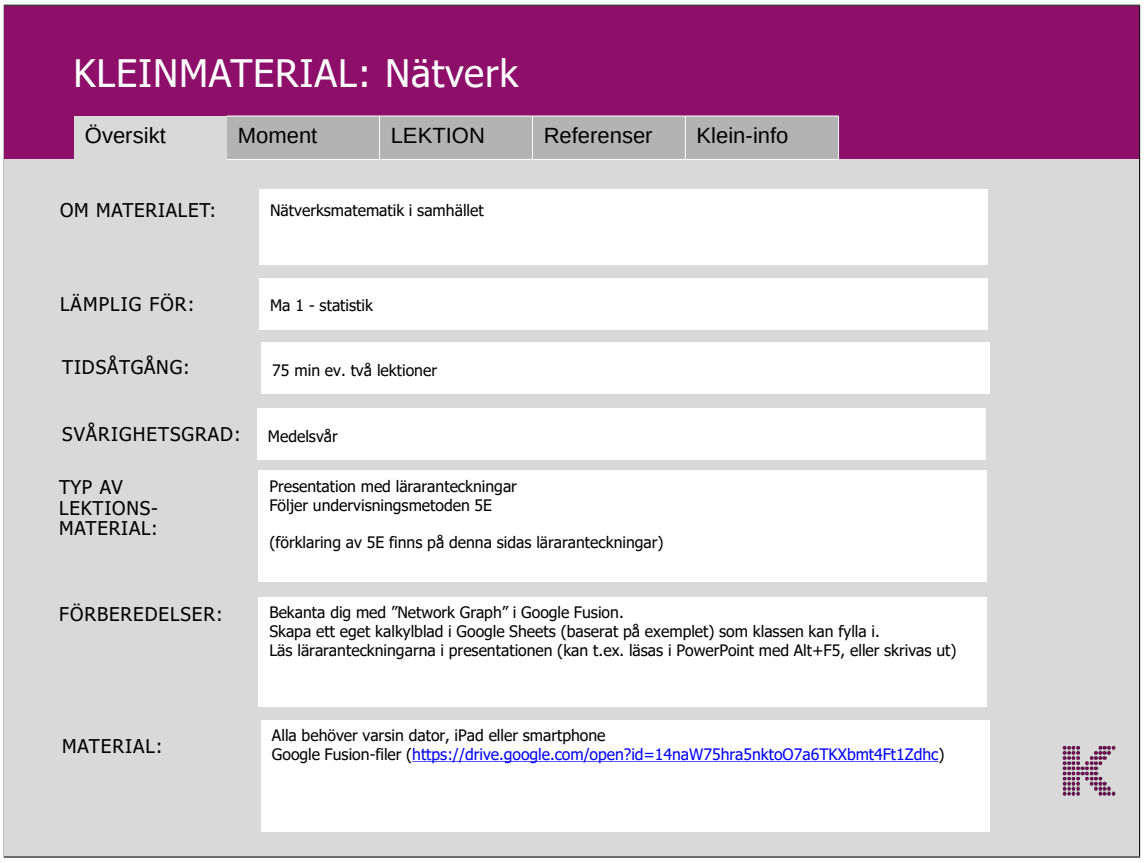
**Table A.1:** Summary of all revisions in this study.

| Name of material | URL to original | URL to revised version |
|---|---|---|
| Konsten att bestämma arean | https://kleindagarna.se/app/uploads/13kleinlektionAnalys.pdf | https://github.com/Niwsters/teaching-materials-thesis/raw/master/revisions/material_bestamma_arean_revision.odt |
| Den dolda och tvetydiga matematiken | https://kleindagarna.se/app/uploads/13kleinlektionalge.pdf | https://github.com/Niwsters/teaching-materials-thesis/raw/master/revisions/material_tvetydiga_matematiken_revision.odt |
| Vad ska lotten kosta? | https://kleindagarna.se/app/uploads/Kleindagar-augusti-2017-lektionsutkast-Grupp-1-Finansmatematik-20170820.pdf | https://github.com/Niwsters/teaching-materials-thesis/raw/master/revisions/material_lotteri_revision.odt |
| Mönster och talföljder - Pascals triangel ur slantsingling | https://kleindagarna.se/app/uploads/Kleinlektion-augusti-2017-rev-vers-170821.pdf | https://github.com/Niwsters/teaching-materials-thesis/blob/master/revisions/material_pascals_triangel_revision.odt |
| Nätverk - insamling av data | http://kleindagarna.se/app/uploads/Kleinlektion-grupplektion-Natverk.pdf | https://github.com/Niwsters/teaching-materials-thesis/raw/master/revisions/material_natverk_revision.pptx |

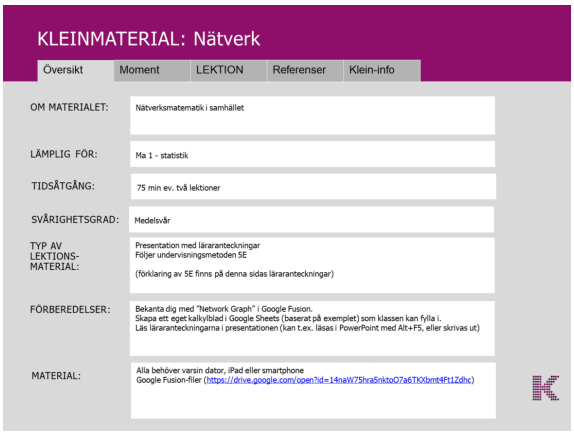
Here is another valuable link pointing to a list of all materials, including Swedish descriptions and more (last updated 2018-08-22):
https://niwsters.github.io/teaching-materials-thesis/

# A.2 Revised Kleinmaterial: Nätverk

Presentation slide 1 of 10




Teacher notes slide 1 of 10




**5E-metoden**

***Engage – Engagera eleverna.** Vi gör en aktivitet med eleverna som knyter an till vad vi ska lära oss.

***Explore – Undersök utan genomgång.** Vi börjar med en gemensam uppgift och sen flera individuella.

***Explain – Gå igenom teorin.** Vi förklarar begrepp, nödvändig teori och fyller i luckor.

***Elaborate – Fördjupa kunskaperna.** Vi kopplar an till omvärlden, ge elever anledning att vilja lära mer.

***Evaluate – Avgör vad eleverna lärt sig.** Vi har en diskussion, repeterar och knyter ihop säcken.

Presentation slide 2 of 10

## KLEINMATERIAL: Nätverk

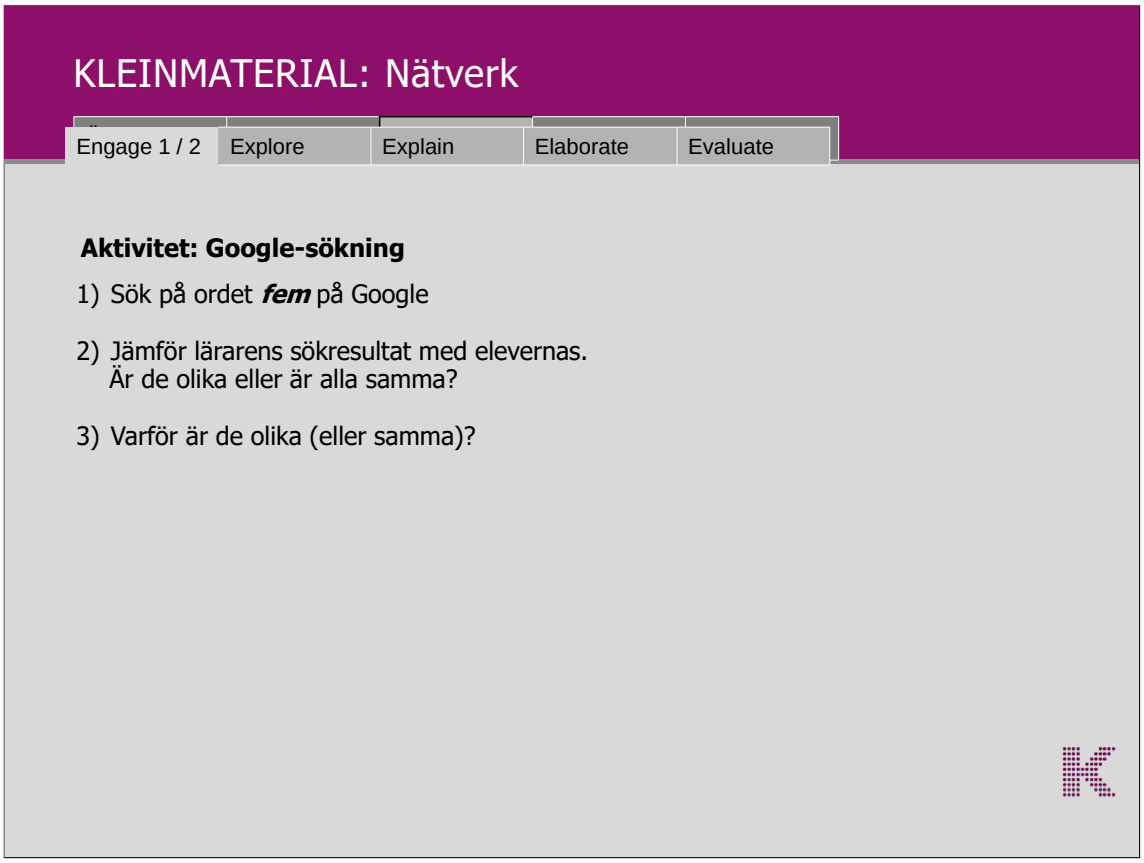
Översikt | Moment | LEKTION | Referenser | Klein-info

| Moment | Beskrivning | Tidsåtgång | Tidsstämpel |
|---|---|---|---|
| Engage | Aktivitet: Google-sökning | 20 | 0-20 |
| Explore | Aktivitet: Skapa nätverk | 20 | 20-40 |
| Explain | Nätverksteori | 15 | 40-55 |
| Elaborate | Algoritmer | 10 | 55-65 |
| Evaluate | Dagens lärdomar | 10 | 65-75 |

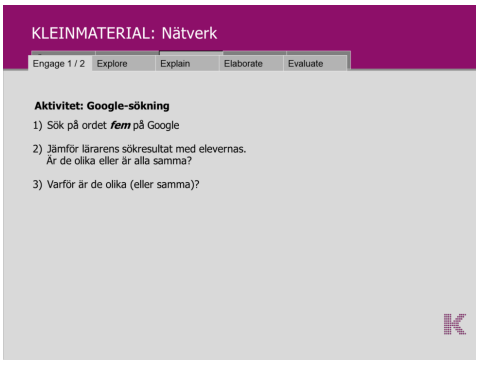
Teacher notes slide 2 of 10


**Moment:** Benämning av slide/sida
**Beskrivning:** Vad som läres/utföres på slide
**Tidsåtgång:** Uppskattat antal minuter på slide
**Tidsstämpel:** Antal minuter från lektionsstart

Presentation slide 3 of 10




Teacher notes slide 3 of 10




1) Både lärare och elever söker på ordet ”fem” på Google. Till detta krävs att alla har varsin enhet (dator, smartphone etc.) som kan använda internet.

2) Läraren visar upp sina sökresultat i tur och ordning och uppmanar elever att räcka upp handen så länge det ser likadant ut för dem. Då kan läraren sedan fråga de som inte räcker upp handen hur det ser ut för dem.

3) Resultaten förväntas vara olika bland annat baserat på tidigare sökhistorik. De första resultaten är nog samma hos alla (i skrivande stund är det ”finita elementmetoden” och ”fem (tal)” på Wikipedia) då de anses vara av intresse för allmänheten, men senare kan variera och kan vara en nyhet eller från en webbplats som läraren/eleven använt innan.

Presentation slide 4 of 10

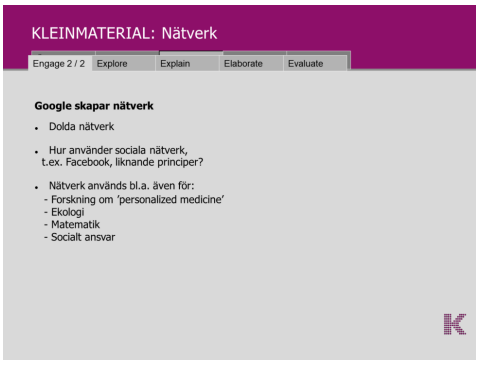
## KLEINMATERIAL: Nätverk

Engage 2 / 2 | Explore | Explain | Elaborate | Evaluate

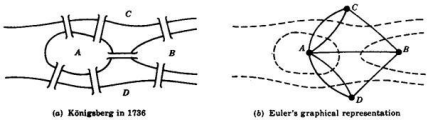
**Google skapar nätverk**

- Dolda nätverk
- Hur använder sociala nätverk, t.ex. Facebook, liknande principer?
- Nätverk används bl.a. även för:
  - Forskning om 'personalized medicine'
  - Ekologi
  - Matematik
  - Socialt ansvar

Teacher notes slide 4 of 10




Matematiska problemet "Königsbergs sju broar"




• Dolda nätverk – förklara att Google samlar in sökhistorik (data) för att gissa vad du vill du se i framtiden. De kan gissa vem du är genom dina sökningar, och då visa dig samma som andra som de tycker påminner om dig. De bygger alltså upp dolda nätverk.

• Hur använder sociala nätverk [...] liknande principer? - Såväl reklam, rekommendation på innehåll (artiklar etc.) och förslag på vänner.

- Forskning om 'personalized medicine' - denna forskning syftar till att kategorisera patienter och på så sätt se till att medicinen de får ska vara "rätt för dem".
- Ekologi - med nätverk kartlägger man vilka arter som interagerar med varandra, för att ta reda på hur stabila ekosystem ser ut.
- Matematik – handelsresandeproblemet (traveling salesman problem) och Königsbergs sju broar är två kända matematiska problem där man kan utnyttja nätverksteori.
- Socialt ansvar – nätverk är tänkta att bl.a. minska antal dödsfall genom självkörande bilar, insamlad data bestämmer med hjälp av programmering och matematik hur bilen ska bete sig i olika situationer. (neurala nätverk)

Presentation slide 5 of 10

## KLEINMATERIAL: Nätverk

Engage | Explore | Explain | Elaborate | Evaluate

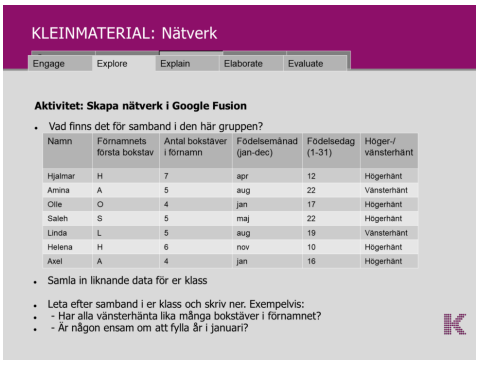
**Aktivitet: Skapa nätverk i Google Fusion**

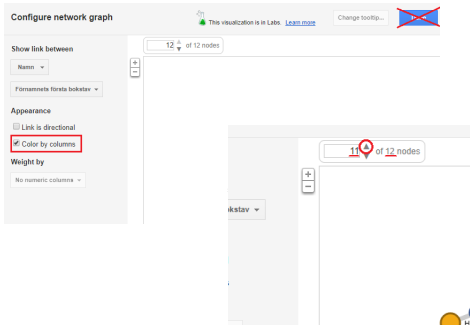
- Vad finns det för samband i den här gruppen?

| Namn | Förnamnets första bokstav | Antal bokstäver i förnamn | Födelsemånad (jan-dec) | Födelsedag (1-31) | Höger-/ vänsterhänt |
|---|---|---|---|---|---|
| Hjalmar | H | 7 | apr | 12 | Högerhänt |
| Amina | A | 5 | aug | 22 | Vänsterhänt |
| Olle | O | 4 | jan | 17 | Högerhänt |
| Saleh | S | 5 | maj | 22 | Högerhänt |
| Linda | L | 5 | aug | 19 | Vänsterhänt |
| Helena | H | 6 | nov | 10 | Högerhänt |
| Axel | A | 4 | jan | 16 | Högerhänt |

- Samla in liknande data för er klass
- Leta efter samband i er klass och skriv ner. Exempelvis:
- - Har alla vänsterhänta lika många bokstäver i förnamnet?
- - Är någon ensam om att fylla år i januari?

Teacher notes slide 5 of 10




- Använd gärna någon kollaborativ molntjänst, exempelvis Google Sheets för insamlande av data, så att eleverna snabbt kan fylla i tabellen. Google Forms kan användas ifall man inte vill ge eleverna möjlighet att ta bort eller modifiera i dokumentet.
- När datan är importerad, så klickar man på +-tecknet och väljer ”add chart”. Sedan trycker man på ”Network chart” längst ner på sidan. Ifall man inte ser några noder så kan man gå in under ”Edit→Change Columns” ändra alla kolumners typ till ”Text”. Det rekommenderas att man väljer ”Color by columns” (se bild). Om man trycker på ”Done” så ’låser’ man grafen och kan då inte fortsätta växla vad som ska visas under ”Show link between”.
- Viktigt att visa för eleverna är att Google Fusion ibland (i skrivande stund) får för sig att bara visa några av noderna. Så man får vara noga med att se till att den alltid visar så maximalt antal genom att trycka på ”uppåt-pilen) (se bild).
- Ni kan göra en egen undersökning där ni samlar in egen data, men tänk på att mycket data kan vara känslig. Man kan oavsiktligen råka skapa en situation där ett nätverk synliggör känsliga avvikelser. Om man t.ex. väljer att ha längd och det finns en kort pojke eller lång tjej, så kan de känna sig utanför eller bli retade för att nätverket klumpar ihop dem med elever av annat kön.

Presentation slide 6 of 10

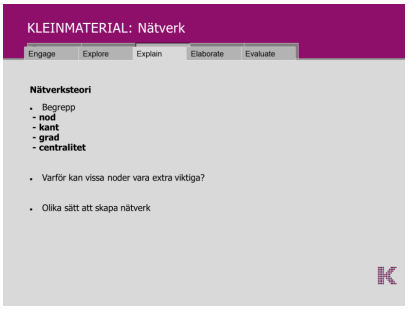
## KLEINMATERIAL: Nätverk

Engage | Explore | Explain | Elaborate | Evaluate

**Nätverksteori**

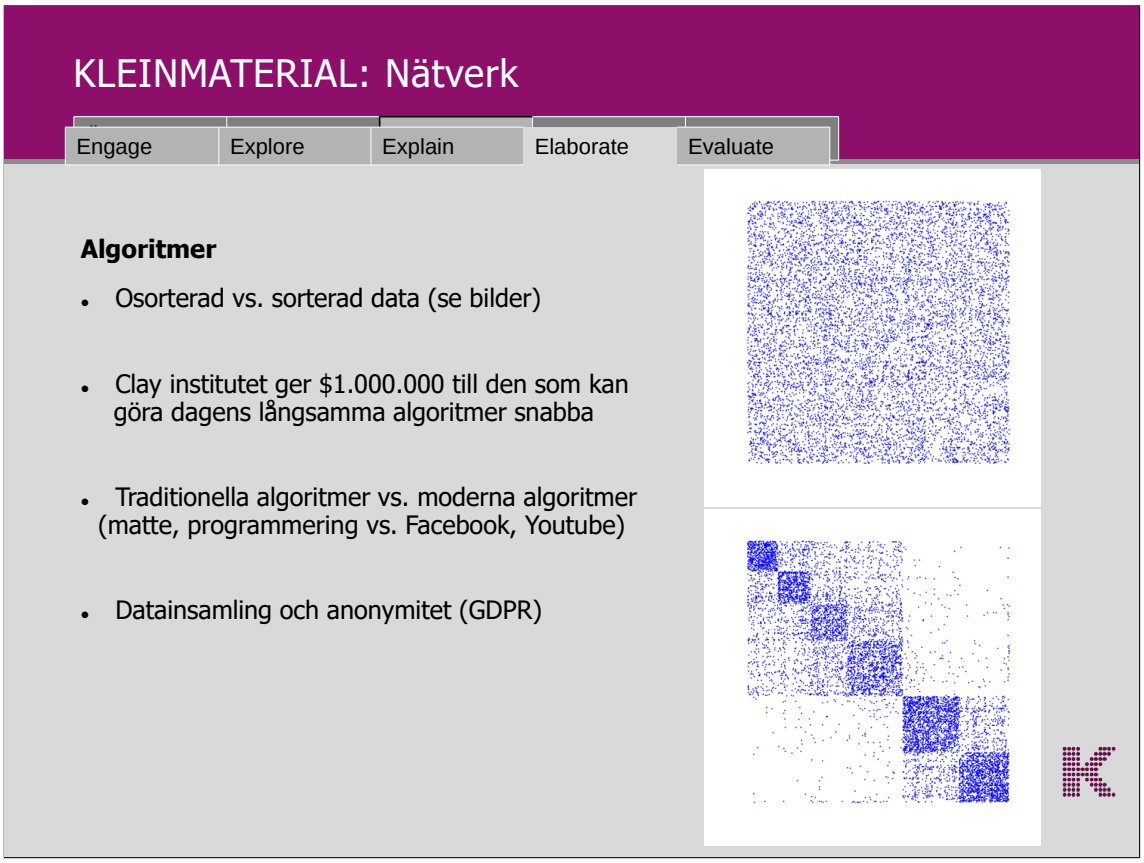
- Begrepp
  - **nod**
  - **kant**
  - **grad**
  - **centralitet**
- Varför kan vissa noder vara extra viktiga?
- Olika sätt att skapa nätverk

Teacher notes slide 6 of 10

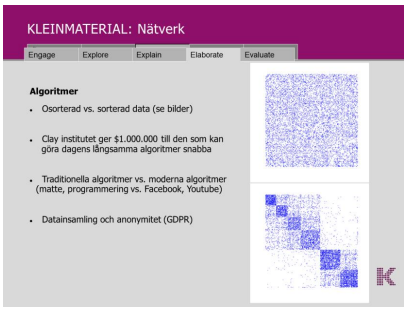



- Begrepp
  - **nod** Varje cirkel är en nod
  - **kant** Ett streck mellan cirklar/noder
  - **grad** Graden för en nod är det antal kanter som går till den.
  - **centralitet** Det finns olika typer av centralitet. Närhetscentralitet är troligen den vanligaste. Där använder man sig av kortaste vägen mellan noder, för att bestämma vilken nod som har det kortaste genomsnittliga avståndet till de andra noderna. Denna nod är den mest (närhets-)centrala noden.
- **Varför kan vissa noder vara extra viktiga?**
  Om t.ex. den noden som är mest (närhets-)central skulle försvinna, så skulle det generella avståndet mellan de andra noderna i grafen öka. Om t.ex. din TV skulle gå sönder, så ökar det avståndet mellan dig och din spelkonsoll.
- **Olika sätt att skapa nätverk**
  Noder kan kopplas till andra noder av samma typ, Facebook kopplar personer till andra personer. Men Facebook kopplar också personer till grupper, vilket gör att personerna inte är direkt knutna till varandra. Detta är två olika sätt. Och i nästa slide finns ett annat sätt att visa nätverk på.

Presentation slide 7 of 10




Teacher notes slide 7 of 10




- **Osorterad vs. sorterad data (se bilder)**
  Här visas ett nätverk i tabellform istället. Rader och kolumner är noder (cirklarna) och ett ifyllda rutor är samma sak som ett (streck). Tomma rutor betyder alltså inget streck.
  Den översta bilden är denna data osorterad, som man har samlat in slumpmässigt. Sedan har en dator sorterat datan och det då i detta fall syns ett tydligt mönster.
- **Clay institutet […]**
  Clay institutet har skapat en lista på några olika problem som de delar ut stora summor pengar till om man löser. Anledningen till detta är att världen kommer att förändras markant ifall någon lyckas lösa ett sådant här problem. Ett problem innebär att hitta ett sätt att göra vissa specifika långsamma uträkningar snabbare.
- **Traditionella algoritmer […]**
  En algoritm är t.ex. en lista av steg som krävs för att slå in en viss typ av uträkning på en miniräknare. Du kanske inte skulle ha någon aning om hur man ska göra, men om du får se algoritmen så förstår du hur det funkar.
  Moderna algoritmer, t.ex. hur Youtube avgör vilka videor just du ska bli rekommenderad, är mer avancerade. De anpassar sig själva baserat på användande på Youtube och inte ens de som skrivit programmet från början kan längre berätta varför algoritmen har valt ut just de videor som du får rekommenderat.
- **Datainsamling och anonymitet (GDPR)**
  Youtube, Google, Apple, Facebook m.fl. samlar in information om dig. I huvudsak är det information som hjälper deras algoritmer förbättra din upplevelse.
  Men för att förhindra de viktigaste delarna av våra liv från att beslutas enbart av algoritmer, så står det i den nya personuppgiftslagen (GDPR) att alla har ”rätt till en förklaring” till varför ett visst beslut har fattats.

Presentation slide 8 of 10

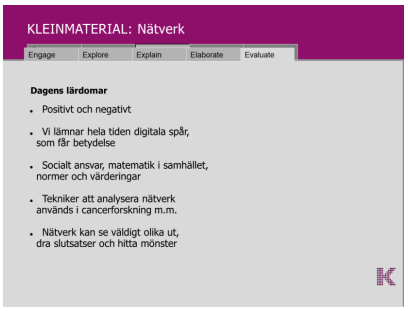
## KLEINMATERIAL: Nätverk

Engage | Explore | Explain | Elaborate | Evaluate

**Dagens lärdomar**

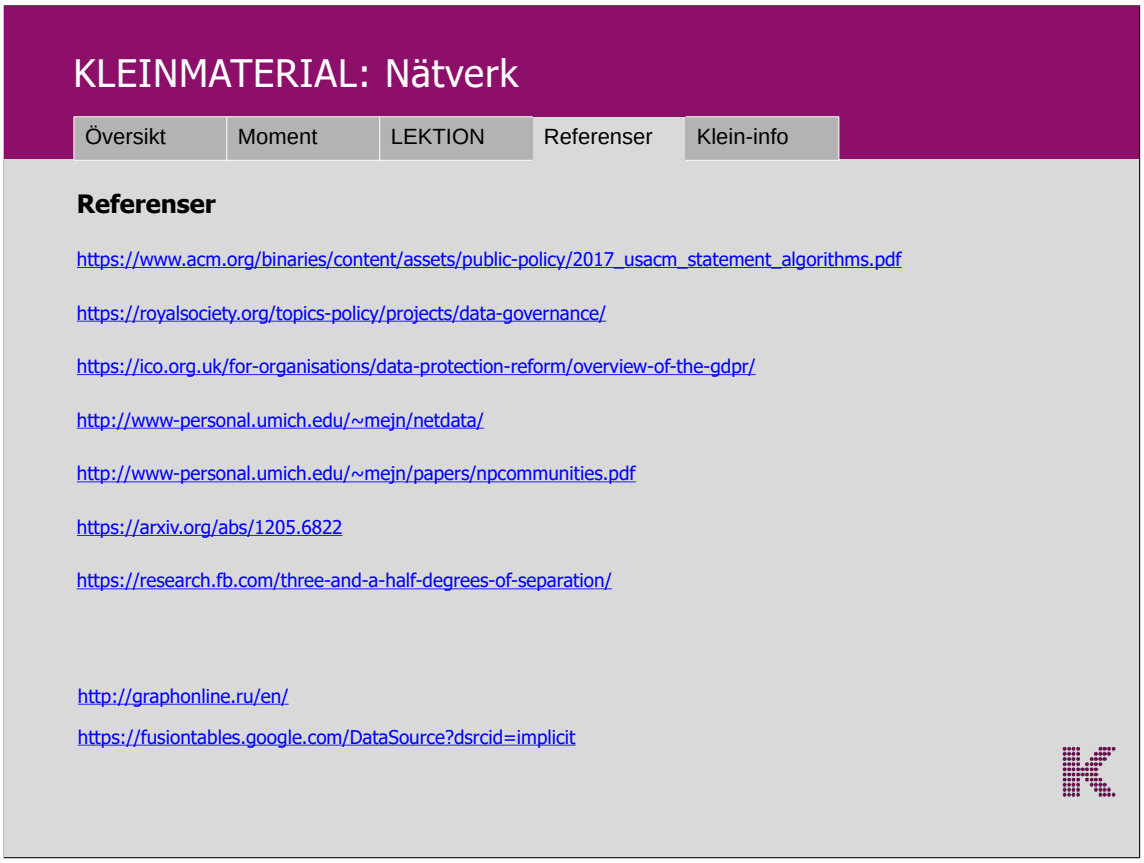
- Positivt och negativt
- Vi lämnar hela tiden digitala spår, som får betydelse
- Socialt ansvar, matematik i samhället, normer och värderingar
- Tekniker att analysera nätverk används i cancerforskning m.m.
- Nätverk kan se väldigt olika ut, dra slutsatser och hitta mönster

Teacher notes slide 8 of 10

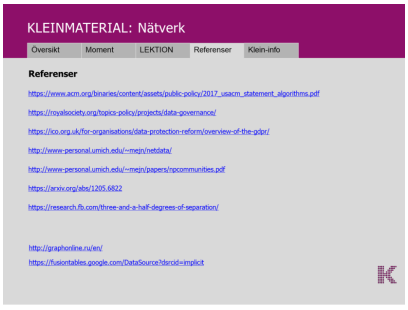



- **Positivt och negativt**
  Låt gärna eleverna skapa en lista på tavlan med positiva och negativa aspekter av nätverk som de samlat på sig under dagen.
- **Vi lämnar hela tiden digitala fotspår, som får betydelse**
  *Diskutera*
- **Socialt ansvar, matematik i samhället, normer och värderingar**
  *Diskutera*
- **Tekniker att analyser nätverk används i cancerforskning m.m**.
  *Diskutera*
- **Nätverk kan se väldigt olika ut, dra slutsatser och hitta mönster**
  *Diskutera*

Presentation slide 9 of 10

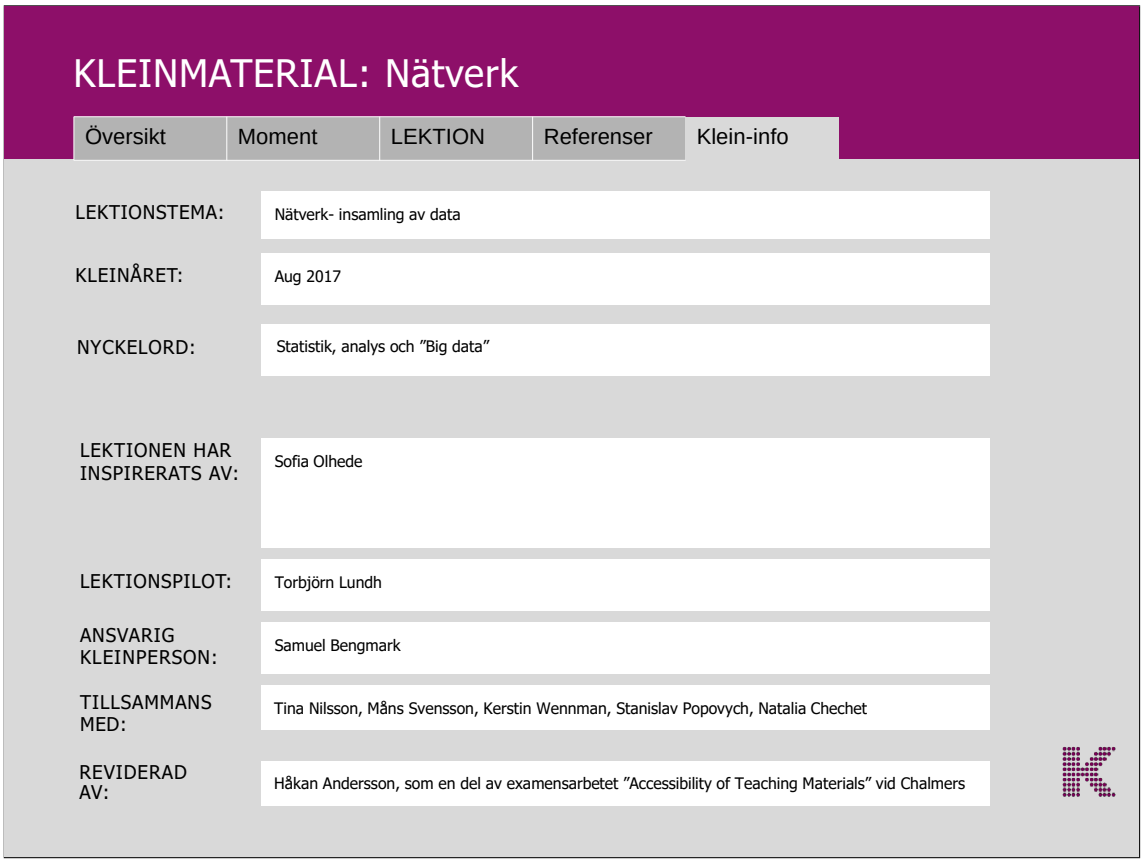



Teacher notes slide 9 of 10

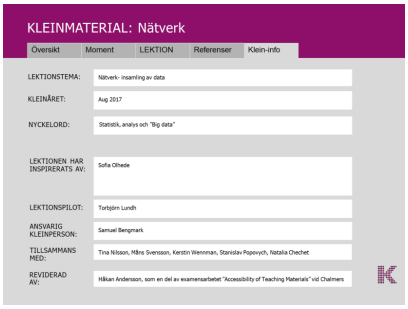



Denna lektion baserades på en föreläsning som hölls under Kleindagarna. Sedan dess har den reviderats som en del av ett examensarbete på Chalmers. Vissa referenser är från Kleindagarna och har tillkommit senare.

Presentation slide 10 of 10




Teacher notes slide 10 of 10




Detta är information mestadels om vilka personer som under Kleindagarna arbetade fram materialet.

## A.3 Revised Kleinmaterial: Den dolda och tvetydiga matematiken

Teacher document page 1 of 4

# Den dolda och tvetydiga matematiken

Vanliga missuppfattningar i algebra och aritmetik

### Engage

#### Del A (ett papper per grupp)

Engage/Elaborate I introduktionen ges eleverna uppgiften:

Skapa tal mellan 0 och 9 med hjälp av parenteser och operationstecken med de fyra talen:

4 4 4 4

Ex:

4 * ( 4 + 4 ) - 4 = 4 * 8 - 4 =28

Eleverna arbetar 2 o 2

2 grupper får i slutet av tiden skriva upp sina beräkningar på tavlan Genomgången diskuterar om det finns ytterligare varianter.

#### Del B – Tävling?

Elaborate Beräkna, förenkla eller lös ekvationen på följande kort 2 o 2 med rotation. Skriv på korten. Rotation innebär att eleven arbetar med olika personer under lösningens gång (3 + 3 + (3) +5 min).

Ange: Beräkning (B), Förenkling (F) och Ekvationslösning (E)

Ange: Svaret

B:2

Sortera B, F, E

B:3

### Explain

Byt kort för rättningen. Här dras ett kort i taget och görs på tavlan, med redogörelse och kommentarer. Vilken grupp har flest rätt? Korten återlämnas. (Pris?)

#### Del C

Elaborate/Explore - Beräkningsuppgifterna (1, 3, 5, 9, 11, 15, 16) ska nu skrivas upp på samma sätt som för att skriva in i en ”dålig” räknare. (testas med räknare) (två grupper på tavlan)

Teacher document page 2 of 4

## Slutsats

Evaluate- Att gå från tvetydighet till övertydlighet. Slösa med parenteser!

Material: (kladdpapper, räknare (del 5), utskrivna kort, pris)

Teacher document page 3 of 4

Uppgiftsblad

| # | Uppgift | Typ | Svar |
|---|---|---|---|
| 1 | $3 + 7/5$ | | |
| 2 | $5 - 3x + x$ | | |
| 3 | $3 + 5/5$ | | |
| 4 | $x^2 = 4$ | | |
| 5 | $\sqrt{4}$ | | |
| 6 | $\frac{x+5}{5}$ | | |
| 7 | $2\frac{1}{2} = 2x$ | | |
| 8 | $200X = 2005$ | | |
| 9 | $3 + 4 \cdot 5$ | | |
| 10 | $3x = x$ | | |
| 11 | $10^{3^2}$ | | |
| 12 | $\frac{\frac{16}{4}}{2}$ | | |
| 13 | $x - \frac{x+1}{1}$ | | |
| 14 | $\frac{x}{2} - \frac{3+x}{2}$ | | |
| 15 | $-3^2$ | | |
| 16 | $3,2 - 0,2\,(7 + 3)$ | | |

Teacher document page 4 of 4

Facit

| # | Uppgift | Typ | Svar |
|---|---|---|---|
| 1 | $3 + 7/5$ | B | $4{,}4$ |
| 2 | $5 - 3x + x$ | F | $5 - 2x$ |
| 3 | $3 + 5/5$ | B | $4$ |
| 4 | $x^2 = 4$ | E | $x = 2, x = -2$ |
| 5 | $\sqrt{4}$ | B | $2$ |
| 6 | $\frac{x+5}{5}$ | F | $\frac{x+5}{5}$ |
| 7 | $2\frac{1}{2} = 2x$ | E | $1{,}25$ |
| 8 | $200X = 2005$ | E | $x = 2005/200$ |
| 9 | $3 + 4 \cdot 5$ | B | $23$ |
| 10 | $3x = x$ | E | $x = 0$ |
| 11 | $10^{3^2}$ | B | $10^9$ |
| 12 | $\frac{\frac{16}{4}}{2}$ | B | ? OBS ej entydigt uttryck |
| 13 | $x - \frac{x+1}{1}$ | F | $-1$ |
| 14 | $\frac{x}{2} - \frac{3+x}{2}$ | F | $-1{,}5$ |
| 15 | $-3^2$ | B | $-9$ |
| 16 | $3,2 - 0,2\,(7 + 3)$ | B | $1{,}2$ |

# B

# Deliverable methodology

The KRUT-methodology (including the Swedish usability testing manuscript) created for this study is an inspirational tool for usability testing teaching materials. In true accessibility spirit, it is encouraged for users to make modifications to this as deemed appropriate and share the revised version with others. For easy access, this deliverable was included at the very end of this study report.

## B.1 KRUT-methodolgy

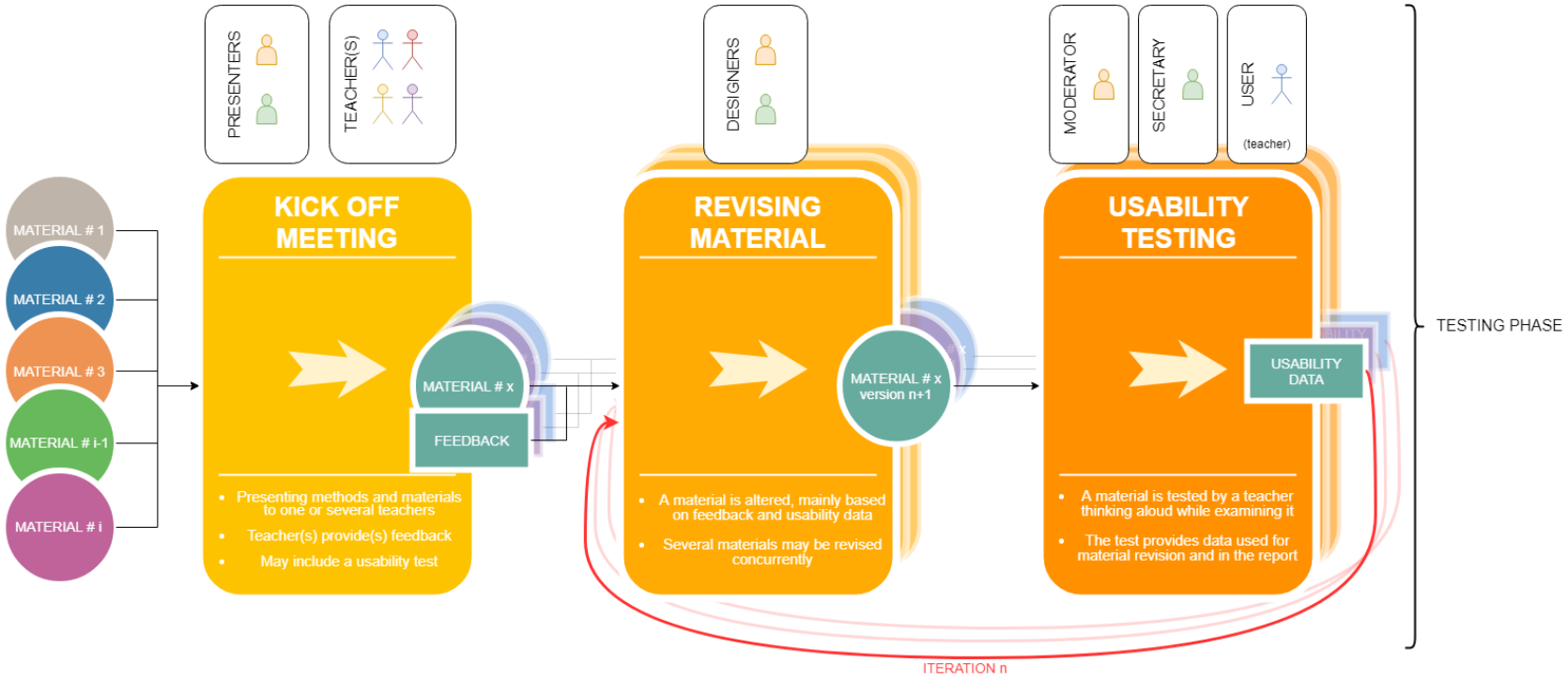



**Figure B.1:** The custom KRUT-methodology, created for usability testing teaching materials.

## B.2 The KRUT usability testing manuscript

In this study, a manuscript was created for usability testing the teaching materials. This manuscript is written in Swedish and can be used as a template for anyone interested. This manuscript was created with the assumption that the test subject is presented with a list of teaching materials, and would start the test by deciding what material is to be tested. As the situation probably will differ when other people test a material, it is encouraged that the manuscript is modified based on any current needs. It is also encouraged that any changes made to the manuscript and any findings made from usability testing teaching materials are shared publicly, so that as many as possible can benefit.

| | |
|---|---|
| **Kodnamn** | |
| **Datum och tid** | |
| **Inspelat film och ljud?** | |
| **#iteration på materialet (1, 2, … , n)** | |
| **Ålder** | |
| **Lärare/lärarstudent/annat** | |
| **Antal år arbetat som lärare** | |
| **Skolämnen** | |

I. Testet
- Syfte med testet
- Planeras ta 15 minuter
- Kommer få välja ut ett undervisningsmaterial
- ...och tänka högt medan du skummar igenom det
- Vi testar materialet, inte dig
- Det finns inget rätt eller fel

II. Fyll i listan ^

III. ”Hur ser en typisk lektion ut för dig?” (verktyg, metoder, strategier)

---

1. ”Kolla materialen på datorn. Välj ett, men klicka inte på det ännu.”

| |
|---|
| **Materialgrupp som testas** |
| **Material som valdes** |

2. ”Nu får du öppna och gå igenom materialet. Tänk gärna högt.”

3. ”Om du behövde använda det här materialet i en lektion, hur skulle du göra det?”

4. ”Har du några andra tankar eller kommentarer som inte tagits upp än?”

5. Fler tester senare?

**Figure B.2:** The custom manuscript, used when usability testing teaching materials.

This manuscript can also be found as a editable text document on any of the following links:

`https://github.com/Niwsters/teaching-materials-thesis/raw/master/usability_tests/usabilitytest_mall.odt`

`https://goo.gl/vauvUR` (note that this url is case-sensitive).