Master thesis

Example choice experiment

Using animations

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Abstract

What are best practices in learning methods? That question has been and is still today still a much discussed topic. Some say learning by doing, some say read and memorize and some are not sure and try to think in new methods. One of these methods is a theory called the Example Choice theory.

The purpose of this study is to investigate the effects of the Examples Choice theory in learning with the use of animations. By setting up an experiment we might be able to determine if the theory can enforce and improve learning outcomes. In the first part of the paper we will go through today's school and look at how students perform on test and look at different learning theories. The cognitive science also a part of this study even if it's not the focus in this paper it is important to understand learning.

To find out if there was any hold in the theory we made an experiment. Our subjects in the experiment were 50 people in age-group 24-28 years. The subjects were randomly selected to go through a learning program with pre and post-tests to measure the outcome. The results in this study provide some support for the Example Choice theory but also raise some questions that need to be put under the loupe before making any final conclusions about the theory.

Acknowledgements

Writing this master thesis has taken its time and many things have happened in my life during this period. Sickness and frustrations has been a burden to me, but finally I can say that I have delivered and that my project was at the end a great experience.

For that I would like to thank my supervisors Weiqin Chen and Rolf Reber for helping me when I came with my doubts to them.

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Contents

1 Introduction

This master thesis is intended to give the readers a new perspective about learning and how learning could be improved with some new tools and ideas. By using interactive animations we will test the learning effect example choice theory has on a group of people. This is the foundation in this paper. Exploring new ways of learning requires many tools I don't possess at the start of writing this thesis but which I will have to apply in order to write it. Research fields like psychology and pedagogics are strangers to me now, but during this project some of the fields within the areas will be more familiar to me, and at the end I will know more things than I did before about all of this.

Students today are "forced" to learn by the book which is one way of learning. With this paper I hope to cast a light over the effects examples choice could have, and if it proves to have an effect it should be put to use. To help achieve this was my contribution when writing the thesis and is a huge motivating factor to me.

1.1 The problem

All over the world children are learning formal mathematical and scientific contents, for example basic arithmetic operations, fraction, probability calculus, the periodic table of elements, laws of physics, to name just a few. In school performance surveys on mathematical and scientific knowledge Norwegian students are not doing well compared to other countries (for PISA, see Kjærnsli, Lie, Olsen, & Roe, 2007; for TIMSS, see Grønmo, Bergem, Kjærnsli, Lie, & Turmo, 2004; Grønmo & Onstad, 2009). One example of TIMSS 2004 that made the headlines of Norwegian tabloids was that only 30% of the Norwegian 4th graders were able to calculate 9 * 15 (see Grønmo, Bergem, Kjærnsli, Lie, & Turmo, 2004, for details of the study).

The decrease of mathematics and science skills has different reasons. Grønmo et al. (2004) points at the Norwegian reform of the educational objectives in 1997 (L97) to have given the students more freedom to construct their own knowledge, which is a postulate of constructivist approaches to learning (see Shuell, 2001), and that formal contents are combined with everyday experiences, which is a postulate of situated learning approaches (see Lave and Wenger, 1991). The so-called Kunnskapsløftet (Ko6) added mathematics lessons in elementary school and focused attention on natural science. This might have improved the situation when you look at the results in TIMSS 2007 but the results are still below OECD average (Gronmo & Onstad, 2009). Why is this and what can be done to help the situation?

From the first years at school students have access to computers. This tool enables other learning ways then pure text or one way driven communication from a blackboard. The use of animations in learning is getting more used as you read this paper, but with stronger learning theories that are supporting learning with animations will make them much more welcome and used.

The purpose of this project is to show how animations and the example choice theory could be used at schools to improve the learning of formal principles and to help students in improving their skills and in that way perform better in tests like TIMSS.

1.1.1 What we offer

In this paper we will investigate if context of examples given by interactive animations could help to improve students' learning results. Students will be tested to see if the example choice has any effect when it comes to learning and understanding new principles.
The thesis will undertake a small part of a bigger project called ExampleWiki which is not the main focus in this study (Se next part). However this study is a part of it and can be seen as a contribution to ExampleWiki hence the bigger picture is relevant. The next pages will give a short presentation of ExampleWiki and present the main parts of it to help understand the questions asked in this paper and how this paper could give valuable information to ExampleWiki project.

1.2 Example Wiki-Project

The Example Wiki-project is a large project driven by my supervisors Rolf Reber and Weiqin Chen. This project is not what my paper is about, however it has some relevance both for the choice of theme and my paper might give more insight in the Example choice theory and examples for the Example Wiki-project. Below the project is described in four stages and afterwards we will look which one that has relevance in this thesis.

Example Wiki-project short description

(1)First the study will identify formal principles and how these problems could be tackled, either by the use of ICT in teaching, or by new teaching methods. The focus will be on two often neglected aspects in science teaching: First, how formal rule systems can be combined with the students personal interests; and second, how the rules could be partitioned into components that are adapted to the students' knowledge and cognitive system (Anderson, 2000). Although we focus on the combination of formal contents and personal interest, which is the innovative part of the project, we take care that the ExampleWiki is crafted according to the knowledge and cognitive capacities of the students (see Mayer, 2001). We shall focus on mathematics teaching, with applications in science.

(2) Then we begin to build a network of school partners that help plan, build up, and evaluate the content of the ExampleWiki. In the network group will be researchers from different backgrounds and mathematics teachers. In the forprosjekt, the network group is responsible for (1) contributing contents and (2) quality monitoring. Although both Weiqin Chen and Rolf Reber are university teachers and work with examples in their teaching, feedback from practitioners in the field will certainly enhance the quality of both form and content of ExampleWiki.

(3) ExampleWiki will be built, which is the main part of the forprosjekt. The objective is to provide a platform that allows entering, editing and retrieving formal principles and examples. We build a prototype of the wiki, with about twelve formal principles and 12 to 20 examples each. The system architecture will include three main components: examples,

short explanation of the formal principles linked to the related examples, and the formal principles themselves. This design reflects the principle of example choice (Reber et al., accepted for publication). The prototype will be based on MediaWiki or other free software wiki package which was originally for use for the web-based encyclopedia --Wikipedia project. A web server with a backend MySQL database which includes the wiki pages will be used. Of course, activities listed in Point **1** (theoretical elaboration) and Point **2** (networking) will continue while building the platform.

(4) The quality of ExampleWiki is continuously monitored by the network group. The group identifies strengths and weaknesses; first formative evaluations with a few students are done in order to improve ExampleWiki.

The ExampleWiki project is as mentioned a larger project, and in this paper we will just try to fill in a small piece of the puzzle. Mainly this study will undertake two of the parts about from ExampleWiki project; Part one and three.
Testing the combination of formal contents and personal interest will be done in this project and is part 1 in ExampleWiki. Part three, the construction of a prototype could not be done without any examples to populate it. Constructing examples is a big part of this study and could be used in such a project if wanted. When referring to ExampleWiki later in this paper the information in this chapter is relevant to understand the context.

1.3 Problem description

This paper needs to narrow the scope down. And to do that we will be more specific and present one primary question followed a hypothesis that we can test in the project.

Primary question:
Can self-chosen examples improve learning of formal principles compared to given examples?

From the primary question we can form hypothesizes

Primary hypothesis:

H0: Students that can choose their own learning examples does not perform better in tests than students that get random examples
H1: Students that can choose their own learning examples performs better in tests than students that get random examples

Operationalizing or making our primary question measurable by turning it into hypothesizes enables us to explore, test and measure the effects to answer our questions in this study. The hypothesis simply serves the question if there is any point of making many examples for student to choose to help improve the learning quality or is it the same if everyone has the same material like in schools today.

1.4 Different outcomes

If the data analyses indicate our suspicions that teaching formal principles with example choices will improve learning, ExampleWiki will most likely be developed further and the research on this teaching method will continue. Another effect of a positive outcome is that this way of learning potentially also becomes a trend, and schools invest money and time in education systems that use the example choice theory in practice. If science proves the effect of example choice ExampleWiki can be one of these resources that are used for educational purposes. Should the data show no significant improvement of learning, further studies is need to make sure if this study is correct or wrong in its conclusions

1.5 Motivation for the study

Education is in my mind the most important part of society, since it is what develops people and makes us able to take on professions like teacher, doctor, nurse and other important occupations. The reason I choose to look at learning theories in my master thesis was to learn more about education and the theories that is controlling the ways we educate people today. I don’t think the learning situation is perfect today in Norwegian schools, and probably it won’t be after this paper. Looking at a new theory and testing if it could improve learning was for me the perfect project. The usefulness of what you are doing is for me important. My study is not about a computer game, computer software, how to get most points in wordfoud, my paper is about people, education, and how people could learn easier without dropping out from school or giving up because it was “too hard”. I don’t believe anything is too hard if you put your mind to it, but sometimes you need to present problems in a way that fits to the individual you are going to teach, and that is what I wanted examine in my paper. For me three things needs to be present if I should be 100% motivated: It should be useful, it should be important to the society and finally it should be within an area of my personal interest. This project supports all three of my motivation “pillars”.

1.6 Research method

In this project I will use experiment and quantitative method to get the data needed. Quantitative method is used when you want data that can be quantified or said in another way data that can be translated easy into numbers and is measurable. The reason why I choose experiment was because of my problem description which was to measure learning effect by using pre and post-tests. I was also considering other methods like design science since a big part of the project is to create examples, but I choose to focus on one method and not do any triangulation in this paper since the learning part is the most interesting for me in this paper.

1.7 Organization of the thesis

In the next chapters in this thesis related fields and previous research will be presented. The next step is to look at the design and development choices we have made to test the problem. We will also explain the tools we have been using and how those where put to use during the project. Finally we will go through the evaluation processes in this project and take a closer look at the experiment, data analyses and finally a conclusion and discussion of the findings based on the data collected.

2 Related research

In this chapter we will go through some essential theories and literature that affects this study. Some of it will be more about the brain and how cognitive psychology affects the way we need to make examples that work good, and other parts will be more about design and what principles or guidelines that exists to use when making the animations.

2.1 Constructivist & situated learning approaches

Both constructivist and situated learning approaches have been heavily criticized by cognitive psychologists. Some constructivist methods, such as pure discovery learning has proven ineffective (Mayer, 2004a). Even if some studies can document better understanding of arithmetic operations when they were performed in everyday situations (e.g., Carraher, Carraher, & Schliemann, 1985), situated learning is often inefficient (see Anderson et al., 1996). It might be that some of the assumptions of the L97 are theoretically plausible, but not evidence-based. Studies on learning to throw darts to targets underwater (Judd, 1908) or sexing chickens (Biederman & Shiffrar, 1987) are examples of a proven learning method that combines teaching of basic principles with practice in relevant settings. In sexing chicken, novices learned a formal principle that enabled them to perform the task within 20 minutes at an expert level; practitioners who never have learnt the formal principle needed years to attain expert performance from mere practice. When constructivist approaches apparently fail to provide high-quality science teaching: Should schools go back to traditional modes of teaching, e.g., teaching formal principles and presenting an example which often is unattractive to students, such as teaching probability calculus with an example from gambling (see Buckley, 2009, for examples from computer science)? Modern information technology makes possible what would not have been possible two decades ago. For example, a teacher could not think of giving different examples — suited to individual interests — for every student. Teachers often do not know the individual interests of their students; even if they do, they do not know good examples connected to each topic of interest; even if they do, they are not able to present all examples simultaneously.

2.2 Example Choice

The example wiki-project undertakes the building of a database that provides different examples for formal principles. That will enable teachers with a choice: Before or after presenting the basic principle, they either can let students work on their favorite examples, or they can print out examples and distribute them to the students. Teachers could also give students a task to present their favorite example in front of class so that all the students gets to see multiple examples that illustrate the principle to be learned (Atkinson, Derry, Renkl, & Wortham, 2000) Reber, Hetland, Chen, Norman, & Kobbeltvedt (accepted for publication) call this principle of choosing among several examples *example choice* and conducted an experimental study, discussed in more detail below, which showed that example choice enhances the learning experience by increasing a student‘s interest in the formal principle. The example wiki-project gives the environment needed to use the example choice theory, this thesis will test its effect with animations.

2.3 Background

In the last four decades cognitive perspective has dominated the research in educational psychology. This has led to a deeper understanding on how to shape instruction in accordance to the student‘s cognitive capacities and abilities (see Mayer, 2004b, for a review). Newly there has been more focus in trying to understand how to shape instructions to fit the students' needs and interests (see Pintrich, 2003). Interest is considered as a positive emotion by some researches (Fredrickson, 2003). If a person actively relates to an object, he is showing interest to it, and he is then both enjoying and valuing that relationship (see Dewey, 1913; Krapp 2002 for further discussions about the definition of interest). When students are at school, they relate to formal scientific themes that might not be interesting for them. Even if it is well known that education in science is important, students are commonly not motivated to follow these topics, or they might find them difficult to learn (e.g., Hidi & Harackiewicz, 2000).

The long-term goal is to develop an internet-based learning process that will help the instructor to make things interesting for the students by connecting what students are learning with what they are usually interested in. This project of a new way of learning would work like this (see Reber et al., accepted for publication): The learner might be able to choose from different examples and questions which all are related to confirmation bias. This variety of examples involves: belief in astrological predictions; biased information search in anxiety or jealousy; stereotype and prejudice; perseveration bias in rumors; wrong suspects in criminal investigations. Students would also have the possibility to choose if they want to work on the assignment individually or in groups. Once the student has answered a question that has to do with confirmation bias, the student would get a feedback and then is instructed in class about confirmation bias. This learning process offers more variety in teaching than the instructor could give only with his own effort, and it also supplies the educators with several valid examples related to the same theme.

Some other formal contents that could obtain benefits from this “theme choice” involve probability calculus, statistics, genetics, or organic chemistry. In addition, this method tries to connect topics that might be indifferent or even repulsive intrinsically to topics that are interesting in themselves; this way, fascination for a formal topic would be raised by the fact that it helps to understand more in depth the things that one is really interested in– according to Dewey (1913) the only proper way of —making things interesting.

Hoffmann (2002) published a study similar to the tool it is being planned, but it did not introduce the example choice. It was mentioned how basic physics could be taught as a training in high school to make it more interesting to both boys and girls. Afterwards she connected formal contents to contents that the learners had said they were interesting to them and compared the interest-based learning to more traditional ways of learning. Hoffmann discovered that interest-based learning helped increasing physical achievement in apprentices and made them more interested into the theme. A different focusing also allows the student to create examples (Watson & Mason, 2004). The concept is that understanding is helped along by creating own examples. The proposal exposed here by us, does not preclude that students later construct their own examples and even submit it to ExampleWiki, but before a student can create his/her own example, it is necessary that he or she has a basic knowledge about the formal principle.
In line with criticisms from the viewpoint of cognitive psychology (Mayer, 2004), the project begins by guiding the students to elaborate on the formal principle, before they can actually start to create their own example, as proposed by Watson & Mason (2004).

Hundred and forty-four students from the first year at university were given an online lecture about confirmation bias (Klayman & Ha, 1987). The students had all the time they wanted to have to go through the presentation. One group of participants was given 14 questions they could pick from (Choice group). Topics included stereotyping, jealousy, halo effect, pseudoscientific practices, rumors, and errors in criminal investigations. A different group of participants was given one of the questions, matched to the ones chosen by the former group (No-choice group). The last group was only given the presentation (Presentation-only group). Both the group that had been given the opportunity to choose (Choice group) and the one that had no choice (no-choice group) had to answer the first question. Afterwards, the tree groups were given the presentation; duration of viewing the presentation was assessed as a measure of attentional persistence (see Hidi, 2001, for a critical review of the relationship between interest and attention). Among other things, we assessed interest and control with eleven questions used by Chen, Reber, Gudem, & Stokke-Olsen (2004). The results were that the students forming the first group were, first, more motivated, and second, seemed to be more persistent in attention than the second group. This test, tried to move the example choice from the laboratory to educational scenarios.

2.4 Cognitive science

Cognitive as a term refers to perceiving and knowing, and cognitive scientist seek to understand mental processes such as perceiving thinking, remembering, understanding language and learning (Stillings, Weisler, Chase, Feinstein, Garfield, & Rissland, 1995). We can by looking at that definition see why a closer look into the area of cognitive science would be a very relevant and important supplement to this project.

Much of what is happening in the creation of multimedia instructions could prevent learning rather than promote learning in computer-based training (Sorden, 2005). Sorden claims this because of the brains capacity and way to work when it comes to the working memory and the cognitive load theory should be important consideration for the designer who has to think about these things when designing and not use things because they are available or looks flashy or exciting.

2.4.1 The working memory & cognitive load theory

The working memory sometimes referred to as the short term memory (Atkinson & Shiffrin, 1968) is a system in the brain that holds temporary information and processes it so that verbal and visual information can be stored and integrated (Baddeley (1986). But the working memory has its limitations in how much data it can process, and here we are talking about another theory, the cognitive load theory (CLT). The CLT states that the working memory is limited in its capacity to selectively attend to and proves incoming sensory data (Chandler & Sweller, 1991). When it comes to problem solving and understanding things, humans have a max capacity level according to the CLT.

If people make examples that don't consider these important restrictions the examples could cause an opposite effect then wanted. The layout should be visually appealing and intuitive, but the focus should be on the learning and the concepts rather than on the entertainment (Sorden, 2005). According to Sorden (2005) the working memory can be overloaded by the entertainment or activity before the learner gets to the concept or skill to be learned. However the main goal should not be only to minimize the cognitive load but rather to strive and develop a teaching tool which uses the least amount of cognitive load appropriate to the learner with the prior-knowledge he/she possesses.

In this project there will be focus on minimizing the cognitive load by taking the research that has been done and putting it to use in the design process.

2.4.2 From brain to design

After learning about the brain at its limitations it's time to get some practical knowledge of how to creating efficient learning examples. Sorden (2005) puts it in a simple way that you should avoid putting unnecessary activities into a lesson that requires full attention or concentration to avid overloading the working memory, so that most of the brain focuses on the essential information that should be obtained.

One of the easy ways of reducing extraneous cognitive load is to eliminate redundant text (Chandler & Sweller, 1991). Based on Baddeley`s (1986) model of the working memory Sweller et al (1998) proposed several instructional design techniques based on Cognitive load theory.

The first technique/principle is the *goal-Free effect*. With this Sweller suggest that problems should not have an end-goal. One example Sweller gives is that instead of asking for the value of a particular angle in geometry task you could ask the student to find the values of as many angles as they can. Then the student does not have to maintain several conditions in his working memory and therefore reduces the cognitive load.
Principle number two is called the *worked example effect*. If a student gets a problem made in a good way and so that student's attention is focused on solving it the result could be more effective learning than to have the students find the problems themselves and then solving them.
Another example is the *split-attention effect* which states that one should design teaching instructions in such a way that the learner doesn't need to focus on more than one task at a time. One example is reading a manual while solving a problem, in this case it's better if you read the manual first and then solve the problem.
Modality effects uses Baddeley`s (1986) theory that claims that working memories capacity can be increased by using auditory and visual working memory together then one alone. The information that goes on both channels should be made in that way that they are not giving same information but work together giving meaningful content to the learner.
The *redundancy effect* is another principle Sweller suggests. This principle states that you should try to avoid having the same information in many channels (audio & video) and you should use the right amount of information based on the users. One example is an expert photographer doesn't need to know all info in a photo editing software, while a person unknown to photography will need more info. In the first case more info will be redundant but for the second user not. If you find the perfect balance between information the cognitive load will not be overloaded.

Sweller`s last principle is the *variability effect*. This simply states that you should try to variate situations and task so that the learner will recognize the problems in different conditions and use the material to solve problems more conditions then a static given example.

2.5 Multimedia learning & design principles

Meaningful learning is when the student can use what he has learned in new situations, and the performance is better when they learn by problem solving transfer tests then when they learn by pictures and text alone (Mayer 2001). Two important ways to achieve meaningful e-learning are according to Mayer, Fennel, Farmer & Cambel (2004) first to reduce cognitive load by designing activities that frees working memory capacity during learning. Secondly to increase the learners interest which according to Mayer et al., 2004c should encourage the learner to use the freed capacity to deep processing during learning.

In these studies everything points to that when you want to achieve efficient/good learning, you should reduce the cognitive load in this case in our examples and then also make them interesting to the learners.

The science of E-learning includes three elements: evidence, theory and applications (Mayer 2003). Element of evidence simply means that there should be research based theories, evidence of theory, that there should be research based theories of how people learn with the possibility to put those to the test. The last element of applications Mayer states there should be theory based principles of how to design electronic learning environments, which can be tested in research studies.

As a result of Mayer's studies he has found nine effects that are important. Some of these effects are the same as Sorden (2005), like the modality principle and redundancy principle. But Mayer has also found some other interesting things in his studies that we can apply in this paper. We will now present some of the most relevant effects/principles for this project (Principle from now).

Modality & the redundancy principle see Sorden (2005) earlier.

Contiguity Principle is divided in two kinds of contiguity; Temporal which means that corresponding elements in this example words and pictures should be presented at the same time. Spatial contiguity means that elements should be placed close to each other.

Multimedia principles see Sorden (2005) earlier

With Personalization principle Moreno & Mayer (2010) has found that it's better to use a personal style rather than formal style in the narration in examples.

Coherence principle

All the extra sound, text, picture or video should be removed to achieve better transfer. Moreno & Mayer points out that those instructional designers should pay extra attention to this principle. *Pacing principle* is telling that it's better if the user of an e-learning animations controls the speed himself than that the software itself. This is important so that the animation is performing as fast as the user wants and think is comfortable.
These principles will be used and referred to later it the paper when we look at the design choices made in making examples in this paper. It's important to think of these principles as guidelines when designing and sometimes they get broken (Sorden, 2005).

3 Example design and Development

The design of examples and process of making them is a time consuming part of this project. Even with the use of templates (described later) the amount of examples that needs to be created is a huge process. In this chapter we will be looking closer at the design and development of some of the examples used in this project.

3.1 Design of examples

In this part of this paper we will look at the design of examples and discuss what choices we have done and how we have been using previous research done to make a design that should support the learning theories we have chosen to rely on in this study. This can of course not guarantee any success but it should function as a more secure way of design then random design (Sorden, 2005).

Many examples are needed in the process so it is essential to have everything arranged and a good structure is a must dealing with all this information. In the picture below you can see how the file structure for each category will look like.

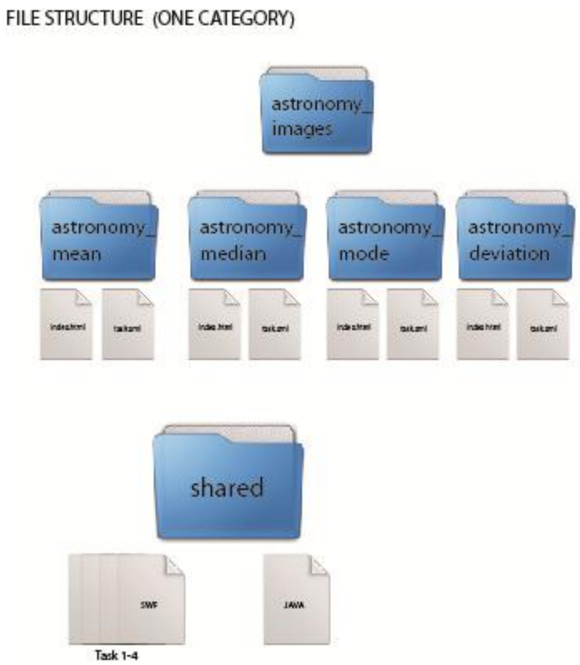
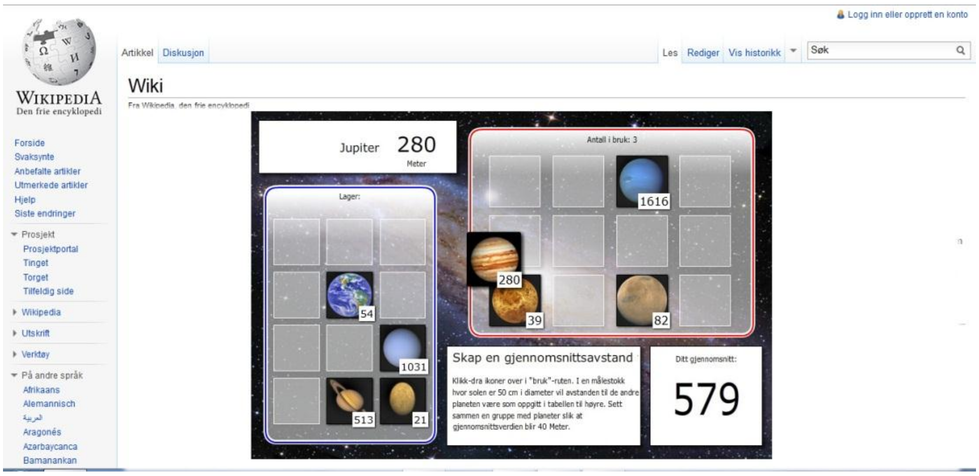


Figure 1: Example file system

The three different principles shares one folder with pictures to make it easier if people want to add or replace pictures in future changes.

3.2 Use of templates

The examples will have 720 x 480 in resolution. The reason for this is that it can be seen on all screens and there will be a suitable size to implement into ExampleWiki or other platforms which needs space around to have other functions. As the picture below shows one of the examples in a Wikipedia screenshot (which could be quite similar to ExampleWiki) you can see that the space around is needed in case you want to have text or expand the menu systems.



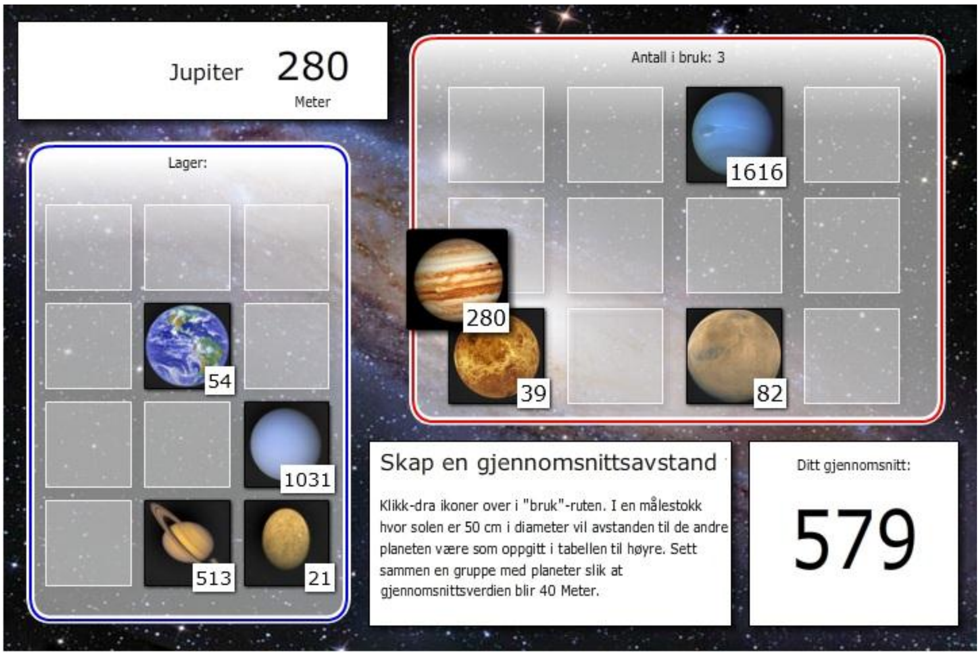
Picture 1: Example put inside Wikipedia's GUI

All the small pictures will be kept in 70x70 and background 720x480 both in 120 dpi which should make them look nice in every screen on the market today. A reason why focusing on the quality is that for the web this is important to avoid hours of loading, even if that should not normally be a problem with downloading pictures to the computer one can imagine if this should be used in other less developed countries with much lower speeds.

To do this project we will use twelve different categories, and then each category will have three examples each (average, mean and mode). This will add up to 36 examples in total making the creation of examples a lot of work. But to help with this we will construct three templates and then change the content that gives us less but still considerable amount of work.

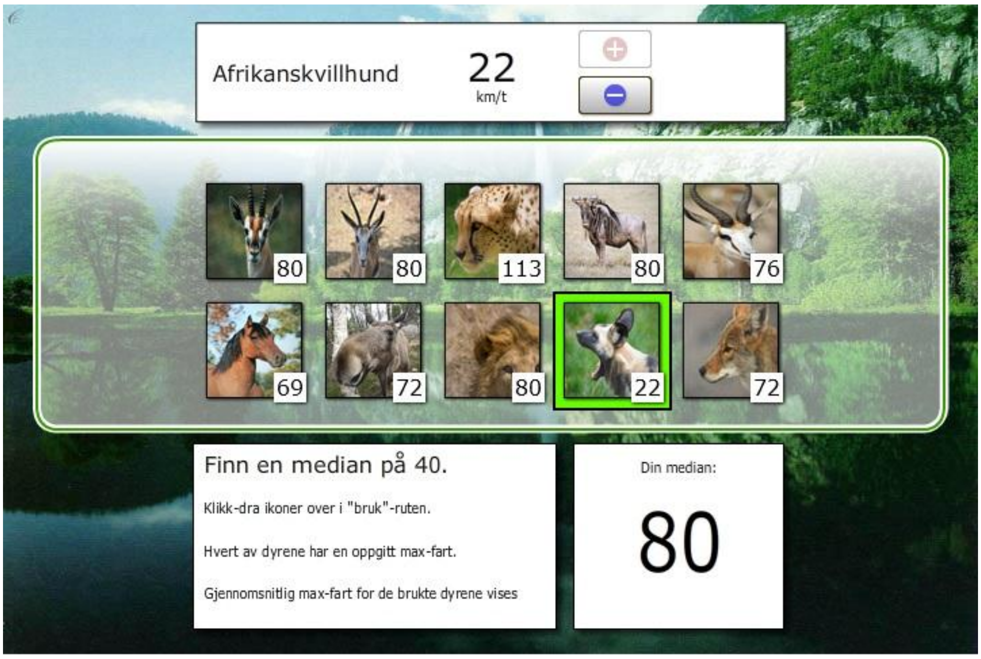
Since 36 examples are too much I will present three examples using the three different templates to show the difference in the design and thoughts behind them. The examples are made using many different tools (tools section).

Template number one shows five windows, highlight window, storage window, in use window, text window and result window. The highlight window in top left shows where your mouse is over or where the user has clicked. In having that window the user has control of where he is at and what he is doing. The storage window keeps the elements that is not in use, and the in use window is where all the chosen elements go into. The text window gives the user a short explanation about what the user should do and what the goal result should be. The result window shows the result of what the user has dropped into the in use window to give him a feedback this changes as soon as he drops or removes something. Same is if the user is correct, then the box will blink to tell the user he is done and has solved the exercise.



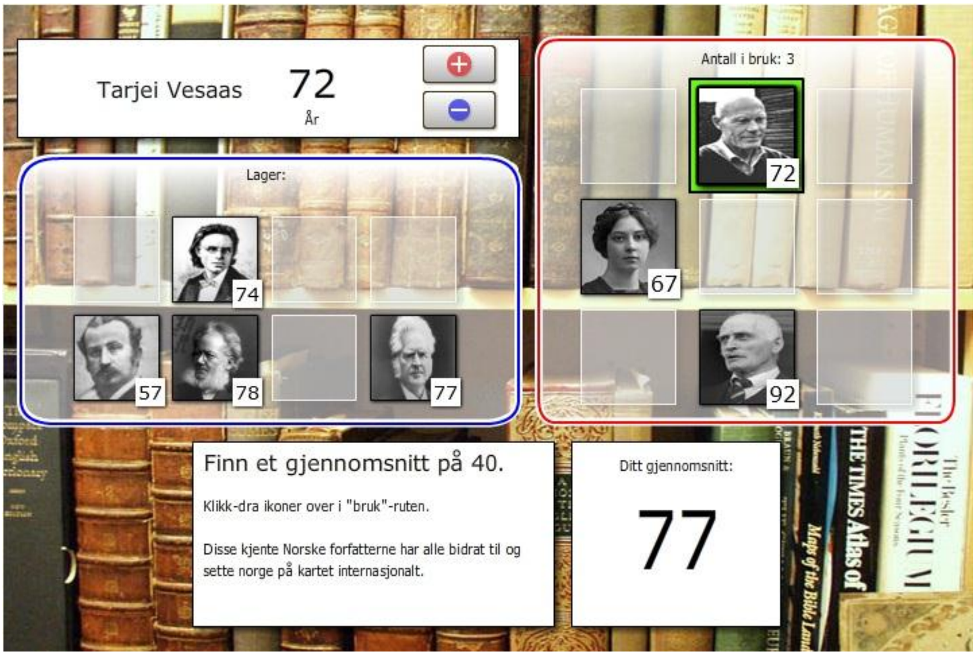
Picture 2: One astronomy example

In template number two you can see all the same windows except that the storage window has been removed. This means that the user can not add or remove any elements. But what the user can do in template number two is to change the value of the elements by clicking +/- in the highlight window the value changes and the result will be different.



Picture 3: Nature category example

In the third template you see the same as in the first only that in this template you can change the elements and change the value they have. This is a kind of mix between template one & two.



Picture 4: Literature category example

3.3 Code design

Since this are hopefully examples that would be used in the ExampleWiki project it is important to create easy changeable examples. By using XML to plot the essential information we keep things very simple in case people want to change some data or elements.

As you can see on picture 5 it is not very complicated to see where the information should go since the example info is already there you can just replace to change the content and thereby the example.

```
<general>
    <task type="1" goal="40" tolerance="0.1" step="1" minVal="20" maxVal="52"/>
    <metatext find="###" replace="40"/>
    <metatext find="***" replace="Meter"/>
    <imagefolder>../astronomi_images/1</imagefolder>
    <stage_img> background.jpg </stage_img>
</general>

<itemlist>

    <item value="21" icon="merkur.jpg">
        <label>Merkur</label>
    </item>
    <item value="39" icon="venus.jpg">
        <label>Venus</label>
    </item>
    <item value="54" icon="jorden.jpg">
        <label>Jorden</label>
    </item>
    <item value="82" icon="mars.jpg">
        <label>Mars</label>
    </item>
    <item value="280" icon="jupiter.jpg">
        <label>Jupiter</label>
    </item>
    <item value="513" icon="saturn.jpg">
        <label>Saturn</label>
    </item>
    <item value="1031" icon="uranus.jpg">
        <label>Uranus</label>
    </item>
    <item value="1616" icon="neptun.jpg">
        <label>Neptun</label>
    </item>
```

Picture 5: Code examples, XML file.

The code is a bit longer for each example but you get an idea of the complexity and amount of work that is needed to make one example work and with right values.

3.4 Tools

To accomplish our goals we needed to make our examples using different tools that we choose based on our needs in this project but also on previous experiences using them. In this project we have used various types of tools and languages including java, html, xml, action script, Adobe Flash, Photoshop and Dreamweaver. In the next part we will explain shortly about how, why and where these tools where put to use during this project.

3.4.1 Software & languages

Photoshop

Photoshop was the obvious choice for editing the pictures in the examples though you could use any software available however one function that was especially handy and time-saving was the batch edit mode. This makes it possible to process many pictures in one session, and helped me a lot when minimizing and making the same size in a total of around 150 pictures.

Adobe Flash

In order to create the examples we used adobe flash CS5. Flash is a versatile program where you can combine most file formats into one file. The program language in flash is called Action-script which is a very logical and easy understandable language. It should therefore be easy for most people to make changes though in this project the XML files contains the material that professors or other might want to change.

Dreamweaver

To create and edit java, xml and html you have plenty of choices. Dreamweaver was just my option since I have the adobe suite and therefore don’t need eclipse, go-live or any other editor.

4 Evaluation

To evaluate we will first look at the experiment design and what our thoughts where when it came to picking subjects and the choices made in that process. In this chapter we will also look at the procedure of the data collection and how it was designed.

4.1 Experiment design

Getting good and enough data makes a good experiment design very important.
The goal with the experiment is to test if group A (Free choice) managed better than group B (Given examples). According to the example choice theory group A should promote the learning effect since they could make the choice after their own interest. To find out if this was the case I needed comparative date, before and after the learning period.

4.1.1 Subjects

In this experiment I decided to have a total of 40 people participating. I could not know if that was being too optimistic but I set a goal getting that many people. Since my fellow students and friends are all in the 20`s I decided to test people from the age of 24 to 28 years old. By having test subjects within a small age group would make things easier for me, but would also rule out age difference as a factor for spread results in the experiment.

4.1.2 Pre & post-test

The pre-test was made at the same time as the post-test to make sure they are the same in appearance but more importantly in difficulty. That said they are not a copy of each other but in terms of difficulty they should be in the same level to observe changes if any after the learning period.

Two pages of 5 tasks in categories average, mode and mean where given to each person that participated. Also three papers explaining the principles (Se appendix C) where handed out before to help explain. The material from this was extracted from matematikk.org (Vedeld &

Venheim 2012).The participants were allowed to use a simple calculator, blank paper and a pen if they wanted since the understanding of principles is the main focus not calculating or putting them up right. During both the pre and post-test the participants were given 10 minutes to complete the tasks.

When the tests was made and animations completed I started to test people that had the time both at the school area but also friends and family members that was in the right age group as mention earlier. The first 20 people I tested now referred to as group A was given the option to choose three out of the 12 categories (9 out of 36 examples) of their choice to support their learning. After group A had been tested the last 20 people referred from now to as group B was going to be tested, only that group B participants would not have any choices regarding their learning period but would receive the same learning as group A. Meaning that nr 1 in group B had the same examples as nr 1 in group A, B2 the same as A2 and so. Reason for doing the selection this way is to make the selection in group B random and even if the examples are the same, one can assume that the interest and choice of example would not be identical in both groups.

4.2 Goal

The goal with the experiment is to test if group A (Free choice) managed better than group B (Given examples). According to the example choice theory group A should promote the learning effect since they could make the choice after their own interest.

The pre-test will be given to each subject to test their pre-skills. To be able to measure if any learning has been achieved during the time, there needs to be data from before and after so that we get comparative data. Therefore the participants will also get a post-test that is very similar to the pre-test.

4.3 Procedure

Since the testing in this project is a huge undertaking for one person, comprehensive planning was needed. In this section I will explain the procedure from test-start to finish how I addressed this phase.

4.3.1 Preparation

This experiment has a relative big mass of participants and given that they have time I tried to do as much pre-work as I could to make things easy for both the participants and myself. Having the tests and animations ready on a computer, usually my laptop or a school computer was a part of the preparations each day during the data collection period. When I approached people in the hallway or elsewhere I always presented myself and my mission to make them people know right away my intentions. After getting people's attention I handed out a prepared single a4 paper that I gave before to make them understand the experiment process and what is required of them before deciding whether or not to participate. This trick proved to work very well since all of asked people did not have any questions or doubts before saying yes, except a few that said no because of lack of time/motivation. I also needed to make sure that the environment I used for testing was optimal. In my case I used rooms with no people in and minimal disturbance of noise or other factors.

4.3.2 Pre-test & post test

When the person has agreed to participate we walked to the test room and started with the pre-test. Group A participants were given another procedure then group B participants.

Group A participants were given categories and time to choose which one they like the most. Group B participants did not receive any such question, and the examples were ready in the computer since each participant was given examples. During the test of group A and B participants I was present in the room observing, taking notes and answering questions if any doubts.

After the pre-test, participants would receive the learning examples and the explanation schemes (Appendix C). When time was up I gave the participants a post-test to see if there was any improvement in scores or not. The subjects filled out the paper and then I thanked them for their time and said goodbye.

4.4 Data analysis

For the data analyses I used word excel. This program was already known for me and not as complicated as other more powerful statistical tools like SPSS which I have tried before to. Excel lets me create graphical figures and do the most basic statistic calculations like running t-test with my data, so the program should cover my needs for this project when it comes to data analysis. The static's will contain some Norwegian due to that my excel version was Norwegian but there should be no problems understanding the results.

All the analysis that is done can be rebuilt using the raw-data that is found in Appendix E. The results will sometimes refer to the appendix or to tables in the appendix part.
In all the t-tests performed in this analysis chapter alpha value is set to standard value (0,05).

Group A: Pre and Post-test results

T-test: Paired two sample for mean

	Pre -est	*Post-test*
Gjennomsnitt	10,16	14,16
Varians	19,39	1,47333333
Observasjoner	25	25
Pearson-korrelasjon	0,493928988	
Antatt avvik mellom gjennomsnittene	0	
Fg	24	
t-Stat	-5,066403971	
P(T<=t) ensidig	0,00001756	
T-kritisk, ensidig	1,71088208	
P(T<=t) tosidig	0,00003513	
T-kritisk, tosidig	2,063898562	

Figure 2: T-test

Figure 2 is the result of a paired two sample t-test that has been made by the pre and post-test results of group A (the free choice group). The p value here is 0,00003513 and shows that the results is statistical different since it is below the alpha value (0,05). We can see in the figure that group A in total has gained 4 point each from the pre to the post-test.

Group B: Pre and Post-test results

T-test: Paired two sample for mean

	Pre-test	*Post-test*
Gjennomsnitt	9,96	13,2
Varians	19,54	5,16666667
Observasjoner	25	25
Pearson-korrelasjon	0,651889219	
Antatt avvik mellom gjennomsnittene	0	
Fg	24	
t-Stat	-4,755117561	
P(T<=t) ensidig	0,000038700	
T-kritisk, ensidig	1,71088208	
P(T<=t) tosidig	0,000077400	
T-kritisk, tosidig	2,063898562	

Figure 3: T-test

Figure 3 is the result of a paired two sample t-test that has been made by the pre and post-test results of group B (the given example group). The p-value here is 0,00007740 and shows that the results is statistical different since it is below the alpha value (0,05). In average the subjects manage to score 3,24 more correctly in the post-test which means that the group was improving even if they had no choice of examples.

Group A and B: Pre-test results

T-test: Two-sample Assuming Unequal variances

	Group A	*Group B*
Gjennomsnitt	10,16	9,96
Varians	19,39	19,54
Observasjoner	25	25

Gruppevarians	19,465
Antatt avvik mellom gjennomsnittene	0
fg	48
t-Stat	0,16027205
P(T<=t) ensidig	0,43666968
T-kritisk, ensidig	1,6772242
P(T<=t) tosidig	0,87333937
T-kritisk, tosidig	2,01063476

Figure 4: T-test

Figure 3 is the result of a paired two sample t-test that has been made by the pre-test results of group A & B. The p-value here is 0,87333937 and is over the alpha value (0,05). The average of 10,16 and 9,96 shows that the groups where quite similar in the pre-test.

Group A and B: Post-test results

T-test: Two-sample Assuming Unequal variances

	Gruppe A	*Gruppe B*
Gjennomsnitt	14,16	13,2
Varians	1,47333333	5,16666667
Observasjoner	25	25
Antatt avvik mellom gjennomsnittene	0	
fg	37	
t-Stat	1,86276126	
P(T<=t) ensidig	0,03522501	
T-kritisk, ensidig	1,68709362	
P(T<=t) tosidig	0,07045002	
T-kritisk, tosidig	2,02619246	

Figure 5: T-test

Figure 3 is the result of a paired two sample t-test that has been made by the post-test results of group A & B. The p-value here is 0,07045002 and is over the alpha level (0,05). Here both groups improved as shown in previous figures, and group A is the best with 14,16 against B groups 13,2 average score.

4.4.1 Findings

Based on the t-test results we can start by looking at figure 2 and 3 which both reveals the same results for both groups; that the subjects was learning! This of course is also revealed in the results of pre vs post-tests in both groups but now we have the numbers.

We also found that group A`s results were better than groups B`s in both the pre and post-tests and that A was the one with the best improvements from pre to post test.

Figure 4 shows that there was no statistically difference between the groups in the pre-test something that could mean that the groups where more or less similar when it came to pre-knowledge about the themes.

Finally figure 5 compared the results of the post-test showing a difference between the groups though not statistically difference and we have to keep our 0 hypothesis

H0: Students that can choose their own learning examples does not perform better in tests than students that get random examples

H1: Students that can choose their own learning examples performs better in tests than students that get random examples

When we keep H0 it does not mean that it can’t be thrown at a later time. The p-value was 0,07 and is not far from the alpha value.

5 Conclusion and Future Work

In order to get to a short conclusion in this paper lets head back to our starting point, the primary question in this paper:

Can self-chosen examples improve learning of formal principles compared to given examples?

Based on the data we got in this experiment it is not possible to draw any conclusion. We can see trends that subjects that can choose examples perform better with better results than the given group. But statistically we cannot say if that is the case and further studies needs to be done to do so.

5.1 Future work

In future studies I would get more test subjects to get significant results. Another problem with my study might be that it simply was too easy for subjects and therefore you get the floor-ceiling effect, in this case the floor which simply means that the task is so simple that too many can do it effortless. Of course you might also be able to get around that problem by picking younger people to the experiment.

The last thing not mention earlier is that this study is not looking into long term learning, and to measure the effect of that one might get different outcomes. After week's maybe students have forgot and some remembered, this could be the next addition to this paper.

In sum I'm happy having done this thesis even if the results did not give any clear results statistically we got god pointers to where things might go with some adjustments mentioned.

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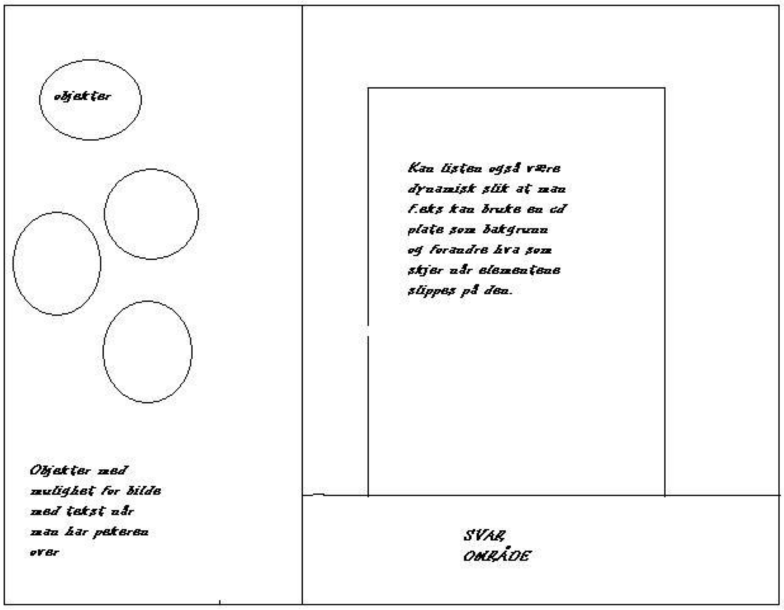
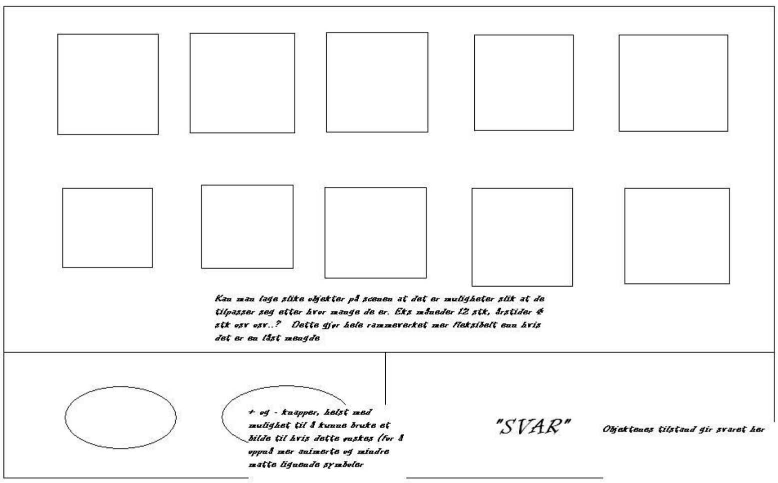
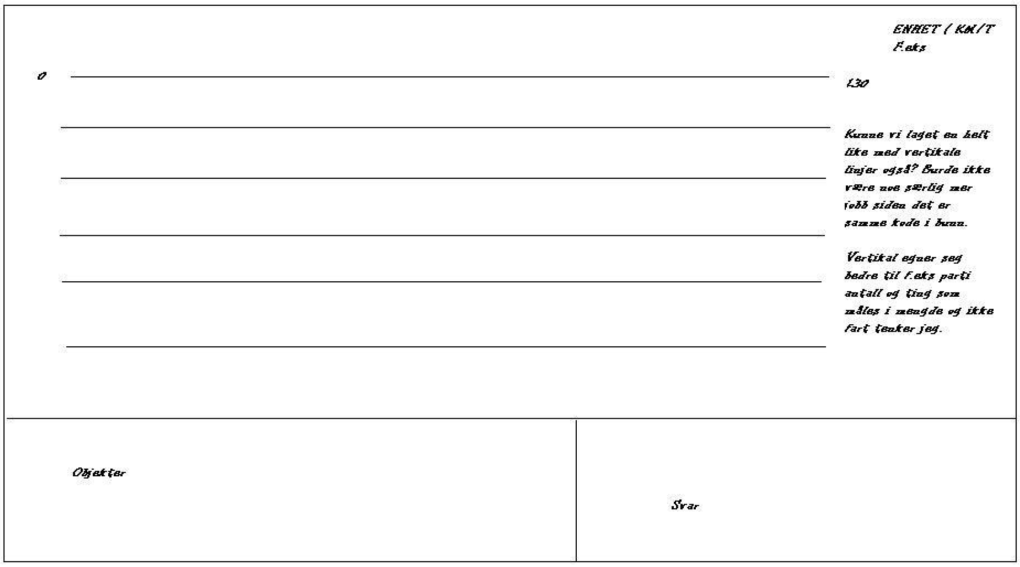
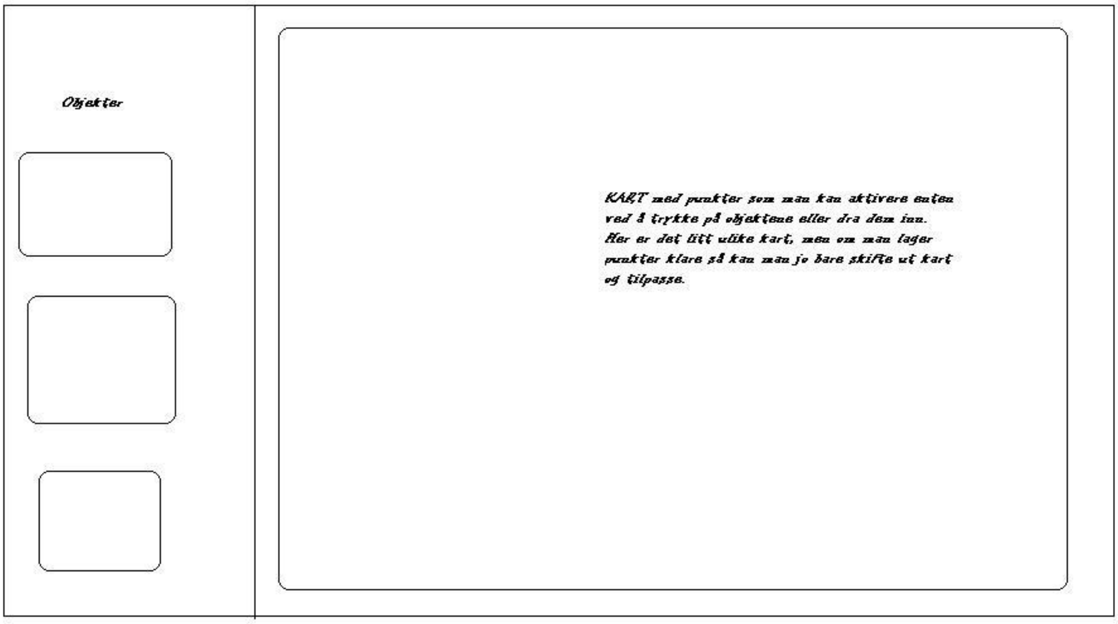
Appendix A: Early sketches of examples






ENHET (KM/T
F.eks
0
130
Kunne vi laget en helt like med vertikale linjer også? Burde ikke være noe særlig mer jobb siden det er samme kode i bunn.
Vertikal egner seg bedre til f.eks parti antall og ting som måles i mengde og ikke fart tenker jeg.
Objekter
Svar


Objekter
KART med punkter som man kan aktivere enten ved å trykke på objektene eller dra dem inn.
Her er det litt ulike kart, men om man lager punkter klare så kan man jo bare skifte ut kart og tilpasse.

Appendix B: Pre and post-tests

Pre-test

Hjelpemidler tillatt: Kalkulator

Tid tilgjengelig: 10 minutter

1. Finn gjennomsnittet

30 + 22 + 14 + 4 = 17,5

6 + 7 + 16 + 15 = 11

2 + 5 + 2 + 4 + 5 + 8 + 2 = 7

45 + 5 + 25 + 4 + 2 + 6 + 11 = 14

10 + 7 + 12 + 15 + 5 + 8 + 9 + 2 + 5 + 7= 8

2. Finn median

5 - 3 - 10 - 5 - 3 - 10 - 10 = 5

2 - 2 - 43 - 32 - 22 - 3 - 45 = 22

50 - 15 - 20 - 20 - 16 - 20 - 16 - 15 - 15 - 51 = 18

13 - 13 - 17 - 12 - 11 - 15 - 13 - 17 - 20 = 13

300 - 13 - 220 - 180 - 14 - 250 - 13 - 320 = 190

Pre test

3. Finn modus

1 2 2 1 3 6 7 8 7 6 4 1 =	1
2 3 4 5 5 4 8 9 9 4 3 7 =	4
7 11 11 3 4 5 6 6 5 6 6 =	6
11 12 22 22 11 54 3 1 1 1 =	1
2 10 10 22 3 4 4 10 2 1 1 =	10

Deltaker opplysninger:

Navn: ______________________________

Epost: ______________________________

Post-test

Hjelpemidler tillatt: Kalkulator

Tid tilgjengelig: 10 minutter

1. Finn gjennomsnittet

23 + 27 + 8 + 30 = **22**

12 + 4 + 7 + 13 = **9**

5 + 3 + 2 + 3 + 6 + 10 + 6 = **7**

4 + 6 + 24 + 35 + 2 + 24 + 10 = **15**

5 + 2 + 15 + 13 + 4 + 4 + 12 + 11 + 22 + 2= **9**

2. Finn median

7 - 13 - 7 - 4 - 13 - 4 - 13 = **7**

33 - 26 - 5 - 22 - 5 - 5 - 33= **22**

9 - 13 - 47 - 9 - 11 - 9 - 13 - 13 - 9 - 48 = **12**

20 - 17 - 17 - 14 - 19 - 18 - 17 - 14 - 20 = **17**

16 - 340 - 19 - 355 - 230 - 255 - 16 - 190 = **210**

Post-test

3. Finn modus

3 4 4 6 6 3 3 8 9 1 9 1=	3
1 1 4 6 6 4 8 9 6 4 6 8 =	6
7 13 3 1 7 5 17 3 3 5 1 =	3
14 6 6 14 25 54 25 3 3 25 =	25
7 11 11 8 7 7 8 10 32 32 9 =	7

Deltaker opplysninger:

Navn: ____________________

Epost: ____________________

Appendix C: Explanation schemes

Gjennomsnitt

Gjennomsnittet, ofte kalt den aritmetiske middelverdien eller bare middelverdien, er summen av alle dataene delt på antall data.

Eksempel

Her er en frekvenstabellen over personers høyder:

Høyde (cm)	Frekvens
170	1
171	1
172	2
173	2
174	1
176	1
177	2
179	2
180	3
181	3
182	5
184	1
185	1
187	1
188	1
189	3

Hva er gjennomsnittshøyden for de 30 perosnenei eksemplet?
Vi summerer alle de 30 verdiene og får:

177+181+172+185+...+189=5397

Vi har altså 5 397 centimeter å fordele på 30 rekrutter. Gjennomsnittet blir:

539730=179,9

Gjennomsnittshøyden på personene er altså 179,9 cm, som vi kan runde av til 180 cm.

Median

Medianen finner vi ved å stille opp alle dataene i stigende rekkefølge, og deretter velge ut det tallet som er akkurat i midten. Dersom antallet data er et partall, er det to tall i midten. Da bruker vi gjennomsnittet av disse to tallene.

Eksempel

Her er en frekvenstabell over personers høyder:

Høyde (cm)	Frekvens
170	1
171	1
172	2
173	2
174	1
176	1
177	2
179	2
180	3
181	3
182	1
185	1
187	1
188	1
189	3

Datapunkter nummer 15 og 16 er i midten av datamaterialet, med høydene 180 cm og 181 cm. Gjennomsnittet av de to høydene er 180,5 cm. Med andre ord: Medianhøyden til personene er 180,5 cm.

Modus

Modusen er den verdien i et datasett som forekommer flest ganger. Dersom flere data forekommer flest antall ganger (For eksempel på en prøve med tallkarakterer der 10 stykker får 5 og 10 stykker får 4), er modusengjennomsnittet av disse dataene, eller vi kan operere med flere moduser for datasettet.

Eksempel 1

Modusen behøver ikke å være et tall. I eksemplet med eksamens-karakterer er modusen karakteren C, siden den karakteren forekommer flest ganger.

Eksempel 2

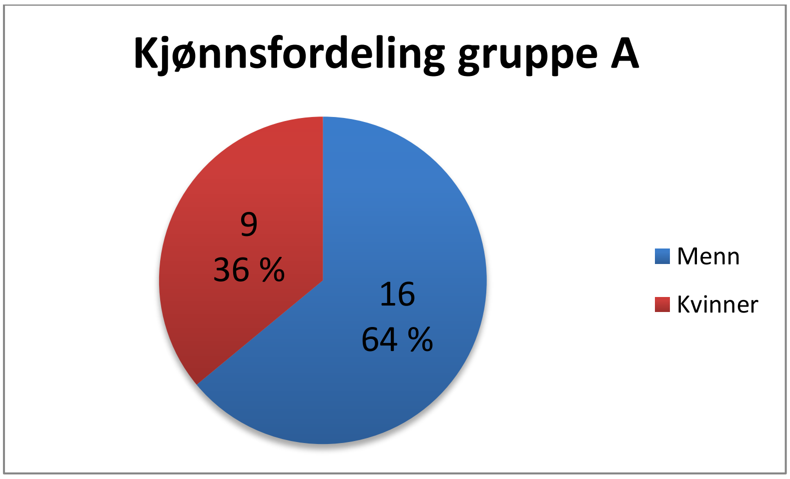
Hva er modusen i eksemplet med personers høyde?

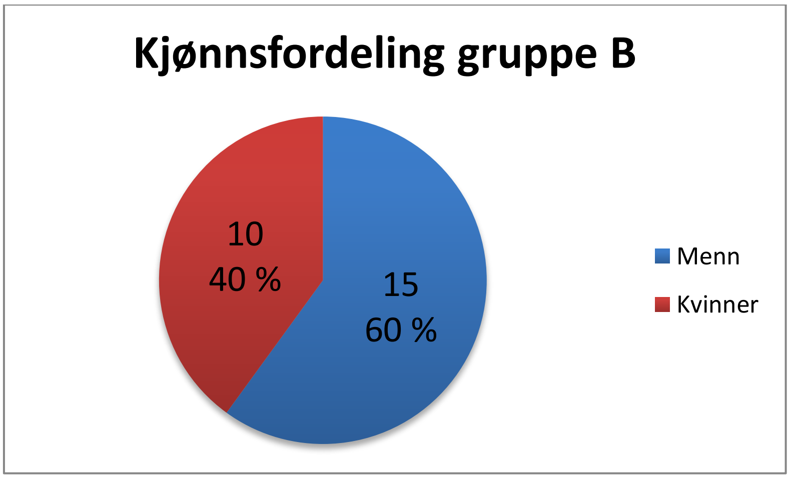
Høyde (cm)	Frekvens
170	1
171	1
172	2
173	2
174	1
176	1
177	2
179	2
180	3
181	3
182	5
184	1
185	1
187	1
188	1
189	3

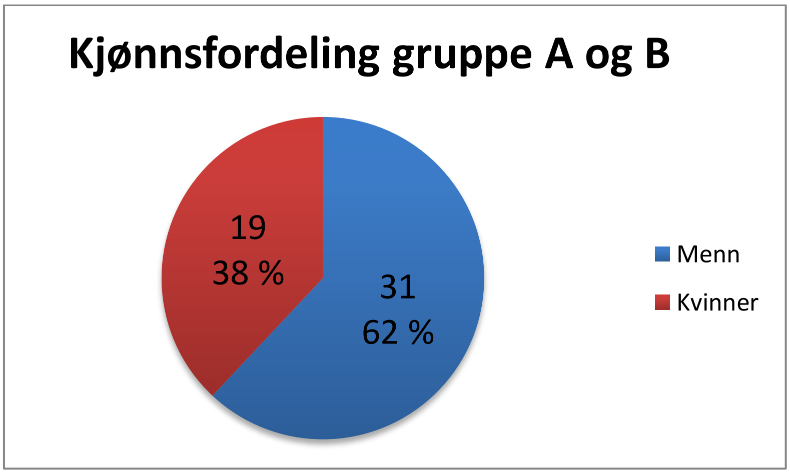
Den høyden som forekommer flest ganger er 182 cm, hele 5 ganger. Derfor er modus (typetallet) 182 cm.

Appendix D: Results

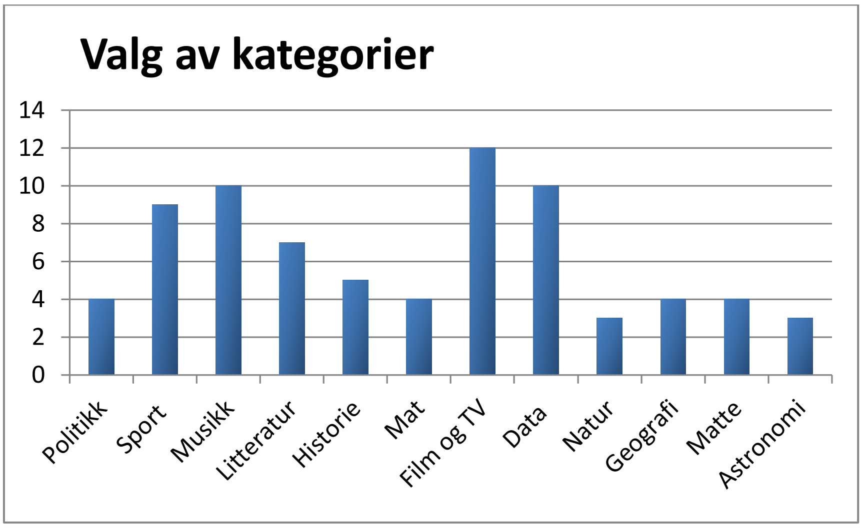
Genders



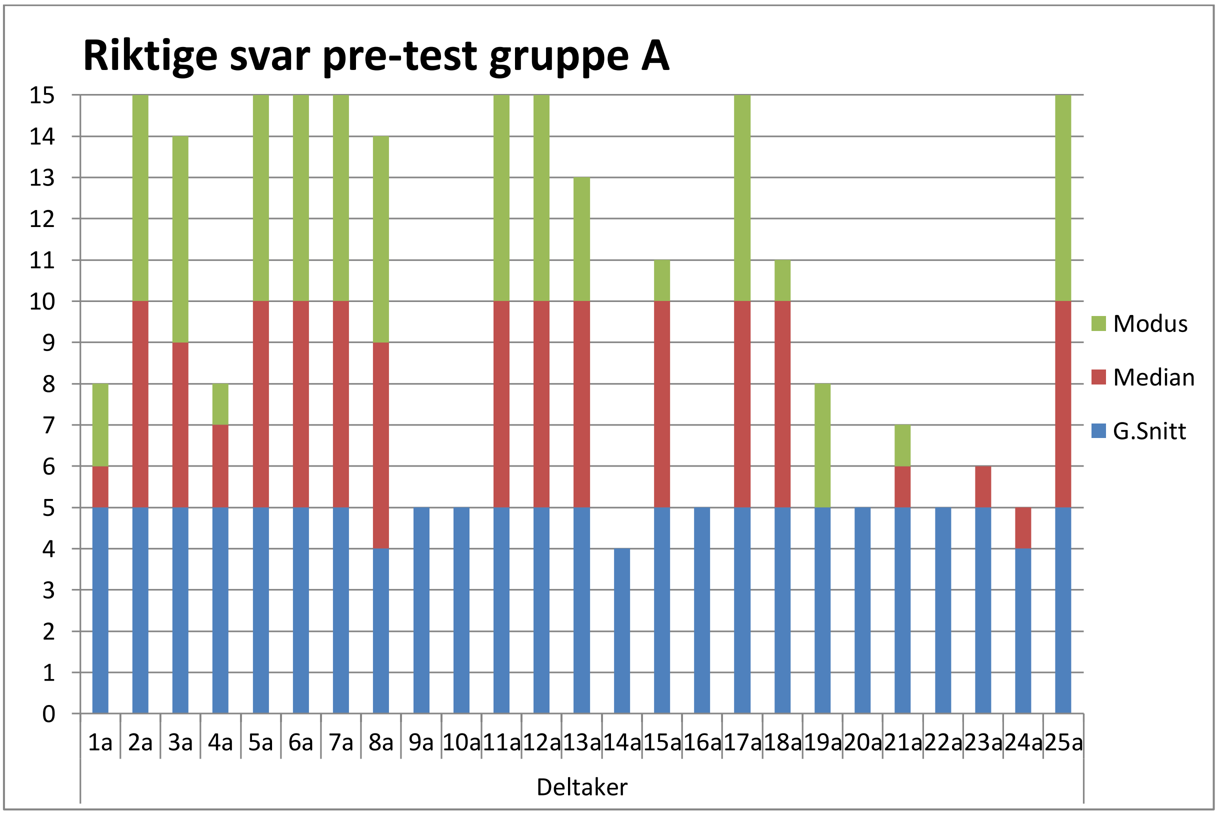


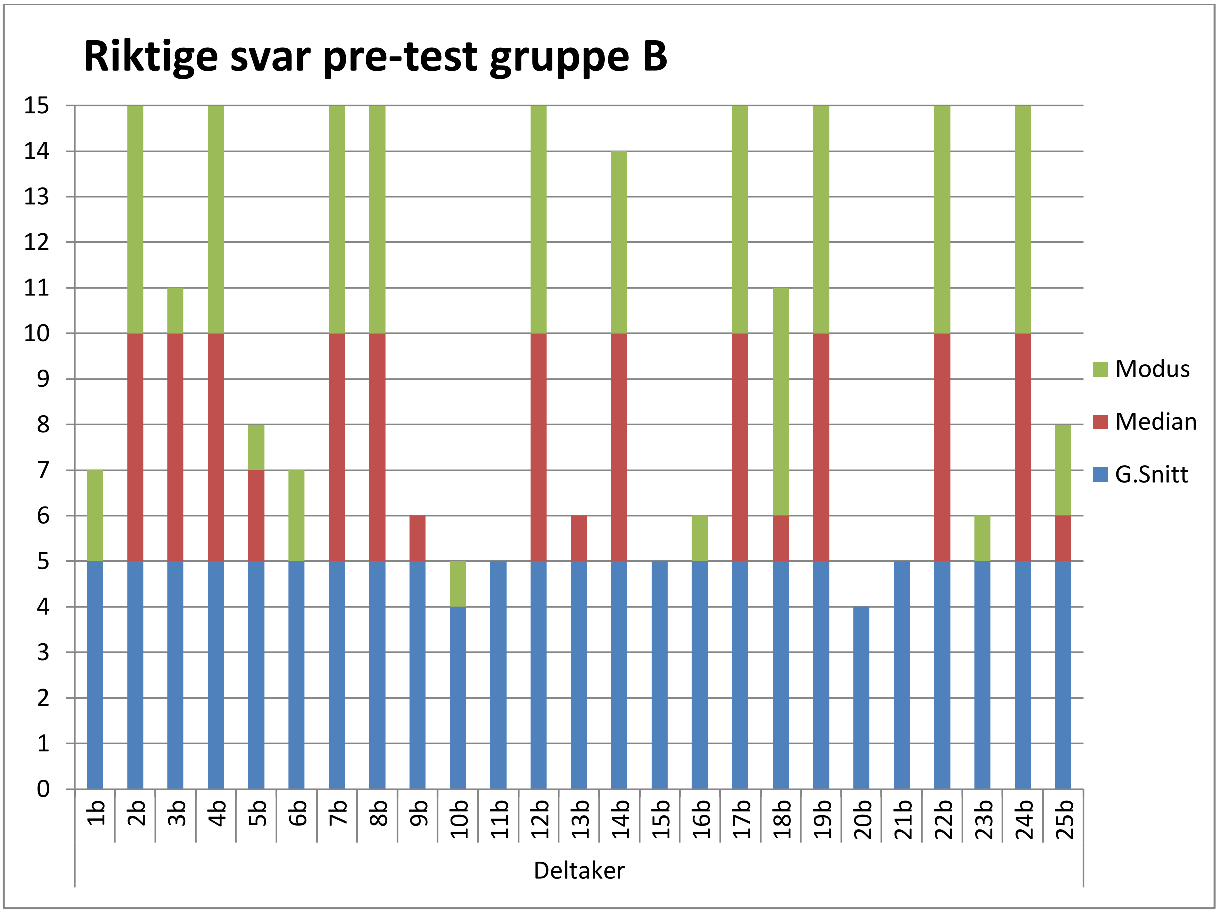


Categories

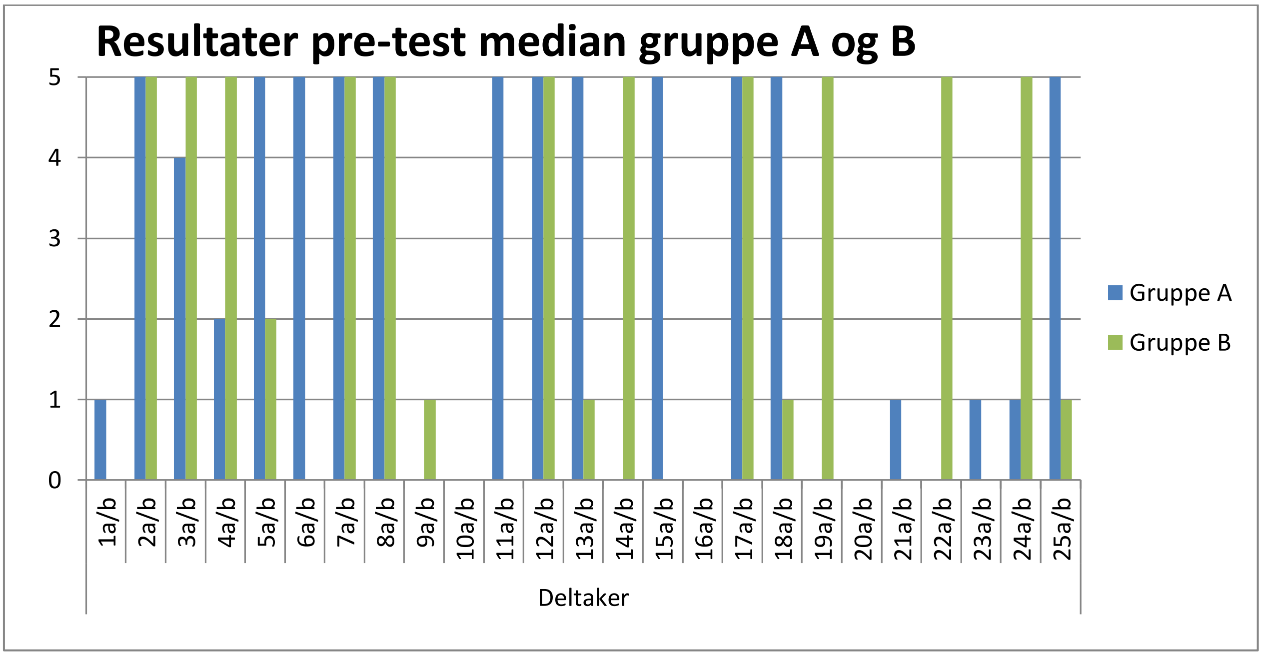


Pre-test

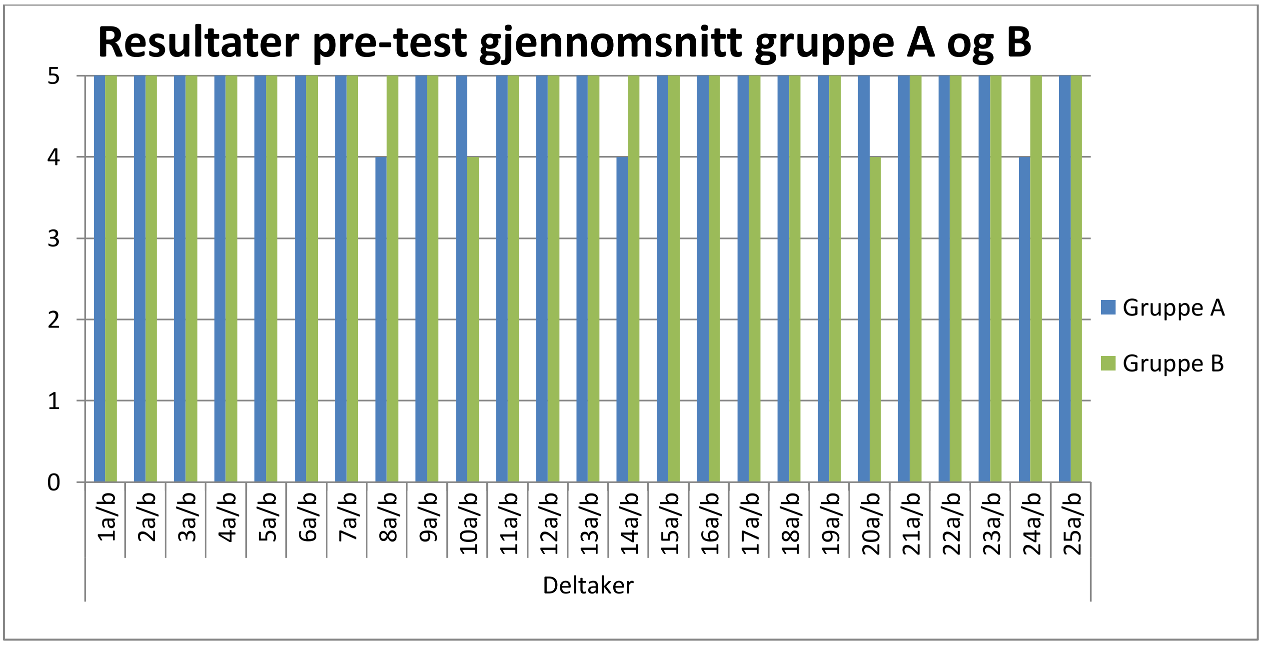




Riktige svar pre-test gruppe B
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1b
2b
3b
4b
5b
6b
7b
8b
9b
10b
11b
12b
13b
14b
15b
16b
17b
18b
19b
20b
21b
22b
23b
24b
25b
Deltaker
Modus
Median
G.Snitt

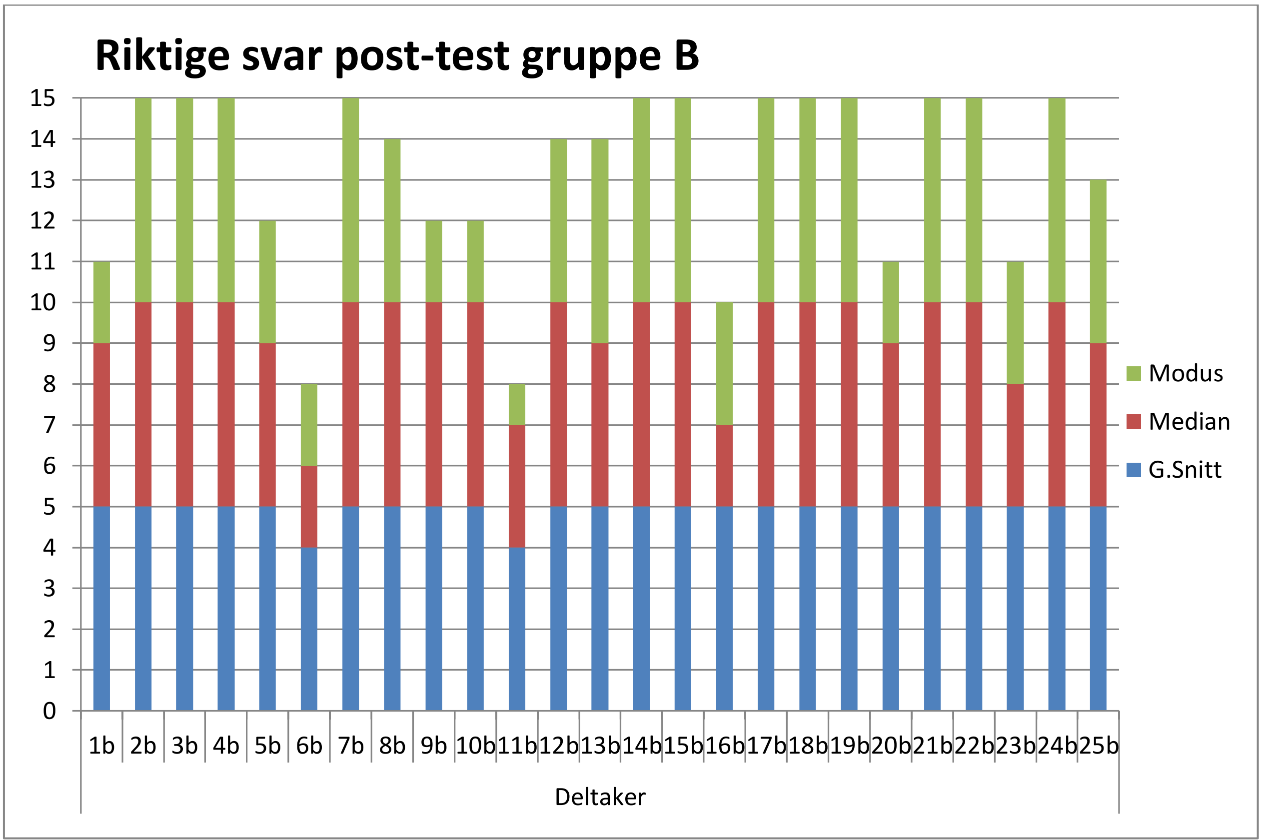


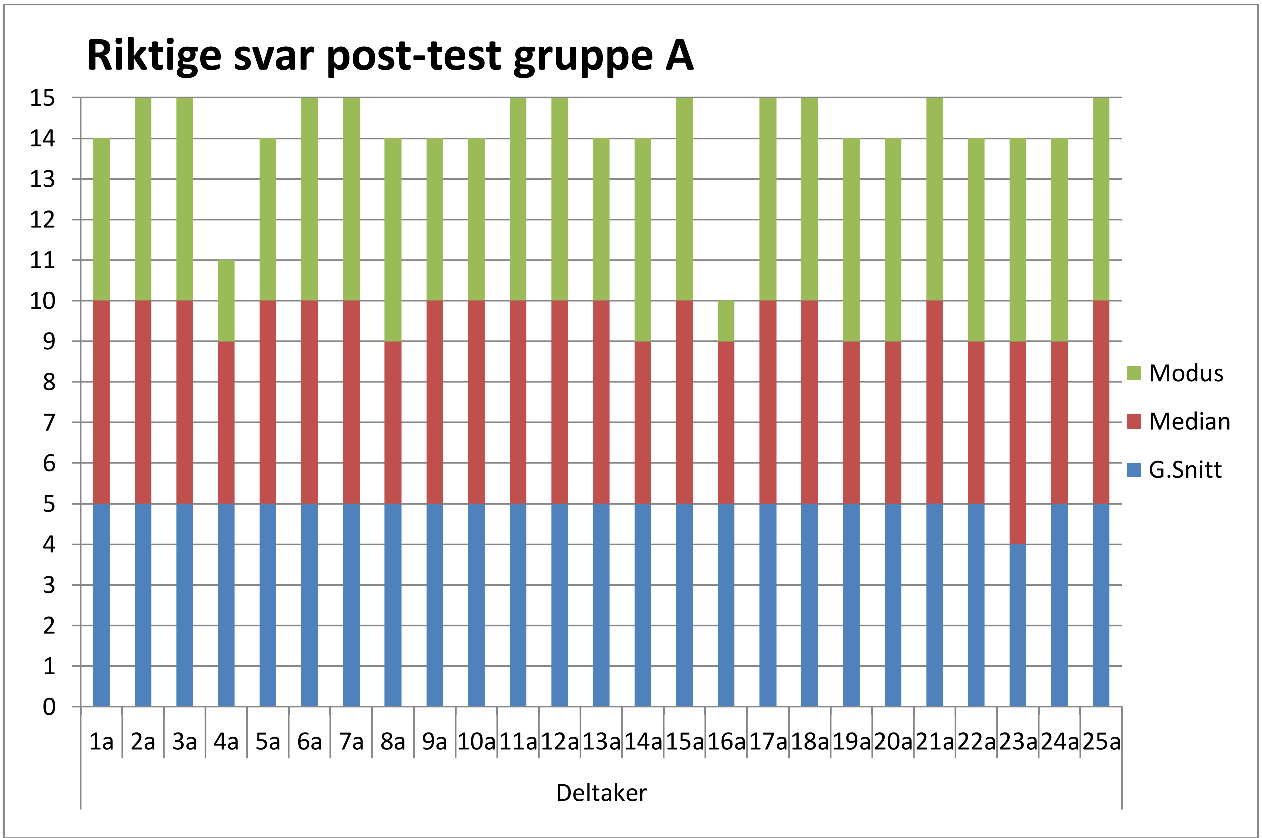
Resultater pre-test median gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

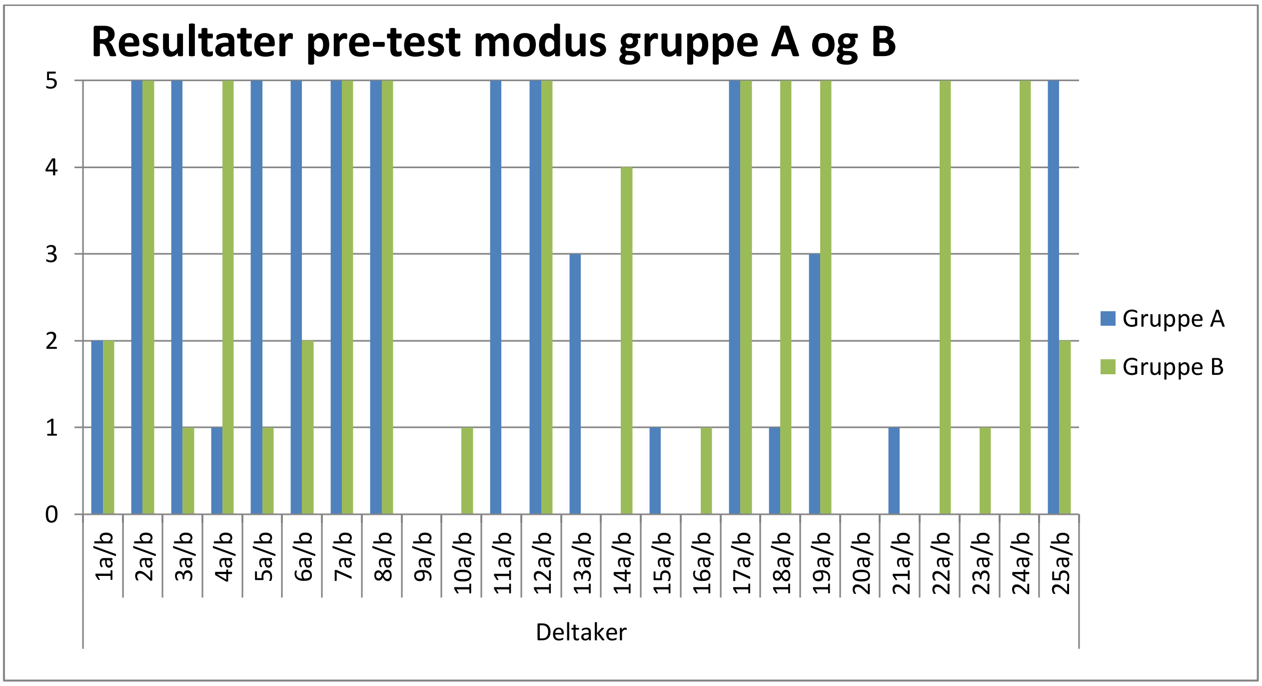


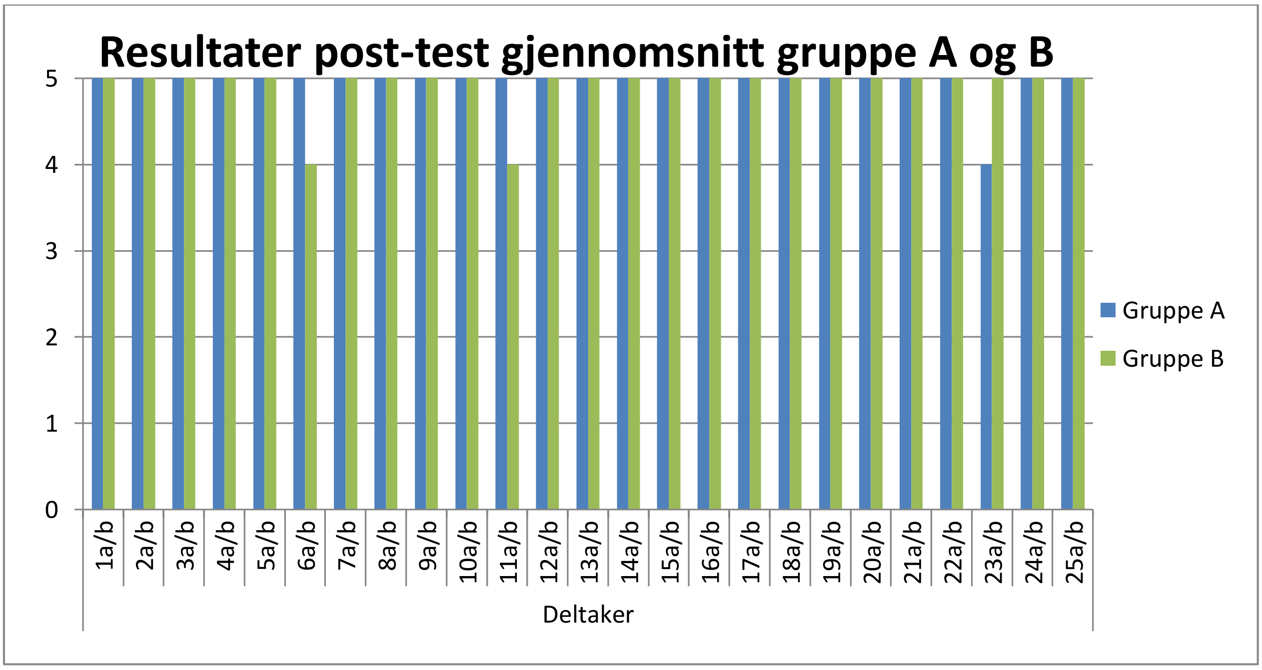
Resultater pre-test gjennomsnitt gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

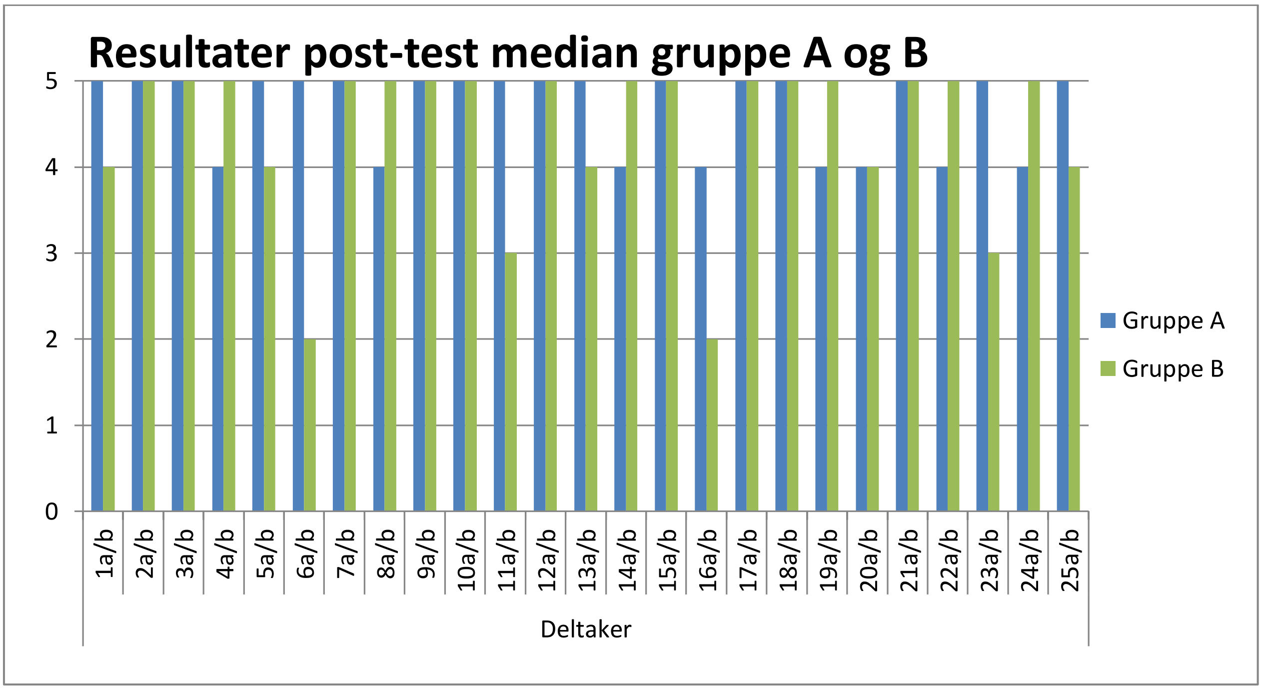
Post-test

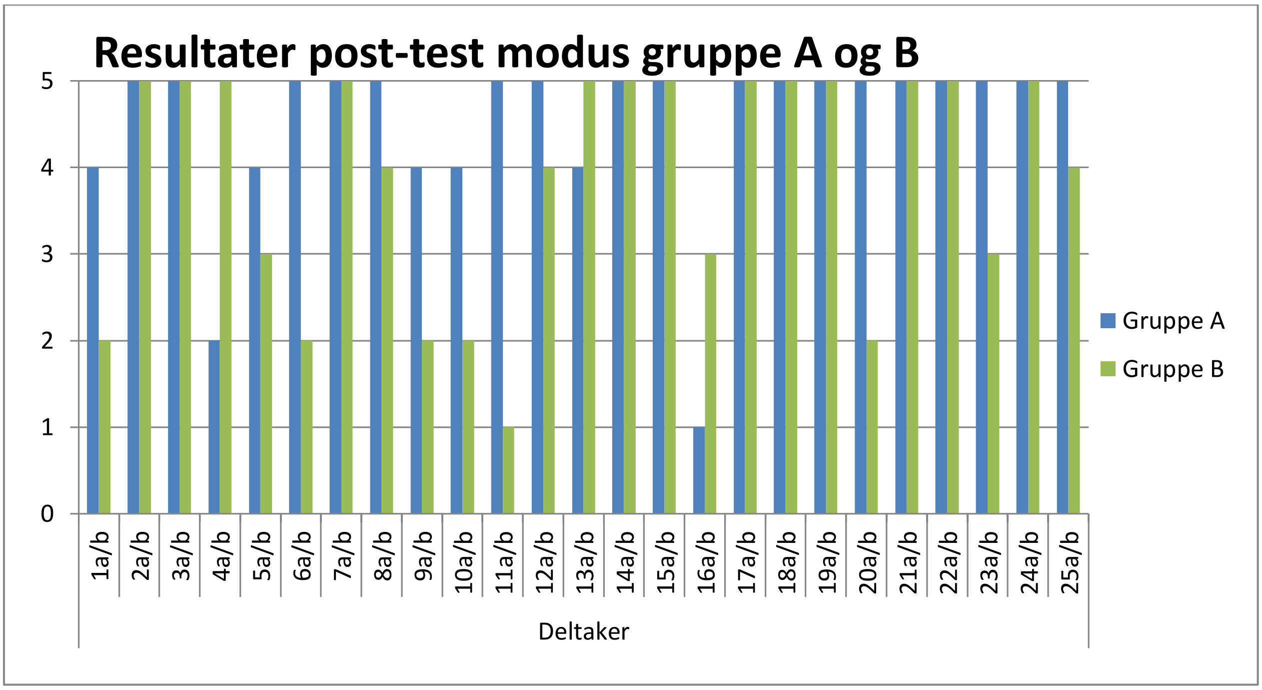

Riktige svar post-test gruppe B
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1b 2b 3b 4b 5b 6b 7b 8b 9b 10b 11b 12b 13b 14b 15b 16b 17b 18b 19b 20b 21b 22b 23b 24b 25b
Deltaker
Modus
Median
G.Snitt


Riktige svar post-test gruppe A
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1a 2a 3a 4a 5a 6a 7a 8a 9a 10a 11a 12a 13a 14a 15a 16a 17a 18a 19a 20a 21a 22a 23a 24a 25a
Deltaker
Modus
Median
G.Snitt

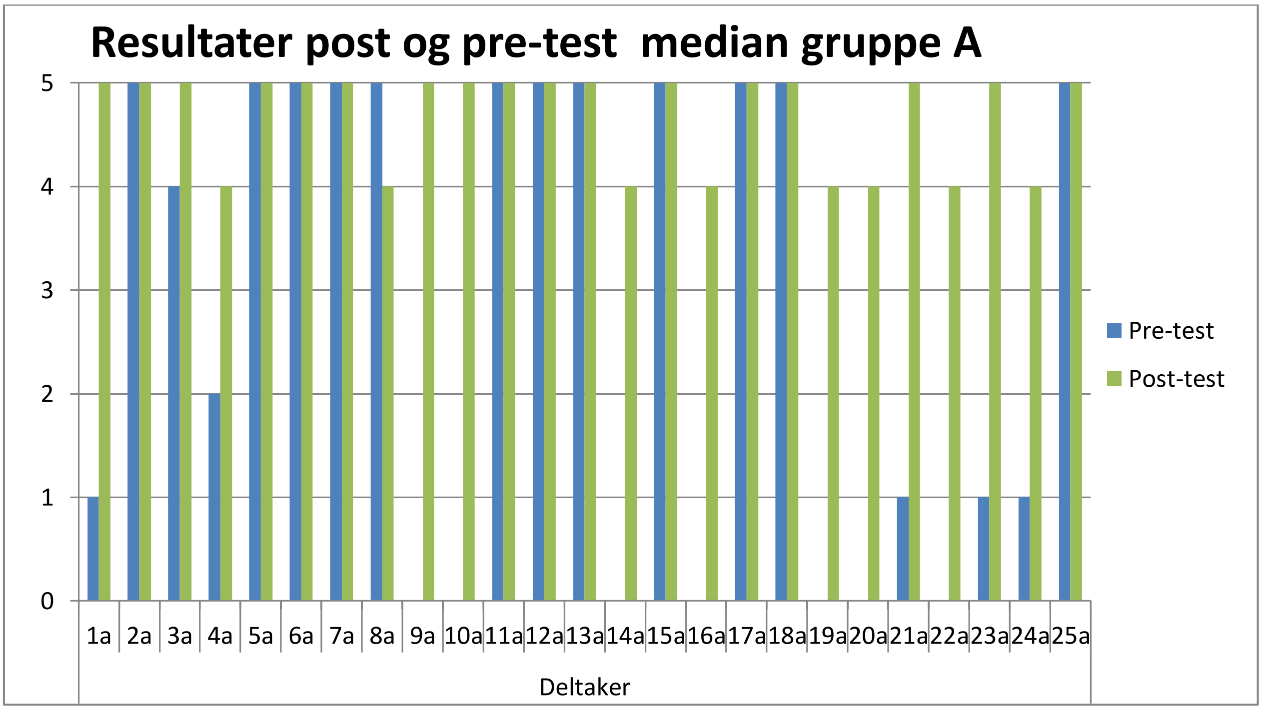

Resultater pre-test modus gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

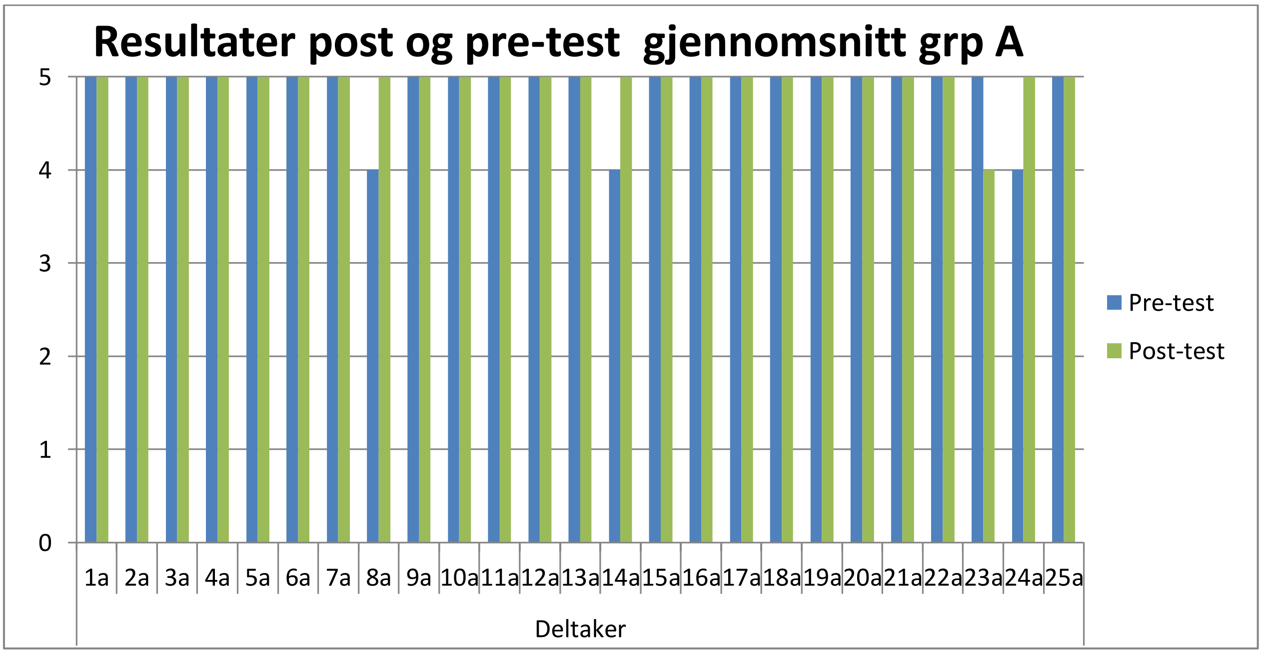

Resultater post-test gjennomsnitt gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

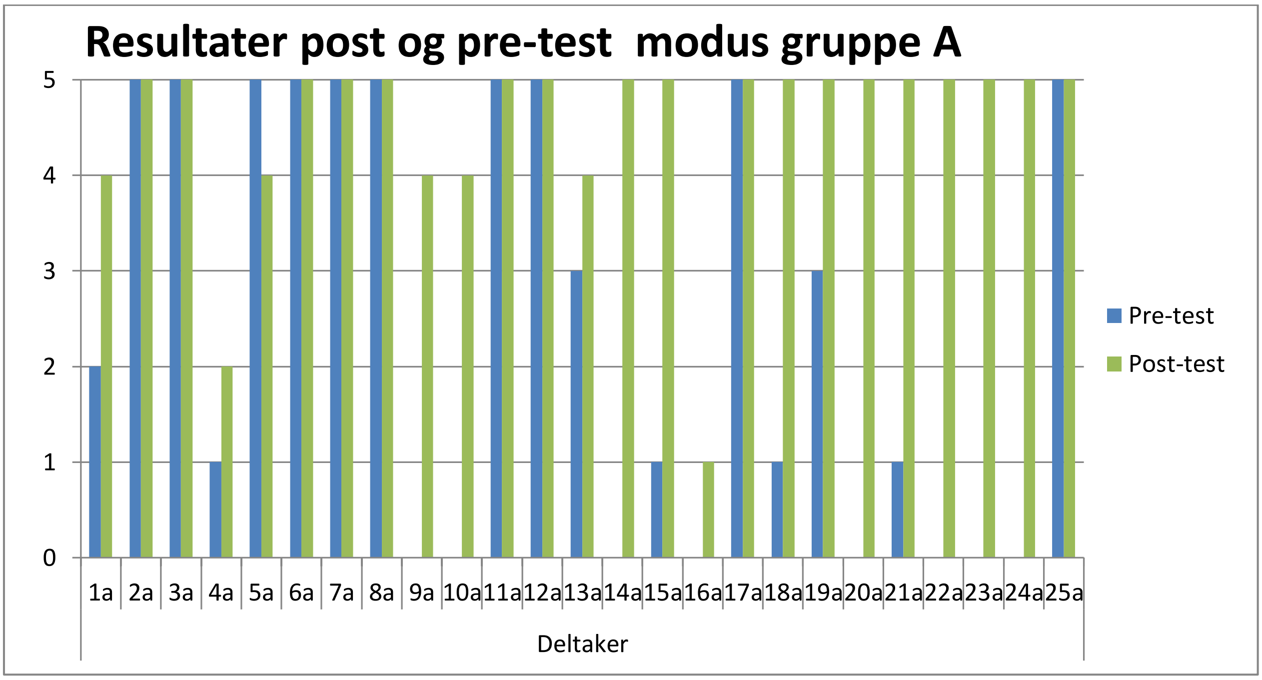

Resultater post-test median gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

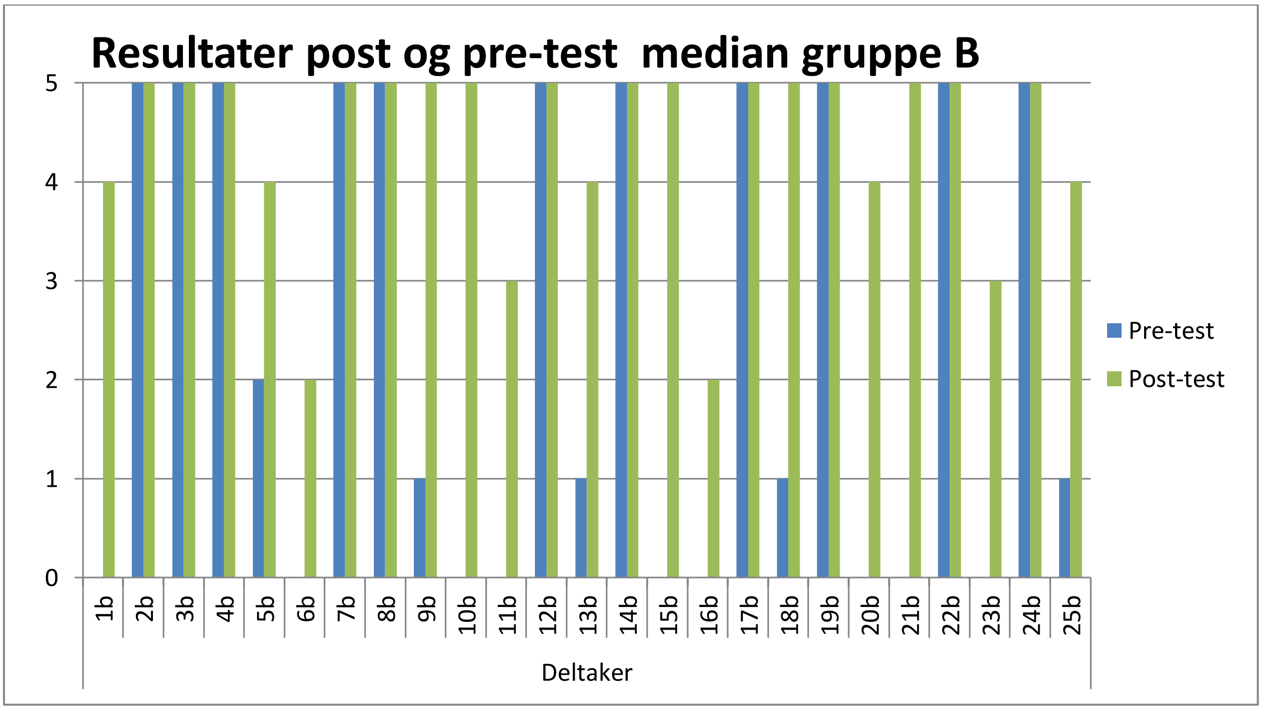

Resultater post-test modus gruppe A og B
5
4
3
2
1
0
1a/b
2a/b
3a/b
4a/b
5a/b
6a/b
7a/b
8a/b
9a/b
10a/b
11a/b
12a/b
13a/b
14a/b
15a/b
16a/b
17a/b
18a/b
19a/b
20a/b
21a/b
22a/b
23a/b
24a/b
25a/b
Deltaker
Gruppe A
Gruppe B

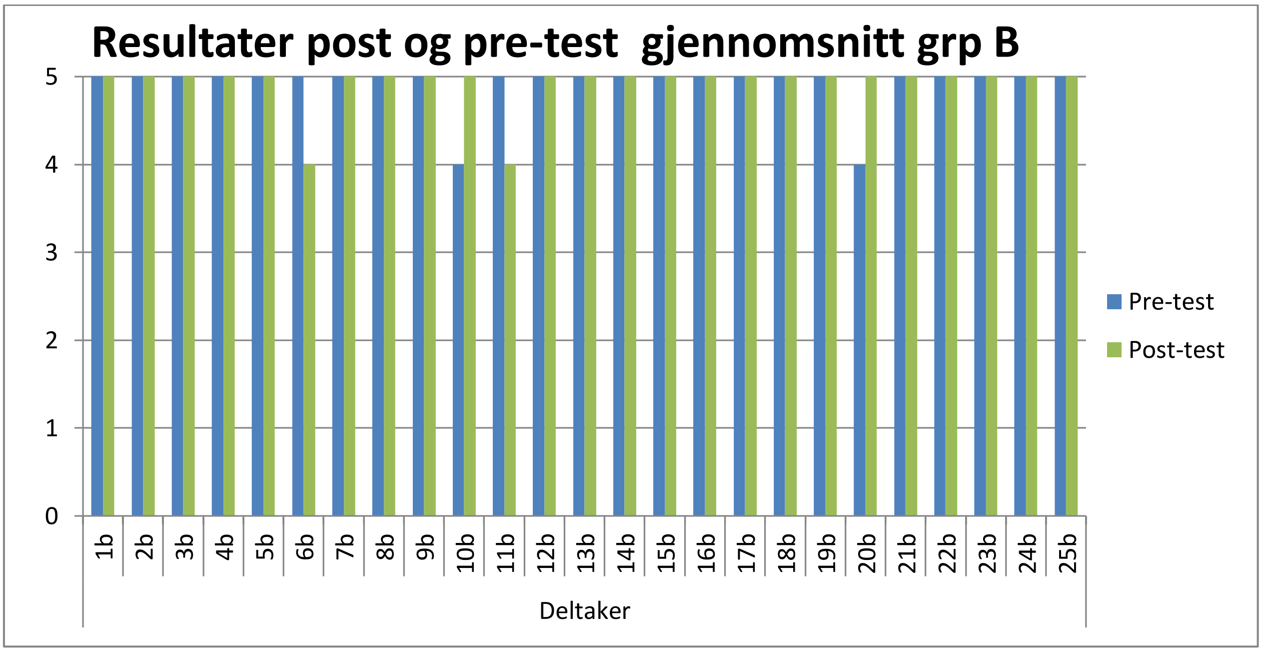
Pre and post-test comparison

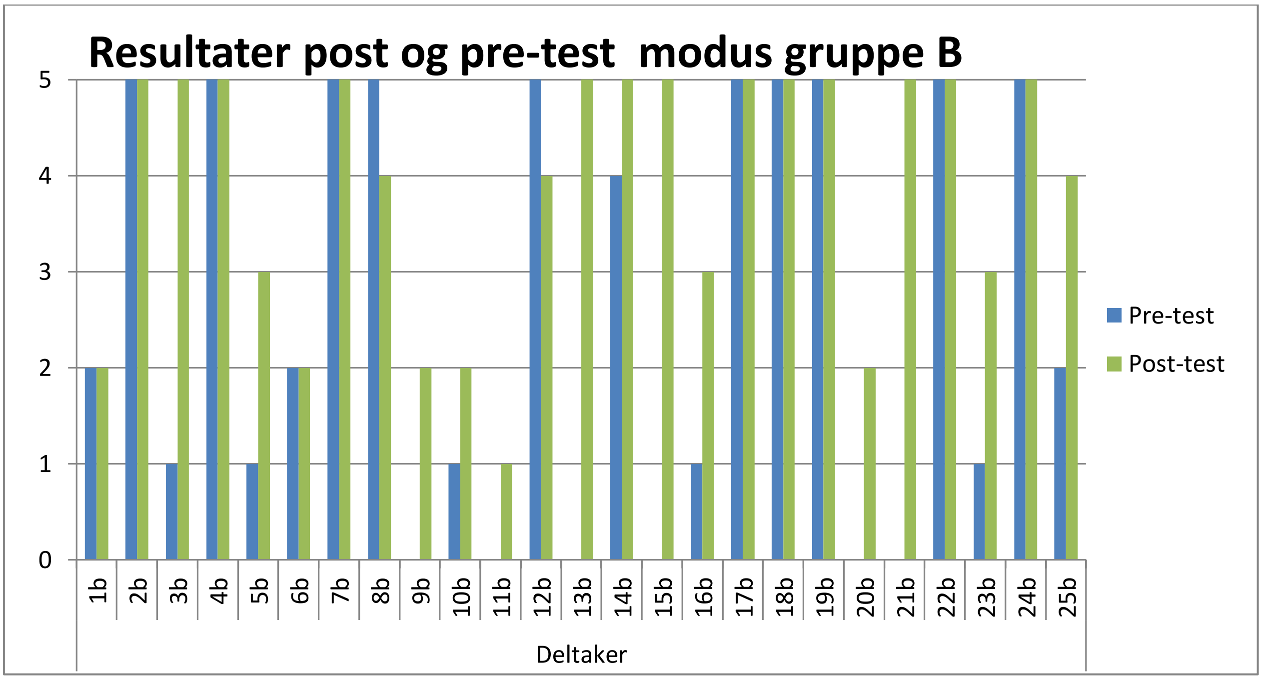





Resultater post og pre-test modus gruppe A
5
4
3
2
1
0
1a
2a
3a
4a
5a
6a
7a
8a
9a
10a
11a
12a
13a
14a
15a
16a
17a
18a
19a
20a
21a
22a
23a
24a
25a
Deltaker
Pre-test
Post-test


Resultater post og pre-test median gruppe B
5
4
3
2
1
0
1b
2b
3b
4b
5b
6b
7b
8b
9b
10b
11b
12b
13b
14b
15b
16b
17b
18b
19b
20b
21b
22b
23b
24b
25b
Deltaker
Pre-test
Post-test


Resultater post og pre-test gjennomsnitt grp B
5
4
3
2
1
0
1b
2b
3b
4b
5b
6b
7b
8b
9b
10b
11b
12b
13b
14b
15b
16b
17b
18b
19b
20b
21b
22b
23b
24b
25b
Deltaker
Pre-test
Post-test


Resultater post og pre-test modus gruppe B
5
4
3
2
1
0
1b
2b
3b
4b
5b
6b
7b
8b
9b
10b
11b
12b
13b
14b
15b
16b
17b
18b
19b
20b
21b
22b
23b
24b
25b
Deltaker
Pre-test
Post-test

Appendix E: Raw data

Category chosen

	Deltaker	Kategori 1	Kategori 2	Kategori 3	Kjønn
CHOICE	1a	8	7	2	G
	2a	3	4	6	G
	3a	8	11	7	G
	4a	8	3	2	G
	5a	10	5	8	G
	6a	7	1	2	G
	7a	2	12	8	J
	8a	8	7	2	G
	9a	7	8	10	J
	10a	3	7	6	J
	11a	8	3	4	G
	12a	4	5	11	G
	13a	5	3	10	G
	14a	8	7	2	G
	15a	7	1	3	G
	16a	1	9	11	J
	17a	4	3	2	J
	18a	1	7	6	J
	19a	10	9	11	J
	20a	7	3	12	G
	21a	2	4	7	J
	22a	5	3	7	G
	23a	5	9	4	G
	24a	2	4	12	J
	25a	6	3	8	G
					16G 9J
GIVEN	1b	8	7	2	G
	2b	3	4	6	G
	3b	8	11	7	J
	4b	8	3	2	J
	5b	10	5	8	G
	6b	7	1	2	G
	7b	2	12	8	G
	8b	8	7	2	J
	9b	7	8	10	G
	10b	3	7	6	J
	11b	8	3	4	J
	12b	4	5	11	J
	13b	5	3	10	J

14b	8	7	2	G
15b	7	1	3	G
16b	1	9	11	J
17b	4	3	2	G
18b	1	7	6	G
19b	10	9	11	G
20b	7	3	12	G
21b	2	4	7	G
22b	5	3	7	J
23b	5	9	4	G
24b	2	4	12	G
25b	6	3	8	J
				15G/10J
				31G/19J

Results Pre-test

Resultat pre-test		
G.Snitt	**Median**	**Modus**
5	1	2
5	5	5
5	4	5
5	2	1
5	5	5
5	5	5
5	5	5
4	5	5
5	0	0
5	0	0
5	5	5
5	5	5
5	5	3
4	0	0
5	5	1
5	0	0
5	5	5
5	5	1
5	0	3
5	0	0
5	1	1
5	0	0
5	1	0
4	1	0
5	5	5
122	**70**	**62**
5	0	2
5	5	5

5	5	1
5	5	5
5	2	1
5	0	2
5	5	5
5	5	5
5	1	0
4	0	1
5	0	0
5	5	5
5	1	0
5	5	4
5	0	0
5	0	1
5	5	5
5	1	5
5	5	5
4	0	0
5	0	0
5	5	5
5	0	1
5	5	5
5	1	2
123	**61**	**65**

Results Post-test

Resultat post-test		
G.snitt	**Median**	**Modus**
5	5	4
5	5	5
5	5	5
5	4	2
5	5	4
5	5	5
5	5	5
5	4	5
5	5	4
5	5	4
5	5	5
5	5	5
5	5	4
5	4	5
5	5	5
5	4	1

5	5	5
5	5	5
5	4	5
5	4	5
5	5	5
5	4	5
4	5	5
5	4	5
5	5	5
124	**117**	**113**
5	4	2
5	5	5
5	5	5
5	5	5
5	4	3
4	2	2
5	5	5
5	5	4
5	5	2
5	5	2
4	3	1
5	5	4
5	4	5
5	5	5
5	5	5
5	2	3
5	5	5
5	5	5
5	5	5
5	4	2
5	5	5
5	5	5
5	3	3
5	5	5
5	4	4
123	**110**	**97**