



CHALMERS
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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

HÅKAN ANDERSSON
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MASTER'S THESIS 2018:NN

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Abstract

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 obtainability aspect is primarily explored via literature study. The usability aspect is analyzed by testing of existing teaching materials. The methodology is inspired by usability testing methods found in computer science and IT.

Research questions created to be answered in this thesis are:

- RQ1: How can usability testing be used to improve the usability of teaching materials?
- RQ2: How can usability testing as a method be made accessible for teachers with limited experience of usability design?
- RQ3: What factors do teachers consider when deciding on how to use a teaching material?
- RQ4: From the perspective of a technological system, how can usability design for teaching materials be used to help teachers?

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

Acknowledgements

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1

Introduction

[Short introduction]

1.1 Research Questions

1. How can usability testing be adopted to improve the usability of teaching materials?
2. How can usability testing as a method be made accessible for teachers with limited experience of usability design?
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 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:

Taken from the planning report.

"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, pages 16 and 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.

2.2 Institutionalization

"Institutionalization, in this particular understanding – needless to say there are others – means that you set up a separate entity with the express delegated authority to do a thing.

The importance of institutionalization to our study need to be explained. Source: <https://www.quora.com/Why-is-political-institutionalization-important>

Thereby the entity becomes the only proper Doing-a-thing-place. Doing the thing outside of the institution is either senseless (Playing chess without adhering to the rules of chess.) or will get you sanctioned. (Firing a gun outside of narrowly controlled circumstances.)"

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." [SOURCE: DON'T MAKE ME THINK REVISITED, 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/designed/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 [SOURCE: ROCKET SURGERY MADE EASY]. 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.

3

Methods

When discussing *accessibility* of a teaching material, in this study, it has been separated into two aspects: *obtainability* and *usability*. Collecting data for these aspects has been done separately and with different methods. The purpose of describing this study's methodology is both to give insight in how data has been collected, as well as describing a methodology one can use when revising their own shareable teaching material.

3.1 Obtainability

Obtainability describes how easy it is for a teacher to obtain a teaching material, and the data for this aspect of accessibility has mainly been acquired through studying literature. Some data connected to obtainability has also been acquired while performing usability testing, partly because these aspects have proven hard to isolate from each other.

3.2 Usability

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 3.1 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)

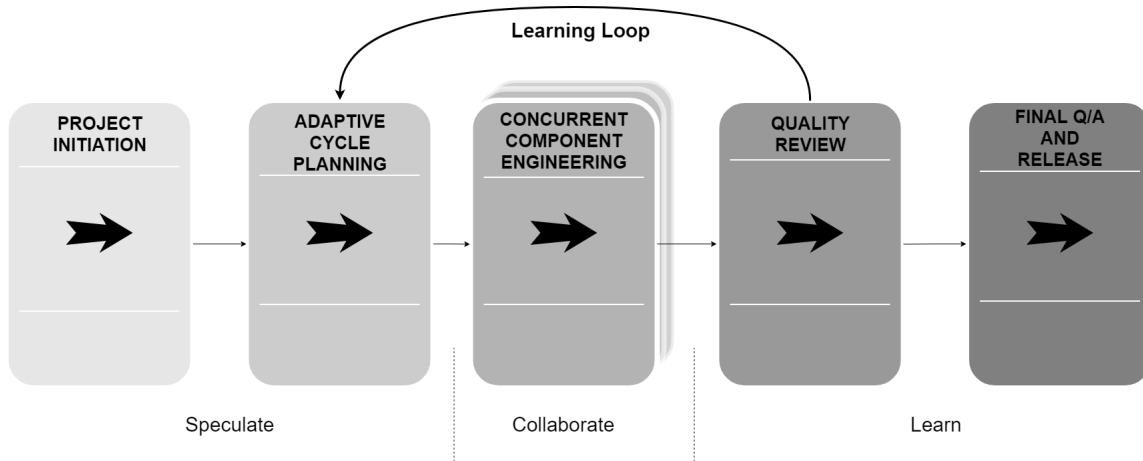


Figure 3.1: A redrawn illustration of the ASD model

3.2.1 Comparing ASD to the used methodology

While deciding on the aim of this study, a custom methodology was developed, as this process helped clarify what the study did and did not aim to investigate and how that was expected to play out. As with ASD, this custom designed method includes a learning loop and can be used for collecting data on usability of teaching materials. The method also describes the roles of the different actors, based on the current stage of the testing phase. That methodology is described in Figure 3.2, and compared to the ASD methodology to indicate similarities and differences. Comparing the methodology developed for this study with the ASD model, 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 parts contained inside the *Learning Loop*.

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 this study. 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 Steve Krug's script for usability testing websites. 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

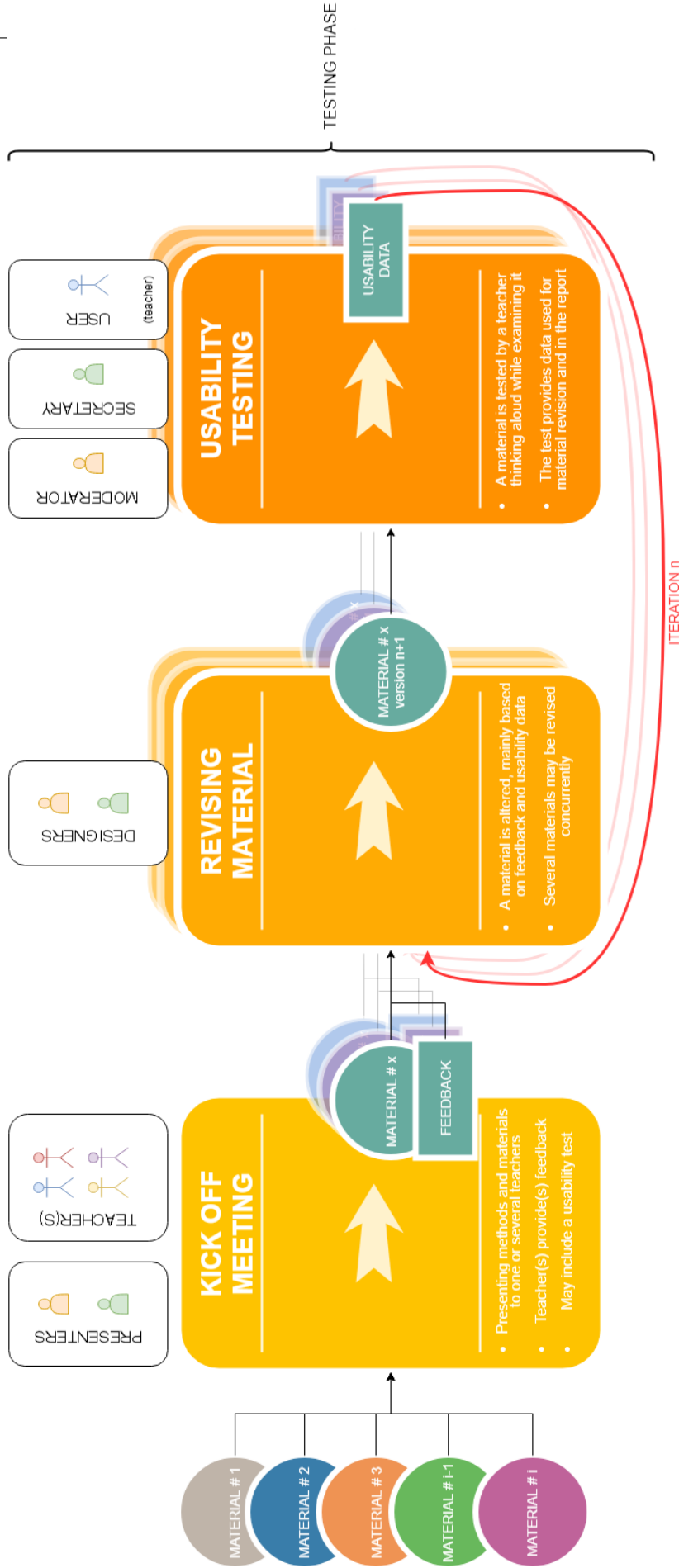


Figure 3.2: The custom methodology created for usability testing teaching materials

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. (Krug, 2009)

The end goal of ASD is called ***Final QA and Release***. In the case of this thesis, this has been replaced with this final report (not visualized in Figure 3.2).

3.2.2 Implementation of methodology

During the Kick Off Meeting of each teacher involved in the study, the teacher was able to choose what teaching material they wanted to use for their usability testing. A list of sample teaching materials was compiled, consisting of a selection of materials produced at Kleindagarna. This was done as a compromise between delimiting the study and offering teaching materials that feel relevant to the teachers.

When revising material, the decisions of what to revise when is determined from a combination of data from Usability Tests and by studying literature. There may have been instances where a teacher's assumptions of how the next revision will look have been unmet. These cases need to be analyzed and mentioned in the final report, as they may lead to interesting discussions. If for example a revision is made following a certain pedagogic template, and the resulting material makes the test subject less inclined to use it on a lesson, new conclusions can possibly be drawn about accessibility of designing teaching materials.

3.2.3 Test subject anonymity

There are several ways of presenting the personal details of test subjects in scientific studies. In this study some personal details have been disclosed and some have been 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.

By results, do we limit ourselves to the usability tests? If not we need to change this opening text. /H

4.1 Summary of usability test results

Table 4.1: Values of $f(t)$ for $t = 0, 1, \dots, 5$.

t	0	1	2	3	4	5
$f(t)$	1	1	4	9	16	25

4.2 Sample case. Kleinmaterial: Nätverk

Each teaching material tested has a different story to tell. Keep in mind that some of the content of the steps below are common to all teaching materials tested, while some are specific to the particular teaching material.

4.2.1 The preexisting work

The sample teaching material was produced by a team at Kleindagarna. These originators consisted of a handful of teachers, a subject expert and a Klein-representative.

When the workshop at Kleindagarna was over, the teaching material was published on Kleindagarna's website.

4.2.2 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 methodology consisted of a 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 are meant to be executed by teacher or students.
- The material, maybe involuntarily, expect 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 is 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.

4.2.3 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.

4.2.4 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.

4.2.5 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 is also teaching 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). Results from this test included:

- The teaching material wasn't considered complete by the creators.
- The biggest remaining problem of the material design lies in a student activity 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. 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.

4.2.6 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. This also clarified the structure to the user, enabling the user to quickly get an overview of the structure.
- The presentation's first slides contains useful information targeted to a curious teacher including how to read the important presentation notes (as these consists of teacher instructions and explanations).

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. This was previously missing from the teacher material, or carelessly intertwined with content that seemed to be aimed to students.

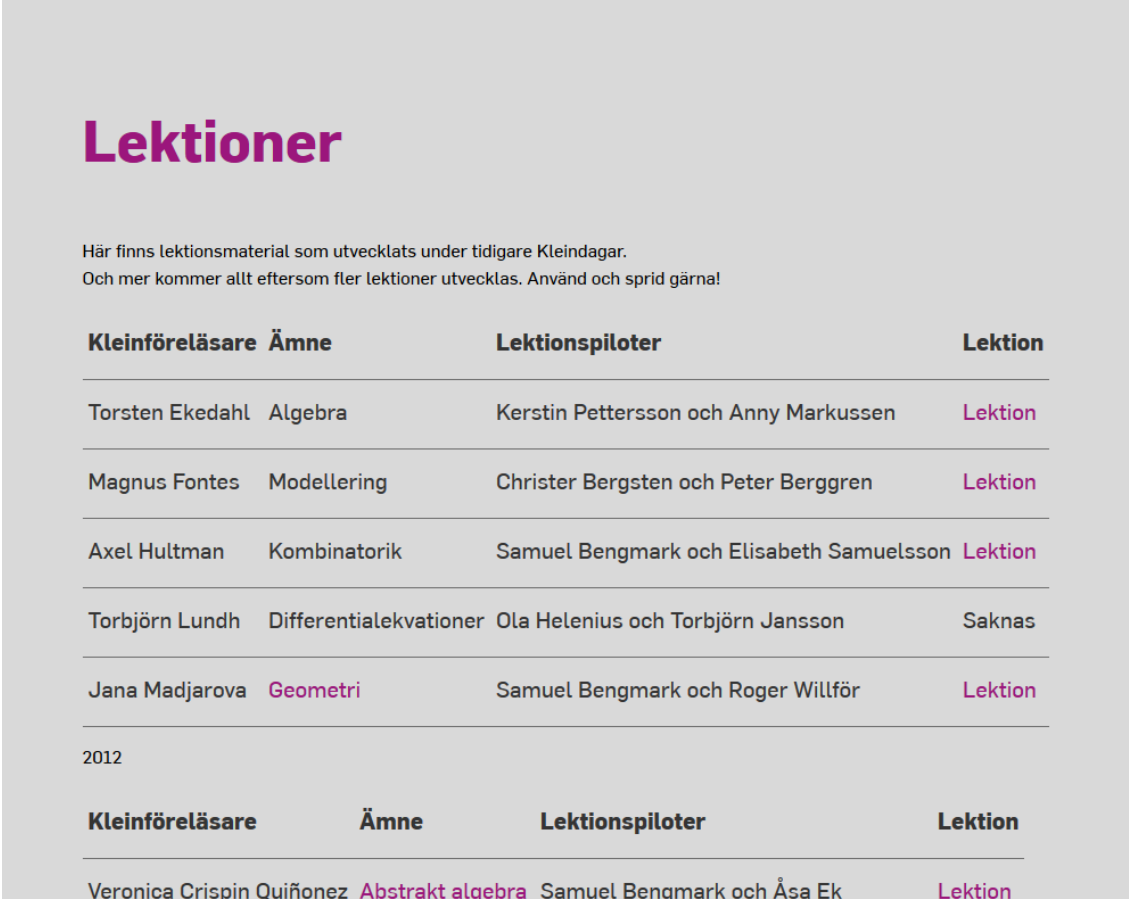
- Activities were altered to be either less vague or more closely tied to what the students are expected to learn.
- The content was modified to be easily understood and conveyed. An example of this was replacing the headings so that they describe their respective slide, instead of being named after the current 5E-phase.

4.2.7 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 is conveyed to a reader. Maybe there's 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 perfectly.
- 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. It was decided that the two types of material explored in this thesis would be *document with proposed lesson plan* and *ready-made presentation*.

4.3 The materials list



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 4.1: The original list of materials on Kleindagarna’s official website [SOURCE].

It is important to note that the design of Kleindagarna’s list of materials changed in the middle of the thesis. Most of the information in the list remained the same, but colors and fonts changed. A screenshot of the list before Kleindagarna’s change wasn’t made and thus the exact changes were lost. The first and second thesis-revisions of the list were made before Kleindagarna made changes to their list.

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 streck 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 4.2: The second revision of the list of materials, based on Kleindagarna's original [FIGURE REFERENCE?].

5

Discussion

5.1 Required adaptability depends on the teacher's autonomy

The effects of teaching materials on teacher workload is complex. A lot boils down to the autonomy in which the teacher can choose and work with a material.

If a teacher is forced to use a material, either due to rules or due to external factors, the material might have negative consequences. But if a teacher has the right to use or not use a material in the way they want, they can choose to use the parts that help them, and ignore the parts that hold them back. For example, "I use the book for simplicity's sake, but when something requires extra attention I find a material that better suits the students' needs."

How materials are used in a school is part of the school's material technology. Teachers and students both learn habits that affect the rest of the school. Thus, the school as a whole should consider how to best make use of materials as a resource: Do they have access to new material when needed and/or wanted, and do they have a stable method to fall back on when the materials produce too much workload? Note that being forced to use some new and different material is just as negative on the teacher's autonomy as being forced to do like everyone else.

Some speculations that I decided to write down to see where the final report might end up. Better make risky speculations early rather than late, so we get a chance to revise them. /S

5.2 Obtainability

Words like obtainable and teaching materials are broad by definition, and school as an institution is complex by nature. This discussion on obtainability can therefore be expected to fail at giving a complete explanation to how these words fit together, but it will try to answer some of the difficulties teachers are facing in obtaining teaching materials.

this could possibly be the first paragraph of this section in the final report. It is phrased as it aims to answer an RQ, so maybe it shouldn't be in discussion(?) /H

5.3 Future work

5.3.1 For teachers

Teachers can use the methods presented in this thesis e.g. as activities in teacher team meetings, as a way to accessibility of teacher materials. They could also discuss how they are affected by accessibility of teacher materials. Does their economy deny better quality education (obtainability issue)? Is quality of education unreasonably

dependent on teachers finding their own teaching materials (obtainability issue)? Do teachers use teaching materials that can be shared to others, e.g. substitute teachers, without a significant drop in educational quality (usability issue)? Do teachers produce their own material with the sole intent of only using it themselves (obtainability and usability issue)?

5.3.2 For universities and colleges

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

5.3.3 For others

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

6

Conclusion

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Appendix 1

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