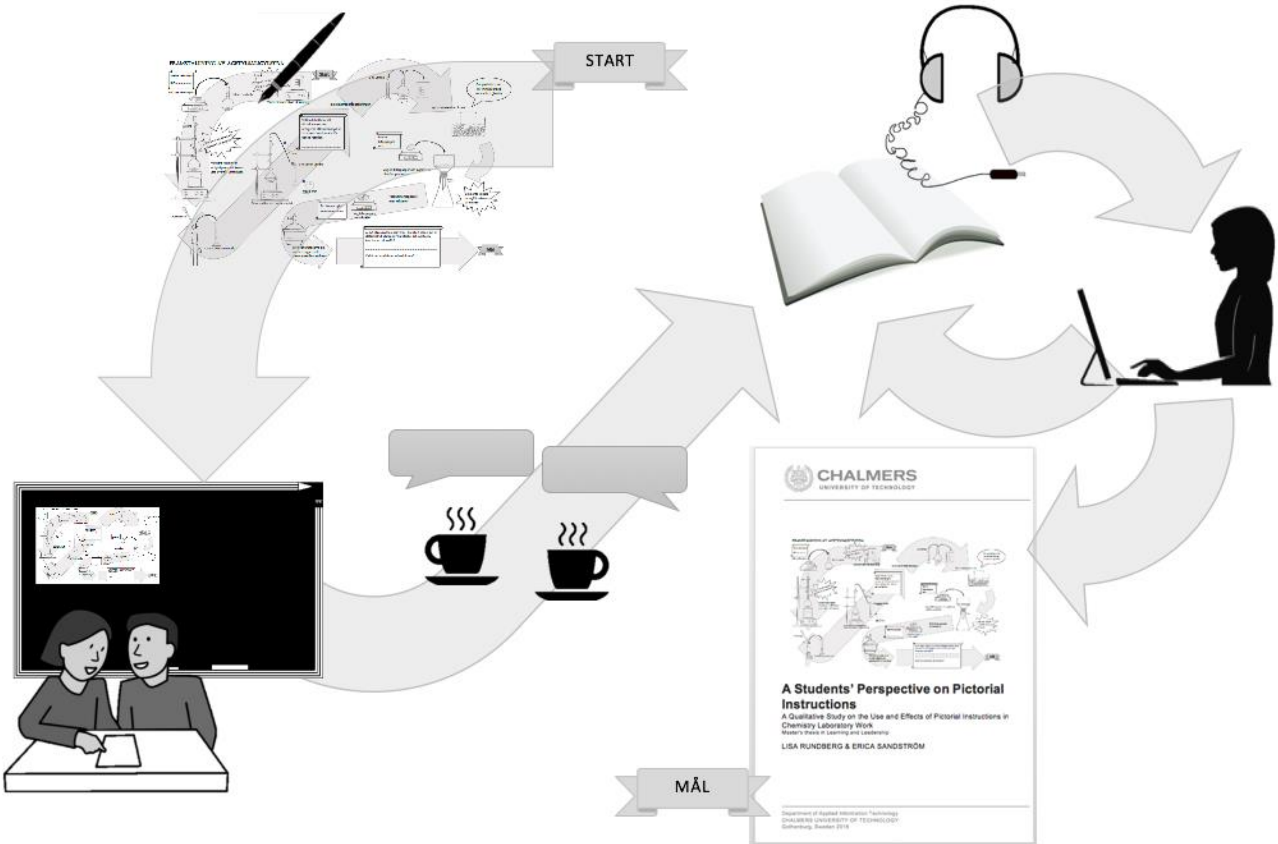

A Students' Perspective on Chemistry Laboratory Classes

A Qualitative Study using Pictorial Instructions to investigate student approaches to their Chemistry Laboratory Work

Master's thesis in Learning and Leadership

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Department of Communication and Learning in Science
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2016

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Cover:
[Illustration of the workflow for this study, that ended with this report]

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Abstract

In the chemistry curriculum in the Swedish upper secondary school it is explicitly stated that the chemistry classes are to provide the students with the opportunity to develop their ability to: "…plan, execute, interpret and present the result of experiments and observations."

This study aims to shine light on the students' perspective on their chemistry laboratory classes and answer the questions:

- How do students approach their chemistry laboratory classes?
- How do the students reflect upon their own approaches and strategies?
- What role can pictorial instructions play for students in chemistry laboratory classes?

The data used in the study was collected through semi structured focus group discussions. To facilitate and enhance the discussion on the students' approaches to the laboratory work, the students were prompted to slightly change their approaches during one of their laboratory classes. This was achieved by letting the students use pictorial instructions in place of the instructions they were used to. To further enhance the discussions stimuli in the form of video clips from the students' laboratory work were used.

The focus group discussions revealed that the students adapt their strategies during the laboratory class to what they think will benefit their grades. There are instances where they find that learning and grades are at odds and in these instances the grades are prioritized. The students also expressed that even though they knew that they were being assessed during the laboratory classes, how and on what they were being assessed was unclear to them. Further studies into how and what teachers assess during the laboratory classes and how this is communicated to the students is therefore of interest. The influence of the pictorial instructions was small but included less worrying do to easier ways to relocate information and more collaboration by providing a tool to use when posting questions.

Keywords: Chemistry Laboratory Work, Pictorial Instructions, Learning Strategies, Upper Secondary School, Assessment

Preface

This project is the concluding part of our education at Chalmers University of technology. The final part of an education that has offered us the opportunity to work as engineers or as teachers. During our education, both at Chalmers and earlier, laboratory classes has had a recurring place in the curriculum. We would like to start this report in honesty and admit that we as students might not have always used the laboratory classes as efficiently as they could have been used. Sometimes the laboratory classes have been reduced to stressful hours in a crowded room where the main goal has been to finish the task and be allowed to leave. If learning occurred it was afterwards when working with the report, not during. To help us use the laboratory classes' efficiently different tactics have been used by our teachers. Among these were for example mandatory preparations before and quizzes at the start of the classes. For one class the mandatory preparations included creating a flow chart equipped with pictures. For us this was a big help in using the laboratory class more efficiently and understanding the task as we performed it not only afterwards.

In our new role as teachers we will be responsible for new students' experiences of laboratory classes. In our new mission of facilitating learning we find it important, as well as interesting, to explore how students experience their laboratory classes. Will flow charts or pictorial instructions help other students as well or what other aspects do they find are important to be able to use their laboratory classes effectively?

In this study, we have let the students' experiences, thoughts and priorities guide us. As a result, the pictorial instructions moved more and more to the background as the project progressed. Instead the students concern for their future and how their actions in the laboratory classes will affect it were given more attention. This can be seen in this report but is even more prominent in the two papers that were written afterwards. The data from this study was used for the papers but approached it from a slightly different angle. You will find the articles in appendix E and F.

To conclude this preface, we would like to give thanks to some of the people who made this study possible. To the students for taking their time to take part of this study and chairing their insight and thought, thank you for invaluable lessons both in regard to this study, our future work as teachers as well as in life in general. We are also thankful to their teachers for their support and the confidence to let us conduct the research in their classes. We would also like to thank Tom Adawi and Jens Kabo for interesting discussions during the study. And thank you to Patric Wallin for invaluable advice, support, inspiration and coaching. Thank you for being a role model and for your endless efforts in making this project a place for us to grow and learn.

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1. Introduction

In the academic setting, chemistry has only been a field of its own since the 18th century. Before that period of time chemistry was a part of the natural philosophy division together with other fields like physics, biology and astronomy (Elliott et al. 2008). At the time when chemistry was taught as part of the natural philosophy, practical laboratory work was not a given part of the academic courses (Elliott et al. 2008). At that time, a student might have been able to practice laboratory work by being invited to work in the professor's private laboratory. In the beginning of the 19th century a handful of chemistry professors began offering laboratory instructions to their students (Elliott et al. 2008). This was one of the measures that were taken to try to solve the three main needs of the time; "how to do the research necessary to move the subject forward, a need for precise composition analysis, and the training of novice chemists on the appropriate laboratory skills" (Elliott et al. 2008).

Moving forward to the present, student centred approaches have received large attention and different instructional designs have been proposed to place students in the driver's seat of their inquiries. One type of instructions that are more adapted for students' own ideas and strategies are the inquiry instructions (Wolf & Fraser 2008). Inquiry instructions contain less direction and rely on the students' ability to develop their own way of solving the given problem. They also provide students with the knowledge on how actual research within the field of chemistry is conducted today (Elliott et al. 2008). Despite the positive research findings, adaptation rates are low and according to a review of laboratory instructions styles by Domin in 1999, the most common instruction style is the expository instruction. One of the typical features of an expository lesson is that it requires the students to follow a specific set of instructions in the laboratory work like in a cookbook (Domin 1999). This means that during laboratory work students and teachers time for "meaningful, conceptually driven inquiry" is often seriously limited because the technical and inflexible details of the task consume most of their time and energy (Hofstein & Lunetta 2003). To enhance the procedural knowledge within the expository instructions one way is to combine them with illustrative flowcharts (Booher 1975) and create pictorial instructions. These pictures help the students by giving them multiple cognitive pathways to grasp the information (Zadina 2014b). Besides the encouraging research findings, there is a lack of research studies that look at pictorial instructions in the Swedish school system and what effects these instructions have on students.

In the Swedish upper secondary school, chemistry became a subject of its own around 1878 (Tansjö & Sandström 2016). Since then, the Swedish school system has gone through several adaptations, including two reforms during the last twenty years. These reforms aimed to address the changed demands and expectations in schools, and provide students with learning experiences that are relevant and developing. Amongst other things, the changes included altering the curriculum for the subject chemistry, as well as influencing how the subject is being taught and how it is assessed. While today most teachers agree that practical laboratory work is a crucial part of the students' chemistry education (Johnstone et al. 1994), the reforms tried to create a stronger alignment between the students' laboratory and theoretical work, as well as emphasize the importance of student centred inquiries during the laboratories. However, there are nearly no studies that aim to understand how the students in Swedish upper secondary schools perceive the chemistry laboratory work and the instructions that they get after the latest reform in 2011. In particular, studies that try to openly and qualitatively explore the students' learning experiences through their eyes and focus on the students' own accounts. These types of studies are clearly needed to know if the reforms have the desired effects and what potential side-effects students experience and describe. As Hofstein and Lunetta (2003) put it:

> "While there have been substantial developments in scholarship that can guide the development of teaching and curriculum, that scholarship has had only marginal impact on schools. […] To acquire a more valid understanding of these important issues, science educators need to conduct more intensive, focused research to examine the effects of specific school laboratory experiences and associated contexts on students' learning. The research should examine the teachers' and students' perceptions of purpose, teacher and student behaviour, and the resulting perceptions and understandings (conceptual and procedural) that the students construct."

In this study, we address both the lack of studies that investigate the laboratory work in Swedish chemistry classes after the latest reforms, and the potential of pictorial instructions to improve laboratory work. To be able to understand how students perceive and work during their laboratory work, including the effects of using pictorial instructions, a qualitative research approach using observations and interviews is used. Through this open approach, the students are given a voice and the focus remains on their own experiences. Based on this approach, this study addresses three research questions:

- "How do students approach their chemistry laboratory classes?"
- "How do the students reflect upon their own approaches and strategies?"
- "What role can pictorial instructions play for students in chemistry laboratory classes?"

2. Literature Review

To be able to grasp students' thoughts of their chemistry laboratory work an understanding regarding their learning is of importance as well as understanding of different types of teaching approaches and instructional designs that the students encounter. These two areas all connected to how students learn will be explored in the two following sections with *Student learning* as the first with the focus on the student. The second *Teaching approaches and instructional design* focusing on aspects within a classroom.

2.1 Student Learning

When discussing the students learning there are multiple aspects that are of interest to understand how the learning is conducted and why it is learned in that way. In this section, we will look at how students can approach their learning, what conceptions students can have towards learning and knowledge, as well as what will impact the richness of the information being learnt in form of self-regulation, motivation and emotions.

2.1.1 Learning Approaches

In the 1970s three approaches to learning were identified, a deep approach, a surface approach and a strategic approach (Richardson 2005) the third approach is sometimes also referred to as the achievement approach (Cano 2005). The three approaches are differentiated by the focus students have when learning new material. A student who uses a deep approach is focusing on getting an understanding of the course material and what it means whereas a student who uses a surface approach is focusing on only memorizing the material for the assessment (Richardson 2005). The third approach, the strategic approach, the student is focusing on using an approach that is most efficient for getting a good mark. Whereas the student is using a combination of the two already mentioned approaches and the course assessment is the dependent factor for which one is used (Green & Hood 2013).

Which study approach a student might use during different courses and situations can vary and appears to be connected with internal factors such as how the students are motivated, either intrinsically, extrinsically or by an achievement motivation (Vermunt & Verrmetten 2004) as well as external factors such as assessment, teaching quality and course material and its demands (Richardson 2005). How these internal and external factors are affecting the student learning will be explored later in this section and in the following section 2.2.

In secondary school, there have been reports about how the learning approaches are effecting the students' grades. Where a student using a surface approach have been linked with poorer performance then those students using a deep- or a strategic approach (Cano 2005). How the students are alternating between these approaches and more specifically towards a deep approach have been contrary but one study conducted by Watkins, Hattie and Astilla in 1986 suggest that the students moved towards a deeper approach from year to year (Watkins et al. 1986). Another study carried out by Biggs in 1987 found that students were using both the deep- and surface approach to a smaller extent when progressing from year to year (Biggs 1987). This has been suggested to be linked with that the students are learning how to approach the curriculum which is indicating that they are using a strategic approach more frequently (Cano 2005).

2.1.2 Epistemological Beliefs

Even though students might use different or have preferred learning approaches (Cano 2005) there is also other aspects that need to be taken into consideration when understanding why students might choose one approach over another. One of these are for instance the conceptions of learning and knowledge, also known as epistemological beliefs (Cano 2005). In 1976 Marton and Säljö found two contrasting ideas about learning, a superficial idea and a deep idea (Marton & Säljö 1976). Where the superficial idea is when students are paying attention to details whereas a deep idea is when they are focusing on the meaning of what's being learnt (Cano 2005). These conceptions were later on confirmed and extended by Van Rossum and Schenk in 1984 (Van Rossum & Schenk 1984). The conceptions of learning mentioned are as following (Säljö 1979; Van Rossum & Schenk 1984):

1. Learning as the increase of knowledge
2. Learning as memorizing
3. Learning as the acquisition of facts or procedures
4. Learning as the abstraction of meaning
5. Learning as an interpretative process aimed at the understanding of reality
6. Learning as changing as a person

Students who are indicating a learning conception within 1-3 have a tendency of using a surface approach when performing a certain task, whereas students with conceptions of 4-6 more likely uses a deep approach (Richardson 2005). A more simplistic view of this mentioned by Cano (2005) is that "the more a student believes that learning occurs rapidly and without effort, the more she/he is likely to adopt a surface approach".

When discussing the conceptions of knowledge different models have been proposed and one of these is the Baxter Magolda model of epistemological development. This model is a multi-level model with four different levels of knowing; absolute, transitional, independent and contextual knowing, connected with two different types of patterns for three of the four levels (Magolda 1992).

Table 1 The Baxter Magolda's model of epistemological development regarding different types of conceptions of knowing (Magolda 1992).

Baxter Magolda's model of epistemological development						
Absolute Knowing		Transitional knowing		Independent knowing		Contextual knowing
Mastery Pattern	Receiving Pattern	Impersonal Pattern	Interpersonal Patter	Individual Pattern	Interindividual Pattern	

In the absolute knowing level of Baxter Magolda model a student think that all knowledge is certain and there is a right or wrong answer to every question (Magolda 1992). Authorities are seen as the source of information and the students are focused on memorizing the facts and procedures to be able to repeat them on tests (Felder & Brent 2004). On the next level, transitional knowing, the students start to believe that some knowledge is uncertain and that they need to value their own reasoning to be able to come to a conclusion on these uncertainties (Felder & Brent 2004). In the latter two levels, independent- and contextual knowing, the students start to believe that most or all knowledge is uncertain and they themselves are responsible to collect evidence to support their judgements (Felder & Brent 2004). One of the differences between the two latter levels is that the independent knowing student believes that all conclusions on an uncertainty is equally good if the right procedure is used, this is not the case with the contextual knowing student which instead is open to change their decision as new evidence arise (Felder & Brent 2004).

Research conducted by Kroll (1992) is suggesting that most of the students entering college from upper secondary school are firmly rooted in knowledge being certain. This has also been the case for Perry's research, however he also found that the students are progressing towards more sophisticated conceptions of knowledge, where all knowledge isn't certain, when entering the later years of their studies (Perry 1970). There have also been reports about the correlation between the students' conception of knowledge with their learning strategies where students with less sophisticated conceptions are less likely to use a deep approach whereas the opposite is reported for students with more sophisticated conceptions of knowledge (Green & Hood 2013).

Focusing on the combination of conceptions of knowledge and learning, epistemological beliefs, there have been studies that found that the more sophisticated a student's epistemological beliefs are the more likely the student would get a higher grade (Green & Hood 2013). This phenomenon have been suggested by Schommer in 1993 to be linked with that the students epistemological beliefs are impacting the achievement both directly and indirectly, indirectly by influencing the students approaches to learning (Schommer 1993). Where a more naïve set of epistemological beliefs have been linked with a use of surface approach to learning and a more sophisticated set of epistemological beliefs with a deeper approach (Green & Hood 2013). The use of learning approaches on the other hand have not been suggested to impact the epistemological beliefs (Green & Hood 2013).

2.1.3 Self-regulation, Motivation and Emotions

One aspect that is of relevance for the students own awareness on how they are learning is self-regulation. A student who is self-regulating regarding their learning can have the ability to notice, evaluate and change their strategies, such as their learning approach, to achieve a desired academic outcome (Mclellan & Jackson 2016). A self-regulatory student is planning, monitoring and evaluating his or her own learning (Pekrun et al. 2002) and has the ability to pick out their skills and weaknesses (Mclellan & Jackson 2016).

As mentioned in an earlier paragraph, the students' learning approaches can also be influenced by motivation which in its case is influenced by internal and external psychosocial factors (Harlen & Deakin Crick 2003). Three principles of The American Psychological Association's fourteen Learner Centered Principles are directly associated with the motivation for learning (Harlen & Deakin Crick 2003) and these are (American Psychological Association 1997):

1. "Motivational and emotional influences on learning: What and how much is learned is influenced by the motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.
2. Intrinsic motivation to learn. The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.
3. Effects of motivation on effort. Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion."

As mentioned in the third principle there is a need for the student to have some motivation to learn to be able to put in some effort without someone telling them to learn. And this willpower is what is triggering the students' motivation to process and perform information as well as develop as a learner over time (Harlen & Deakin Crick 2003). How the students are motivated, as mentioned in the second principle, is something that is of relevance if the students are self-regulated regarding their learning or not. Intrinsic motivation which is recognized by that the student finds interest and satisfaction in what they are learning and the learning process is of importance for the students to become self-regulatory (Harlen & Deakin Crick 2003). Extrinsic motivation on the other hand that is triggering the students learning for performing on test or to get good marks can inhibit the students self-regulation if the student isn't able to succeed and the learning may stop (Harlen & Deakin Crick 2003).

In the first principle regarding the students' motivation for learning one aspect that hasn't been covered in the previous segments of this section is how the students' emotions are influencing their learning. Emotions that students might feel in school are an important aspect related to how the students learn or if they get a surface- or deep learning, since these have an impact on memory (Zadina 2014a). However different types of emotions can be felt and they can influence the cognitive mechanisms differently for learning. Pekrun et al. (2002) have produced a cognitive-motivational model, on how emotions impact learning, that takes into consideration two dimension. These dimensions are; positive or negative emotions and activation or deactivation (Pekrun et al. 2002).

Table 2 The cognitive- motivational model by Pekrun et al. (2007) *including examples of emotions for each of the different emotional groups.*

Group	Emotions
Positive activating emotions	i.e. Enjoyment of learning, hope for success, pride
Positive deactivating emotions	i.e. Relief, relaxation after success, contentment
Negative activating emotions	i.e. Anger, anxiety, shame
Negative deactivating emotions	i.e. Boredom, hopelessness

The influence that emotions have on memory according to Zadina (2014a) is that the positive emotions are enhancing memory whereas negative emotions are hindering it. This can though vary since the students perception over their control over for instance stress can influence the learning, where the perception of control might not hinder the learning (Zadina 2014a). The activating or deactivating part of the emotions can also foster or hinder the learning by influencing the motivation (Pekrun et al. 2002). For instance, if a negative activating emotion is taking place for a task, extrinsic motivation can occur. Where the motivation can be that the student is engaged in trying to overcome the obstacle of executing the task (Pekrun et al. 2002). The deactivating emotions on the other hand is putting the attention away from the task at hand and are negatively correlated with learning, however if the emotion is positive new energy can be given to proceed with the next task when the first one is finished (Pekrun et al. 2002). Even though negative emotions might help students to find motivation to perform a task, in the long run the negative emotions have a tendency to prevail students from continuing their studies (Pekrun et al. 2002).

Emotions tend to correlated also with the students' self-regulation where positive emotions being correlated positively with self-regulation and negative emotions positively with perceived external regulation (Pekrun et al. 2002). The other way around with the perception of self-regulation can promote positive feelings whereas external regulation can promote negative feelings is also of relevance for the causation (Pekrun et al. 2002).

2.1.4 Collaboration when Working in Pairs

Early theories on learning seldom took in to account the social aspects of learning. Among the firsts to criticize this and emphasize the importance of the learner being part of a social group were John Dewey and Lev Vygotskij. "According to Dewey the key to real learning is through purposive activities in social contexts. The function of the teacher in this setting is to create conditions that stimulate thinking and to adopt a supportive approach" (Phillips & Soltis 2010). Vygotskij lived 1896-1934 in the Soviet Union (Phillips & Soltis 2010). One of the concepts he invented was the "zone of proximal [or potential] development". He recognized that though a child might have a certain ability to perform intellectual tasks they also have a certain potential in how much further they can develop through interactions with others with more knowledge (Phillips & Soltis 2010).

More modern studies have been conducted where the students own experiences have been investigated. In one study about the impact of social interaction on student learning the students commented that the social interactions for example enhanced the critical thinking and expanded comprehension and retention (Hurst et al. 2013). Other studies that support the value of social interactions include results were students who work cooperatively in science laboratories perform better than both students that worked competitively and individually (Hofstein & Lunetta 2003).

In 2011 Ding and Harskamp conducted a study concerning the effect of collaboration in Chemistry Laboratory Education. They compared three different setups of the laboratory work. In the first one the students worked on their own. In the second setup, the students worked in pairs. The last set up they called, peer tutoring. In this set up the students were assign a laboratory class when they would act as a tutor to one of their classmates. Their results concluded that both pair collaboration and the tutoring set up were beneficial to the students learning. When addressing the long term learning the tutoring was found to be the most beneficial (Ding & Harskamp 2011).

Other interesting findings from Dings and Harskamps study include the finding that students in the pair collaboration set up tended to divide the work between them so that they assumed roles such as assistant or executor. As Dings and Harskamp report:

> "Within the dyad, normally one student carried out the experiment while his/her partner observed or took notes. Some dyads switched roles at times, while other dyads kept the same job allocation in all the experimental sessions."

It is also interesting to note that the student in the pair tutoring setup often read through the instructions as a whole before starting the experiment. In contrast, the students in the other two setups often started conducting the experiment after only reading the first instruction in the manual (Ding & Harskamp 2011).

2.2 Teaching Approaches and Instructional Design

There are other aspects except for the students' approaches and viewpoints that influence the learning. For instance, how we see learning and the way we are teaching can vary because of different aspects. In this section, we look at four viewpoints that impact how the chemistry laboratory work is being taught. One of these aspects is what instructional design are being used in chemistry laboratory work and how the expository instruction design is outlined. We also look at the working environment as well as assessment.

In the section regarding assessment, summative assessment will be the main focus. When exploring the area of the effects of summative assessment, the effects of the extreme case of summative assessment that is high stake testing will be the focus. In this report test-based accountability is used as the definition for high stake testing.

2.2.1 Laboratory Activity Formats

Depending on which instructional design being used in the classroom, the students will adopt different approaches to solve the given or student-generated problem. Classrooms with teaching approaches that have a focus on transmission of information from teacher to student, teacher-focused approaches, is more likely to have student's adopting a surface approach to learning then classrooms with student-focused approaches, where the aim is to bring out conceptual change within the students (Richardson 2005).

A review by Domin (1999) regarding chemistry laboratory instructions was conducted since the view of learning and instructions has changed during the last decades. This review resulted in a taxonomy of the different instructional designs within laboratory work (seen in table 3). The four instructional designs described are as following: expository, inquiry, discovery and problem-based (Domin 1999).

The expository design is recognized by its step by step instructions, much like a cook-book, where students are recording and collecting data (Hofstein & Lunetta 2003) and are to conclude in a predetermined outcome (Domin 1999). Today, the expository is the most commonly used instructional design because of its possibilities to perform with large classes within 2-3 hours, where the instructor involvement is minor and the need for resources is little (Domin 1999). However, the design has been heavily criticized for its lack of opportunities for higher-level of thinking and possible scientific discussions (Hofstein & Lunetta 2003).

The inquiry design on the other hand gives the student much more responsibility than the expository (Domin 1999) by requiring the students to find information on what is already known, plan and execute an investigation of a problem, and interpret and analyze the found results (Hofstein & Lunetta 2003). The teacher's role during the inquiry laboratory work is to act as support to help the students in their reflections and discussions (Wolf & Fraser 2008) and able the students to use critical and logical thinking (Hofstein & Lunetta 2003). The challenge with the inquiry design in contrast to the expository is the need for time, since they can span over several sessions (Wolf & Fraser 2008). The large focus on discussions in the inquiry design laboratory also put demands on a secure and open environment (Wolf & Fraser 2008).

Discovery instructions or guided inquiry as it is also called (Ricci & Ditzler 1991) is similar to the inductive design by having an inductive approach, student generated approach (Domin 1999). The discovery design is focusing on that the students should try and figure out (or discover) the theory behind a specific phenomenon with guiding help of the teacher (Domin 1999). The discovery labs have been suggested to be most successful when complex topics are being investigated and afterwards lead to meaningful group discussions (Kulevich et al. 2014). However the discovery lab could easily become an expository lesson for most of the students when one of their classmates have discovered the desired principle and shares it with the rest (Domin 1999).

The last laboratory design mentioned by Domin is the problem-based. One challenge within the inquiry designed lab that the problem-based design eliminates is the safety issues that can occur when investigating something new (Laredo 2013). The problem-based design has a clear goal (Domin 1999) with guidelines that gives a little direction for students but doesn't eliminate their possibility to choose different approaches to solve the given experiment, such as the expository design (Laredo 2013). The procedure on how to solve the given problem becomes secondary in the problem-based setting in contrast to the inquiry or discovery designed labs (Domin 1999) and students' knowledge of experimental methods enhanced (Laredo 2013). Since the problem-based lab has a deductive approach, the students have to have encountered the concept before the actual lab to be able to solve the given problem (Domin 1999). The design is also time consuming as the inquiry designs (Domin 1999).

Table 3 The different laboratory instructional designs and their descriptors as described by Domin (1999).

Style	**Descriptor**		
	Outcome	Approach	Procedure
Expository	Predetermined	Deductive	Given
Inquiry	Undetermined	Inductive	Student generated
Discovery	Predetermined	Inductive	Given
Problem-based	Predetermined	Deductive	Student generated

Students have preferred teaching approaches which usually is in line with their current epistemological beliefs (Green & Hood 2013) which is something that needs to be taken into consideration when adopting a specific teaching approach. Students who are expected to learn in a way that is far from their comfort might lose self-confidence in their possibility to learn (Harlen & Deakin Crick 2003), which might have been opposite if the approach was their preferred. But since all students are different not a single instruction will be optimized for all, thus a varied approach of teaching might be favored (Harlen & Deakin Crick 2003). Having a varied teaching approach also enhances the learning since the students might encounter that their existing conceptions are being challenged (Green & Hood 2013).

2.2.2 Pictorial Instructions

The instructions the students are provided with during the expository laboratory work can be of different kind – oral, written (text based and/or pictorial) – but is teacher provided (Domin 1999). What kind that works best for different students vary, where for instance verbalizers have a tendency to perform better with oral instructions in contrast to imagers who have a tendency to perform better with pictures (Carney & Levin 2002).

Adding pictures to either oral or text based instructions will greatly enhance the recall for the students, as Zadina (2014b) puts it in her book "If pictures are presented with words rather than words alone, the recall is more than six times better.". Levin and Lesgold (1976) also points out that younger students might perform equally good or better than older students if they are presented the same material but with the difference of adding pictures. This effect is due to the multiple cognitive pathways that the students use when they take in the information (Zadina 2014b).

Depending on what type of pictures being used with the instructions there will be a difference to the positive effect. Carney and Levin (2002) have suggested five functions that pictures serve to text material and the value added for each of these functions. These five functions (starting with the least beneficial for the learning effect of the text material) for pictures are:

1. Decorational – pictures with little or no relationship to the text content. For instance, a picture of the sea for a book about boats.
2. Representational – pictures that partially or fully represent the text content. An example is pictures used in children's books describing a certain scene.
3. Organizational – pictures that organize the text content. The highlighted route for a trail on map is an example of an organizational picture.
4. Interpretational – pictures that clarify intricate text. For instance, a picture of a pump system describing the heart function.
5. Transformational – pictures that improve recall of the text content. An example is a picture that highlights key elements in the text.

2.2.3 Learning Environment

The working environment including its norms can have a big influence on how the students work and are learning. For example Donovan & Bransford (2004) talks about that an environment that build upon the students being rewarded of having the right answer can induce hesitation for their own thinking since a wrongful answer would have the opposite effect. Having an environment that encourage students to express ideas, ask questions and answers questions of fellow students instead is strengthening and provides an effective way of learning (Donovan & Bransford 2004).

One of the important aspects in influencing the students approaches in a beneficial way is that the teachers need to understand and communicate learning targets and supply relevant activities for the students (Butler & McMunn 2011). Otherwise it is impossible for the students to understand what they are supposed to learn and be able to develop required skills posed in the curriculum. Other aspects then the understanding of the learning targets is also essential to take into consideration as to why students might only get a surface learning instead of a deep learning. For instance getting the students to also seek the help for themselves is contributing to their learning and is an important self-regulatory strategy (Ryan et al. 2001).

Even though help seeking is important for the students learning there are some factors that might prevent them from seeking it. Ryan, Pintrich and Midgley (2001) have found that personal characteristics of the students and the classroom environment are two big aspects that might prevent them from seeking help. Within the classroom environment except for the rules and norms, they found that the achievement goal structure within the class and the social/interpersonal climate of the classroom where aspects that could prevent the students from seeking help. For instance, an achievement goal structure focusing on performance-goals communicate to the students that the primary focus of the class is that the students are supposed to show their abilities relative to others not that the personal growth is of relevance. Thus, hindering the students from gaining a deeper understanding or preventing them from replacing a wrongful one since they won't ask for help. Feeling secure in the classroom and having a good relationship between the students and the teacher on the other hand was a factor that enabled the students to seek help (Ryan et al. 2001).

This aspect was also one that were applicable on the personal characteristics. For instance, feeling socially competent aided a student to seek help from others (Ryan et al. 2001). Other aspect regarding the student characteristics that were related to the fact of seeking help or not was their perception of cognitive competence and their achievement-goal orientation. For example, students who perceived themselves as low achievers were less likely to seek help, since that the need for help would have been perceived as incapability to perform by themselves. A student using a performance-goal orientation was also less likely to ask for help since their focus is on attaining a positive image of their abilities in relation to others (Ryan et al. 2001).

2.2.4 Assessment

Assessment is often divided into two types of assessment, summative assessment and formative assessment. Formative assessment is often described as assessment for learning. The purpose of formative assessment (or evaluation) is to aid the students and teachers in, and during, the learning process. Summative assessment is often described as assessment of learning and has the role of evaluating the result of the learning process after the fact.

One form of summative assessment is high stake testing. When it comes to the research on high stake testing results from different studies can be seen as contradicting. In the United States, high stake testing became more common in the states following the "no child left behind" reform of 2001 (Jacob 2005). The reform was introduced to reduce differences and ensure quality within the school system. In Sweden, you can find high stake testing on international level such as the PISA test and on national level in form of Nationella Provet and SweSAT'.

Since the increase of high stake testing a number of studies have been conducted resulting in a wide array of conclusions. Many studies claim that the tests have had no effect, other claim positive results pointing to improved student test scores from Texas among other states (Jacob 2005). Critics of high stake testing attribute the raised test scores to "teaching to the test" and claim that the improvement in results are not due to an improvement in an understanding of what is tested but is a result of the students becoming more adept at taking the test (Abrams 2004). Teachers themselves have attested that high stake testing has affected them to "teach to the test" and report that to increase the test scores they prioritize subjects that will be tested at the expense of other areas that will not be tested (Kortez & Barron 1998). Some teachers report it going as far as excluding complete subjects that will not be tested. In a presentation from 2004 the author Abrams conclude "The overwhelming majority of teachers reported that the state testing program has led them to teach in ways contrary to their own ideas of sound educational practices" (Abrams 2004).

3. Study Design

3.1 Research Context and Boundary Conditions

As a research context for this study two upper secondary schools were selected. Both schools are similar with respect to their central location in Gothenburg, Sweden, and their minimum entry qualifications. The minimum entry qualifications of these schools and programs are among the highest in Gothenburg. As a result, the students taking part in this study can be considered high preforming students. The chemistry education in the Swedish upper secondary school is divided in to two courses, Kemi 1 and Kemi 2. Both courses are taught at both schools where our study was conducted and students from both courses took part in our study. The general aims for these chemistry courses, as defined within curriculum, are structured around five knowledge and skill areas that the students should be able and encouraged to develop:

The chemistry education shall provide students with opportunities to develop the following:

- Knowledge of concepts, models, theories and practices in chemistry and understanding of how these evolve.
- Ability to analyze and answer questions related to the subject as well as to identify, formulate and solve problems. Ability to reflect on and evaluate the chosen strategies, methods and results.
- Ability to plan, implement, interpret and present experiments and observations as well as the ability to handle chemicals and equipment.
- Knowledge of the importance of chemistry for the individual and society.
- Ability to use knowledge in chemistry to communicate as well as to examine and use the information.

For the laboratory sessions of the chemistry courses, it is in particular area three that is a focus area that students should be supported in. It is through careful scaffolding and working in the laboratory that students are able to become more independent chemistry experimenters. Within the curriculum, it is also defined what knowledge and skills students need to have acquired to pass the course, as well as to reach higher grades. A complete list of all these criteria can be found in appendix B (only in Swedish).

For our study, a total of six classes were selected and data was collected over five weeks during the spring 2016. In our study data was collected over five weeks during the spring 2016 from a total of six classes. The six classes were selected do to the teacher already being familiar with us as researchers, and the mutual trust and collaboration this provided. We introduced ourselves and our research study to the students two weeks before starting the data collection. The students were able to ask questions regarding our study and the data collection methods, as well as got all the information in paper form. At this time, the students were also asked if they would be interested in taking part of the filmed observations and interviews during the study. The participation in the interviews and video recordings has been voluntary and the students have been able to terminate their participation whenever they wanted. All students that took part in the interviews and video recordings signed informed consent forms. All students were in the age group 16-19, and other subjects and age groups were not considered. All students that expressed interest in taking part of the study and presented a signed consent form took part in the study. In other words, no further selection was done after the initial selection of classes. Nor was the language or the terms used in the discussions during the observations analyzed specifically.

3.2 Designing Modified Instructions

McDowell and Waddling (1985) talk about that there are three key aspects to consider when designing laboratory instructions. The instructions should support and develop the students' ability to: comprehend the instructions, remember what to do, and to execute the task. To achieve this, the information in instructions can vary from being only in text format to also containing illustrations. Adding illustrations to instructions can provide complementary information to the text, and therefore give the students a richer representation than text alone. Furthermore, when placing the illustrations in a flowchart manner, the students' procedural understanding can be greatly enhanced (McDowell & Waddling 1985). A better initial understanding of the procedural information can be achieved in different ways, according to Booher (1975) the most efficient way to create instructions that include illustrations is when the illustrations act as the primary source of the information whereas the text is the secondary source of the information. The text acts mainly to clarify the illustration. On a more technical level, illustrations are preferably black lined drawings that can be easily recognized and result in clean, explicit, and easy to follow flowchart diagrams (McDowell & Waddling 1985).

The instructions with pictorial representations investigated in this study are based on already existing "cookbook" instructions that are currently used in the schools. The new instructions were created several weeks before the laboratory classes started and all instructions were finished before the first test. The focus was on changing the execution part of the instructions by modifying it with pictures in flowchart diagrams, whereas the rest of the instruction only got a different font and layout to make the whole instruction more cohesive.

When creating the execution part of the instructions individual pictures of the equipment used in the laboratory work were created. These pictures were created by hand and traced to create black line drawings. The amount of detail was limited to make the pictures as clear as possible and focusing on the outlines of the objects. The black line drawings were then photographed and edited in PowerPoint or a photo editor program from Windows, Photo, to clean them up, improve the sharpness, and make them easily usable when create the instructions. In this way, a database of all necessary items was created that could be used to design the laboratory instructions in an efficient manner. A different option would have been to use images from commercially available databases, but the ability to custom made special items and tailor the designs to the specific laboratory classes weighted stronger than the simplicity of paying for access to a database. The individual pictures were combined together to create sequences of the execution, which were further enhanced with textboxes and arrows in Word to create a flowchart. The process from pictures to the whole flowchart can be seen in figure 1.

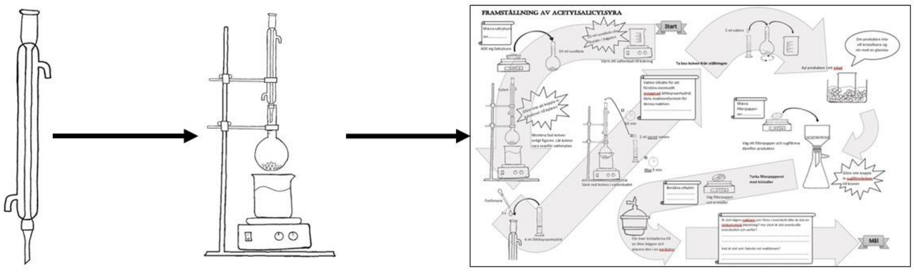

Figure 1 The process from single pictures to whole flowchart of the execution in the instructions.

The execution part of the instruction were printed out on A3 paper whereas the rest of the instruction were printed on A4 (see appendix A, only in A4 format). This allowed us to increase the size of the images, enhance legibility, and support the ability of two to three students working with the instructions simultaneously by discussing and interacting directly with the material.

4. Methodology and Methods

In this section, the methods used for data collection and data analyze will be explained but first will discuss different approaches to research and why we have chosen to use the ones we have.

4.1 Research Approach

At a technical university like Chalmers, most master thesis projects are conducted within the positivist /post-positivist paradigm and use the scientific method to study a well-defined system (Wallin 2015). Within this paradigm, it is assumed that there is an objective truth. In the positivist paradigm, the objective truth is viewed as something that can be discovered through the research. In post-positivist paradigm on the other hand, the researcher only strives to capture an approximation of the objective truth based on the current understanding of it (Wallin 2015). In order to find or approximate an objective truth, a quantitative research approach is commonly used in the positivist /post-positivist paradigm (Borrego et al. 2009). Quantitative research is well suited for deductive studies, where narrow research questions and plausible hypotheses are investigated by collecting and analyzing data to accept or reject the hypotheses (Borrego et al. 2009). The analysis step in quantitative research is determined by isolated variables, continuous or categorical variables, and the conclusion is derived from the collected data and statistical analysis (Borrego et al. 2009). In quantitative research the aim is for the findings to be generalizable to a larger population (Krefting 1991). This is possible only with the assumption that there is an objective truth.

This master thesis differs with respect to the underlying research paradigm and is based within the interpretivist paradigm. The interpretivist paradigm is well suited for work concerning the meaning people attribute to phenomenon or how they interpret the world (Wallin 2015). Instead of on objective truth, the interpretivist paradigm assumes that everyone experience and shape their own subjective reality (Gray 2014). In other words, while reality is viewed as objective and falsifiable in the post-positivistic paradigm it is viewed as consisting of multiple subjective realities in the interpretivist paradigm (Borrego et al. 2009). Within the interpretivist paradigm, a qualitative research approach is often used to study peoples' experiences and interpretations. Qualitative research often focuses on smaller groups, in order to examine a specific context in greater detail (Mack et al. 2005). To answer research questions of What, How or Why in a specific context, qualitative research is often carried out in an inductive way, which starts with rich contextual data of the people and situations of interest (Borrego et al. 2009). This is an open approach that allows new phenomenon to be identified, which wouldn't happen if a prior hypothesis or research instruments drove the research. Hence the theory comes much later in the research process, and acts as a lens through which findings can be interpreted (Borrego et al. 2009). The aim is not to generalize the findings, but to describe them in such detail that other people are able to understand all the implications and possibly transfer them to their own contexts. Instead of generalizability, qualitative research focuses on transferability (Creswell et al. 2007).

In this study, we are interested in the student's experiences and interpretations of chemistry laboratory classes. Therefore, we choose an inductive qualitative research approach based within the interpretivist paradigm, which is well aligned with our research questions. The aim of this study is to acquire access to the students' perspective on their chemistry laboratory classes. To ensure credibility in our study triangulation amongst other things was used: both observations and interviews were used as data collection methods to offset weaknesses in each (triangulation of data collection), as well as all data was read and analyzed by two persons (triangulation of investigators).

4.2 Data Collection Methods

In their book "Qualitative research practice - A guide for social science students and researchers", Ritchie and Lewis (2003) make a distinction between naturally occurring and generated data. According to them, natural occurring data allows researchers to investigate phenomena in their natural setting, while generated data can give insights into people's own perspective. In this project, two data collection methods have been used: observations and interviews. Observations can be used to collect natural occurring data while interviews are a method for collecting generated data. Observations provide the opportunity to analyze behavior and interactions as they occur and are well suited for studies where "behavioral consequences of events form a focal point" (Ritchie & Lewis 2003). Interviews on the other hand can provide an opportunity to explore in detail the individuals' perspectives, thoughts, feelings and motivations. Conducting the interviews not with a single interviewee, but in the form of *focus groups* (two or more interviewees), a technique of using group discussions, also allow the participants to compare and reflect on each other's perceptions of the situation (Ritchie & Lewis 2003).

Before we started our data collections, we visited each chemistry class and briefly introduced ourselves and our research study to the students. The students were able to ask questions regarding our study and the data collection methods. During this introduction, we also handed out the information in paper form and asked students if they would be interested in taking part of the filmed observations and interviews during the study. The participation in the interviews and video recordings has been voluntary and the students have been able to terminate their participation whenever they wanted. All students that took part in the interviews and video recordings signed informed consent forms.

In the next two sections, we will discuss our two data collection methods: observations and interviews in more detail and describe how both methods were used during this study.

4.2.1 Observations

Observing is a form of data collection by registering phenomenon's occurring from the source in question (Lundberg 2016). The use of observations is closely linked to qualitative research, but can also be used in quantitative studies (Ritchie & Lewis 2003). Observations allow the collection of data and enables an investigation of the impact as it occurs (Ritchie & Lewis 2003). They can be either structured or unstructured, as Mulhall (2003) puts it "unstructured observation is used to understand and interpret cultural behavior". In contrast to structured observations where the researcher enters the field with a number of predetermined behaviors to observe or not observe, the unstructured observations enables the observer to change their ideas as to what is important or interesting to observe as more understanding of the situation develops (Mulhall 2003).

In this study, we used qualitative unstructured observations. The observations were focused on the whole class and the overall impression of the perception of the laboratory work and the social interaction between students. As support, we used questions relevant for our aim that were prepared in advance (see appendix C). These questions were used as support while still allowing us to redirect our attention as our understanding developed. Observations were conducted both on students using the modified and the original instructions. As the classes were split into half during their laboratory exercises and both halves (around 8 groups each) worked successively on their experiments, we choose to give the modified version of the instruction to one half, whereas the other half got the original instructions. In this way, we were able to study students from the same class with the same teacher both with the new and the old instructions and take into account class to class variation. When conducting the observations, each of us focused on four groups (half the classroom) in order to be able to observe the groups in more detail and recognize details that might have been lost when observing more groups simultaneously. From the initial test observations that we conducted in the beforehand, we felt that we would be able to get a cohesive overlook of the whole classroom even though we didn't observe the same students.

The students seemed not be disturbed by our presence and appeared to be comfortable by being observed. Some students even choose to turn to us to ask their questions during their laboratory work. One reason for this openness might be that we carefully introduced ourselves at the beginning and shortly described to the students our study. Even though some students approached us directly, we tried to interact as little as possible with the students during the observations and did not actively intervened with the students' work. All the individual notes from the observations were written as a storyline soon after the event to fully profit from the immersive experience of observing the students in action and capturing all aspects of their interactions and behavior.

4.2.2 Interviews

To better understand why different types of phenomenon occur, observations are often combined with interviews (Ritchie & Lewis 2003). The interview is a source for in-depth information about study participants' experiences and viewpoints regarding a specific topic (Turner 2010). There are different possible ways to capture this type of information, and how to carry out the interview. Interviews can range from very structured, with predefined questions, to complete unstructured, with a more open approach. One type of interview design is the semi-structured approach, which is a flexible interview design with pre-constructed questions (Turner 2010). The design is flexible in the sense that the interviewer can ask follow-up questions to an interviewee's answer or change a question completely because of previous given answers. There is a balance provided by the predefined structure that ensures that important areas are covered and the openness to explore certain areas in more detail depending on the interviewees' answers. A method to review interview strategies and pre-constructed questions is having two or more researchers participating in the interviews (Ritchie & Lewis 2003).

Even more efficient in exploring and clarifying interviewees point of views than one to one interviews is focus groups. It is a particular well-suited method to study attitudes and experiences. Focus groups are useful to explore not only what the interviewees think but also why they think that way. Other areas where it is a useful method is when cultural values or work place cultures are of interests. It can be beneficial for the groups to be "natural occurring", for example colleges or others who share their daily lives. To create a successful focus group session, it is important to establish the right atmosphere. Offering comfortable seating's and refreshments are useful tools to help achieve this (Kitzinger 1995).

One way to enhance discussions and reflections further during an interview is to use different stimuli. One interesting method in this respect is stimulated recall. Video-stimulated recall is a method that involves video recording of an activity prior to the interview in order to replay it to the interviewees and enabling them to comment (Rowe 2009). It is an interesting and well-regarded research tool in areas such as education, medicine and psychotherapy (Rowe 2009). When used in education research, one of the benefits in using video-stimulated recall is its ability to capture the complexity of classroom interactions and let the students explain their own behavior and actions (Lyle 2003).

In this study, we used semi-structured interviews following an interview guide developed based on our experiences from the initial observations (appendix D). During the interview, different tools were used to stimulate responses. First, interviewees were shown the modified- and the original instructions and asked to comment on different aspects of the instructions, their approaches, strategies, experiences, and feelings. Second, cards with different types of feelings you might experience during laboratory work were used and interviewees were asked to choose three cards that described their feelings. Third, video-stimulation recall was used during each interview. The video material for the video-stimulated recall was collected during the laboratory class and recorded the interviewees' actions and behaviors while working on their experiments. The camera was placed on the students work bench, or in an equivalent position, where both students were fully visible and their interactions could be captured. After the film was captured the material was reviewed and two clips of interest were selected. The clips were approximately one minute in length. The students were shown the clips and asked to comment on what they saw and how they remembered their experience of the situation.

Both of the researchers were present during the interview the roles of interviewer and observer were alternated in between each interview. One was in charge of the conversation, the interviewer, and the other one made sure that all the topics prepared beforehand had been covered at the end of the interview, the observer. To ensure an open environment between the interviewer and the interviewee(s) a specific seating arrangement was chosen (figure 2) and coffee and sweetbread was served before and during the interview. The interviews lasted for about 50 minutes and the participants in the interviews were students that had used the modified instructions either one or two times. The students were interviewed together with their lab partner(s). All of the interviews were audiotaped and soon after the event transcribed.

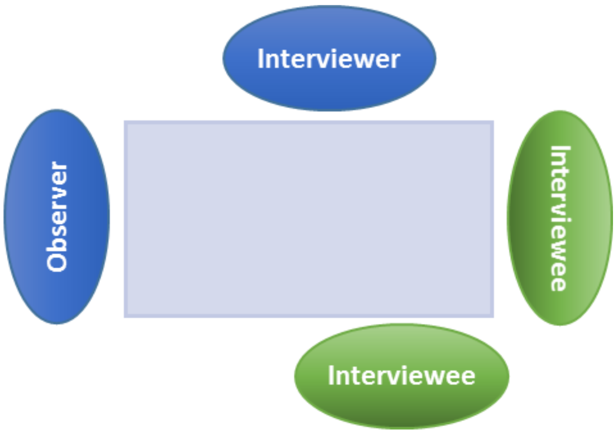

Figure 2 Seating arrangement used during the interviews.

4.3 Data Analysis Method

During the data analysis, the focus has been on the interview data, whereas the storylines from the observations have not been analyzed systematically. Instead they have been used to deepen our understanding of the students' situation during the laboratory work classes. The observations served an important purpose here as it helped to better understand the students, as Mack pointed out: "Generally speaking, the researcher engaged in participant observation tries to learn what life is like for an "insider" while remaining, inevitably, an "outsider"" (Mack et al. 2005). The observations made us more adapt in understanding the students line of thought. This has been a great asset both during the interviews, when it was helpful in the formulation of follow-up questions, as well as during the analysis process of the interview data. In the analysis of the interview data it served "as a check against participants' subjective reporting of what they believe and do"(Mack et al. 2005). The observation data might be analyzed more systematically in a follow up of the project.

To analyze the data from the interviews, we have used a method inspired by the general inductive approach. According to Thomas (2006) the general inductive approach is particularly well suited to "allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data" which in turn will help to unearth the actual effects, not only the planned. In addition, the general inductive approach provides "easily used and systematic set of procedures for analyzing qualitative data that can produce reliable and valid findings" (Thomas 2006). This approach is well aligned with our research approach and research questions to understand the "how" and "why" directly from the students. Due to the amount of data collected and the limited time of our project some modifications of the approach needed to be made.

In the first step of the analysis, the interviews (10 hours in total) were listened to and the transcripts were read through multiple times to get immersed in the data. The listening of the recordings and the reading of the transcripts were either done simultaneously, i.e. the transcriptions were read while listening to the recordings from the interviews, or in an alternating fashion, i.e. the recording was listened to first followed by a read through of the transcription of the same interview. In the next step, quotes containing anything of interest in relation to the research question were identified, and in this way the raw data was deconstructed into units of meaning. This process was conducted by us both separately, and at the end of the process notes and units of meaning were compared and discussed. In the third step, the data was reconstructed from the units of meaning into categories. This work was carried out in an iterative process of constructing and reconstructing that eventually resulted in the emergence of the categories presented in the following results section. At this stage, literature concerning subjects related to our impressions of the data was consulted which allowed us to look at our findings from new angles. Throughout the whole data analysis process, we discussed our thoughts and ideas to capitalize on being two researchers that provide different angles and perspectives to the data. In addition, Patric, our supervisor, acted as a critical friend and took the time to fully understand the context and outcomes our work. He helped to untangle the complex data by asking critical questions and offering new ideas, while being an advocate for the success of the work (Costa & Kallick 1993).

5. Results

5.1 Beliefs, Values and Motivations

Students enter the chemistry laboratory with their own beliefs and values, which will shape their learning experience by influencing their strategies and actions. Students will also have their own motivations and goals when working on their experiments. In this first category, we will explore these factors, students' beliefs, values, and motivations, as they form the foundation on which the students act, learn, and collaborate. These factors will influence how students perceive the laboratory instructions, but will eventually also be shaped by the instructions and tasks that the students engage in.

One central element that the students mention repetitively during the interviews is the importance of high grades and their beliefs about the way they are assessed by the teacher. The students know that tests have a big influence on the grade they will get for the course, but also that it is not the only influence on their grades. The students have also reported that they know that their work during the laboratory classes also influence their grade. Even though they are sure that their laboratory work is being assessed they are unsure about how the work is assessed. This makes the students unwilling to ask the teacher questions because they do not want to show when they do not understand something, since they believe that this could influence their grade negatively. Not knowing how they are assessed and on what grounds creates an environment where the students become afraid to do something wrong:

- I do not really know how we are assessed on the laboratory work [...] You do not want to ask to much because then you might show that you do not understand […] You do not want to do the wrong thing because the practical work is being assessed as well. (S9)

The desire to not doing something wrong during the laboratory work is also related to another believe that the students hold. In the students' mind, the laboratory work is not first and fore most a place for them to gain understanding, but a place to show the teacher what they already are able to do:

- I know that the teacher assesses this, the laboratory work is still a part of the grade. […] [F]or me it's important that the execution is right because that's what I know the teacher is assessing. I also think that it is important for me to do the right thing and to think right because I know the teacher might not tell you "Now I'm assessing you" but I know they still do it. (S12)

For some students, this becomes an internal conflict, where they are unsure when and what to ask, and what questions to avoid. On the one hand, they could learn something new from asking, on the other hand they believe it could affect the teacher's perception of them negatively. The students are unsure of what they are supposed to learn and what they should know already. They do not want to risk the teacher finding out that they do not know something that they already should be familiar with by asking a wrong question:

- I get a little bit like this "should I ask the teacher, will he think that it is good that I ask or will he just, oh she really does not understand" (S4)

Apparently, the idea of negative repercussion of asking questions is not something that the students have come up with on their own. Some of the students talk about teachers that told them not to ask too many questions or their grade would be affected, when they were younger:

- I remember that our woodwork teacher told us that "Do not ask us too many question because then you will lower your grade". I do not know but it could be something like that. Even if she does not say it, you think that "if I ask too many question then I show that I don't know". (S6)

The students' beliefs around the way they assessed and their desire to doing the right thing also strongly affects the students' motivations. On a superficial level, the students are mainly motivated by their grades and want to do everything to achieve as high grades as possible. However, in the interviews it became apparent that the situation is more complicated and the strong focus on grades is a result of the students' beliefs, which overshadow other motivations that the students have. Some students talk about how they wish that they would focus more on gaining a better understanding, but explained that in the end what decides what they will focus on is what they think they will need to perform on the upcoming tests:

- You still want to understand
- Exactly you have to because otherwise we will not manage. Otherwise we will not take with us what we are supposed to take with us from the laboratory class and we will get tested on it at one time or another.
- Yes
- It is a bit sad that all our focus is on what we need to learn for the test, but that is what always happens. We have to, not because it is part of the course or the topic that we are exploring at the moment but because "we have to know this exercise because it will be on the test". (S10, S11)

One of the students explained that gaining a greater understanding was one of the things she looked forward to when she moved up to upper secondary school, but now when she is here she feels as though it still is not what she is spending her time developing:

- "But then I will get to, except of just seeing, I will understand why as well". But it feels like I still do not understand why, I still just do it without really understanding what really happens when I do it. (S19)

Situations that could have been exiting challenges instead become a source of stress because of the thought of how it will affect the grades:

- On one hand, you think that it is a little bit fun. At least I think that problems are fun to solve. So, in that regard it can be fun but on the other hand you get really stressed by the situation. Maybe not by the laboratory work by itself but by everything thing around it, like if a teacher walks past and thinks "what ARE you doing?". (S13)

The learning experiences that the students shape through their own beliefs are not the learning experiences that they want to have, but they lack the tools to recognize and change their own beliefs. It is not something that they feel they can ask their teacher about or that is discussed within the class.

5.2 Emotions

The students' beliefs, values, and motivation will also influence their emotions and feelings during their laboratory exercises, as well as the way they approach certain situations. The fear of how their actions will affect their grades, either through doing something wrong or through giving the teachers the impression that they are uncertain, leaves the students with a feeling of uncertainty:

- I am very afraid of doing the wrong thing to, so I take a look at the people I know are good. So that you do not do the wrong thing. (S17)

Some of the students feel insecure about their own abilities and are questioning their own understanding. They do not want to ask the teacher because they suspect that the information they are looking for actually is available in the instructions, but they have not been able to access it:

- I am a little bit afraid of asking the teacher too much. I am afraid that he will get the impression that I do not understand. Often times it feels like I am asking things that actually are written in the instructions just that I have not read them thoroughly enough. (S6)

The students report that the presence of their classmates helps them reduce the uncertainty they feel and create a more secure environment for them. In particular, the fact that the students work in pairs is important to create this sense of security. The students report that if they would be doing the work by themselves the need for looking at their classmates work and hearing their thought would become even bigger:

- If I would have done it on my own I would have been really unsecure and looked a lot on the others. Because you want to hear what the others are thinking, are they thinking that you should use other materials or whatever it could be. (S20)

It is the strong desire to get confirmation by others that drive the students. It is through this type of confirmation that the students feel that they are on the right track and progress in the right direction:

- You need confirmation
- Yes, on that you are doing the right thing and are thinking correctly (S12, S13)

Here, the pictorial instructions can have a positive effect, as the students discussed. The flowchart diagrams help the students to know where they are going with their laboratory work and help them to feel calmer during their work. The students attribute this to not having to worry about if they have understood the task correctly:

- When I have pictures, I get less worried because then I know what comes next, then it gets easier to plan. Because well, I like to make lists of things I am supposed to do. Instead of focusing on "Oh my god, what can go wrong" I think about "Well next I should" or "The next step is this. Well then I'll get this…" sort of. It allows me to think of something else. (S15)

One of the students adds that in addition to understanding what she should do, the pictorial instructions also helped her understand why:

- I felt really peaceful when I did this laboratory class. I understood what you should do and even why. (S19)

Another related factor that the students talk about when discussing how the pictorial instructions helped them to become calmer during their laboratory exercises is that the students feel that the instructions are clearer. They talk about that the important information is more easily accessible and that they do not have the need to second guess themselves to the same extent as without the pictorial instructions:

- It was easier to check ahead here because it was what we could do

- Here we did not need to think so much about a specific value or something like that a hundred times "ok, 4ml, 4ml…"
- Exactly
- You could see it in front of you and then it was a bit easier to be able to look ahead and see what you were supposed to do. (S10, S11)

Feeling calm and secure are two important factors of the emotional learning environment that the students highlighted during the interviews. From the students' discussions, it become apparent that the pictorial instructions have a positive effect on the students' emotional learning environment and can help them to improve their conditions for learning.

5.3 Strategies

The students use a wide variety of strategies during their laboratory exercises. Here, we focus on the planning strategies, collaboration strategies, and interaction strategies that the students discussed during the interviews. The students also discussed how these strategies influences their learning and experiences during the laboratory work which is also accounted for in this section.

5.3.1 Planning Strategies

The students use a variety of planning strategies before they start with their experiments, in order to know what to do and how to progress. One problem that some students encounter during this planning and preparation phase is that they have difficulties to fully understand the tasks they are supposed to do by only reading the instructions. From the interviews with the students, it become apparent that the teacher's presentation of the laboratory exercise (run through), directly before the students start to work, is a key element for many students' planning strategy. The presentation the teacher gives is the main source of information for the students and helps them to see the task as a whole by understanding how everything is connected:

- I think that when you have read through it before hand and in combination with the "run through" that he has, then I think that you understand the task as a whole. Because when you read it, it can feel foreign because it usually is new. But when he runs through it then you get a grasp of what it is that you are supposed to do (S9)

An additional problem for some students is that they feel that they do not have a sufficient amount of time to process the information provided in the instruction in a way they would like to. The students mention how they like to sit down and carefully go through everything, in order to understand the experiments and feel confident in what they are supposed to do, but they often skip this part due to a perceived lack of time:

- Since you are supposed to manage to do so many different tasks during the time we have for the laboratory work you do not really have time. I would love to, at the beginning, sit down, go through everything and "Ok, what is it that I am supposed to do" and everything so that I know. But you kind of have to skip that to have time to do the laboratory work. (S1)

In this way, the written instructions become secondary and are only used as a reassurance, especially when they are not updated and do not fully reflect the experimental setup used by the students:

- I usually focus mostly on what he has said. Because he changes a lot of things and we are using different materials and stuff like that so then [I get] confused.
- It becomes a lot to think about

- Yes, so then it is easier to just think "and after that he did this and then this" and remember instead. And then you might double-check here [in the instructions] or ask somebody about it. (S19, S20)

The strong focus on the teacher's presentations becomes problematic, as the tasks and experiments that the students' work on become more extensive. It becomes more and more difficult for them to remember and fully understand everything from the presentation only. Some of the students describe how they have trouble following the many stages of an experiment and how they can get lost between the presentation and the written instructions not knowing how directly where to look for the information needed:

- But since there are a lot of different stages during the laboratory tasks. Suddenly he can mention something like "have you used one of these?" […] And then he can start talking about different parts. Then it is a bit harder to follow then it would have been if we had the paper. (S11)

The written instructions do not necessarily provide the students with the needed help in these situations, as they are often challenging for the students to assess. The students discuss their difficulties to remember, interpret, and fully understand the written instructions when reading them quickly, and the need to often go back to the instructions during the experiments:

- If you have it on paper it is easy that it just disappears in your head
- Yes, just a small row of words
- You can forget it and then you probably have to sit down and think about it to piece it all together
- To think like this: "Ok, I read something about it, where do I find it?" and then you have to read the whole thing again. If you have pictures instead then it is easier [to find] where you saw it. (S1, S2)

The need to reread the instructions multiple times eventually leads the students to instead spend a large amount of the laboratory time reading and understanding the instructions, rather than performing their experiments:

- During a typical laboratory class going through the text takes up a lot of time. You just "Hold up, what are we supposed to do now?" and read through the whole thing again. (S1)
- If the instructions are unclear one can easily spend 60-50% of the time on the instructions. (S13)

It is particular in these more complex and demanding laboratory exercises and situations where the students feel lost that they have expressed that they think the pictorial instructions are a good complement. The pictorial instructions helped them get a better overview and understanding of the laboratory work since it helped them see the laboratory work as a whole instead of a number of separate tasks.

- I felt that it was easier to understand how the laboratory exercise should look as a whole than it was when you had the text because then you get more instructions kind of […] you take it more step by step (S1)

The ability to see all steps of an experiment on a single A3 page supports the students to see connections more clearly and the instructions become a map that the students can learn to navigate on their own.

5.3.2 Collaboration Strategies

In the laboratory, the students work together in groups of two or three and use different collaboration strategies to run their experiments. During the interviews, it became clear that the students feel that they need to prioritize finishing the practical work in expense of thorough planning and reflection. Some of the students make comparisons to laboratory work in other subjects where they feel like they have more room for reflection:

- In the laboratory work in biology for example then you work with very small things and then you think and reflect more, but here you do not have time for that. You feel that you have to do the next step all the time and we think "But we will figure that out later, we will do it later" because we have to finish because otherwise we won't get any result. (S20)

The perceived need to work quickly to finish the experiments strongly influences the students' collaboration strategies. Often the preparation and planning phase is not completed after the teachers' presentation, but the students make a more detailed plan collaboratively within their group and go through the instructions. However, in the typical laboratory exercises with written recipe instructions, the students' planning effort is often limited. They start with reading the instructions again, but quickly move on to work on the first task and subsequently approach the work step by step:

- You read through the instructions, then "let's do the first step" and if it is needed to be two at different places then you do that. "Ok, what is next?" That's how I try to do it so that I keep track of "Ok now we are on this step and now let's do this and now we have done this". (S12)

The students feel the need to quickly start with the experiments and the practical work, thus limiting their time to think through all steps in advance. Another example for this time conscious approach is that some students prefer to take turns reading the instructions so the other one can keep working:

- Both read the instructions quietly on their own, preferably at different times because then the other can keep working meanwhile. (S13)

After this initial start-up phase, the students start to work on their experiments together. The need to manage to get results during the limited time of the laboratory class also affects the students' fear of doing something wrong, as discussed in the emotions category. This fear is limiting the students to freely test their ideas, as doing the wrong thing is time consuming and might cause them to be unable to finish the task before the laboratory class is finished:

- If you do the wrong thing, then you have to start over and that is tiresome […] It feels like it takes more time and then you might not finish in time. (S18)

In the interviews, some students describe how the pictorial instructions help them to collaborate and perform their experiments more smoothly. The number of times they need to interrupt and reread the instructions is reduced and they can more easily navigate the instructions. This is particular useful if one student is ahead of the other and needs to explain where they are at the moment and what to do next:

- I was a bit ahead in my thoughts because I had already read so I was like "Ok, now we should get that…"
- Yes, it was then the picture was useful because then I could quickly take one extra look and check what Charlotte said and I did not have to read

Lisa: If you would have [the original instructions] instead], how would that have looked?

- Then I would have probably
- Then you would have yelled "So you are taking 4 ml right now?!"
- Yes, or I would "Wait, wait, wait, wait, let's take it easy now" and I would have read it out loud because
- And I would say "Yes I am already there and I am already on my way to get that" and then "Oh, ok now I'm with you" because that is how it goes.
- Yes (S10, S11)

On a more general level, the students' collaboration is improved through the pictorial instructions by providing them with instructions that support their communication. It is easier to view an image together and discussing simultaneously than working with text in the same manner. Many students report that the pictorial instructions help them to communicate by enabling them to state their questions more clearly and show what they mean when they are trying to explain something to their group:

- It is easier to explain what you mean with things when you have a picture in front of you then if you have a text in front of you… It is easier to point and explain when you have a picture. Yes, I believe I thought it was easier to explain to others what you mean. And it is easier for my classmate to ask about what it is that she is thinking about as well. (S3)

This improvement in the students' communication is not limited to planning and aspects of the experiments that lay ahead of them, but also helps them to go back through the whole experiments, explain certain aspects, and discuss how things are related to each other:

- I think that then you are able to go back a little bit more, because I believe that it is easier to say "but look this is what we did, right?" and then you can point and show what step you mean, instead of saying "Don't you remember when we took the solution and flushed with water?". So I think that it can be, or everything becomes more concrete when you have this illustration. (S6)

The students' collaboration strategies are strongly influenced by their desire to work quickly in order to finish the experiments in time, even though the students are aware of the negative side effects this rushed approach has. The pictorial instructions can help to improve the students' collaboration, mainly by helping them to communicate more efficiently and by providing them with an overview to use collaboratively.

5.3.3 Interaction Strategies

During their laboratory work, the students do not only collaborate within their groups, but also interact actively with their other classmates. The interaction strategies that the students use serve different purposes from reducing the students' uncertainty to being able to ask the teacher first.

Many students talk about how they use their classmates as tools to manage the uncertainty they feel during their laboratory work. Sometimes this is done by asking questions or simply by observing their classmates:

- I can walk around to everybody and sort of [ask] "what is it you are doing? How far have you gotten? How did you do that?" (S2)
- I always, and I mean always, take a sneak peek at the others. (S17)

The ability to easily observe each other and interact is influenced by where the students are sitting. Upon seeing themselves on the video clip, one group of students highlighted the importance where in the classroom they place themselves in relation to other groups, and that this is normally a conscious decision they make:

- So here we are placed opposite to them to be sure of what we are doing
- Look, here you place your self if you are sure of what you are doing [*points to a work bench in the far end of the room where the students are working with their backs to the rest of the students]. And over here it is good to sit if you want to do a lot of comparisons.

…

- It is very important to think about where you place yourself.
- And it is a lot like that if you know that you are going to write a report where you place yourself and who you do the laboratory work with. There is quite a lot of strategy when you enter the classroom. (S10, S11)

While most of the students think that it is important where in the room you sit, the preferences differ amongst students. Some students do not see it as beneficial to be placed across from their classmates. They want to limit their interactions with classmates in order to not get distracted and be able to focus fully on their own work:

- We become a bit separated and the others sort of get to be somewhere else
- So, you get to think about your own stuff.
- So, you can focus when you are there. It simply is a good corner
- You do not have to sit across from someone else who goes on and on. It can affect your concentration to look at what they are doing. So, it is pretty nice to have your own little corner. (S14, S16)

Other students, on the other hand, think that the possibility to interact and actively engage with their classmates is important and helps them during their experiments. When they talk about the benefits of sitting across from someone they mention that they do not have to move around the classroom in search of classmates they can talk to about their work.

- We usually do the laboratory work at the same work bench as someone else.
- Yes, that is sort of the trick…

- Preferably on the same bench as two classmates that we know, know what they are doing. …
- Then one can always discuss fairly easy with each other without having to run around the room in order to find someone who knows what you want to know. (S10, S11)

The way students interact with each other is also shaped by how far they have come with their experiments in relation to each other. On the other hand, some students put in an effort at the beginning of the class to make sure that they are ahead of their classmates. This enables them to ask the teacher before all their classmates have similar questions and a queue is formed, which is an important factor for them:

- If you are at the same time as everyone else, then everyone else will ask the same things at the same time to the teacher. If you are first, then you get to ask first and then you get to move on quicker. So, I am always a little bit stressed in the beginning because I want to get everything going quickly. (S3)

And on other hand, some students talk about that they do not want to take a single step without having seen one of their classmates do it first:

- Yes, I do not really want to be first. I want to see what everybody else dose first and then after that do it myself.
- Yes, so do I. (S4, S5)

The desire to first observing how others are doing every step of the experiment and the students strong awareness of their classmates is also related to the students' fear of doing something wrong. They want to know that something will work without testing it themselves and one way to do that is by observing others. However, this strategy does not allow the students to try their own ideas and develop self-confidence in performing chemistry experiments. The students do not find this all together unproblematic, as they see that they rob them self of the opportunity to try on their own:

- We are afraid of doing the wrong thing
- So, because of that we go straight a way to someone else to double-check and that's not right because we probably had our own thought that we…
- Yes, and we would have managed too but since you feel like "What if I don't manage, it is probably best if I go and check immediately whit someone that is correct" and then you don't get to try yourself either
- No exactly and that is not very good actually (S10, S11)

The interaction strategies that the students use differ between different groups, but independent of the actually strategy the students are fully aware of their importance. They make conscious decisions and have thought through the advantages and disadvantages of different strategies.

5.4 Result Summary

At the heart of what shapes our experiences lies our beliefs, values and motivations. These in turn influence our emotions as well as the strategies that we use. Together these influences how we experience the situation we are in. This was visible also in the students' reflection of their approaches to the chemistry laboratory work. For this reason, our result is divided into these three categories.

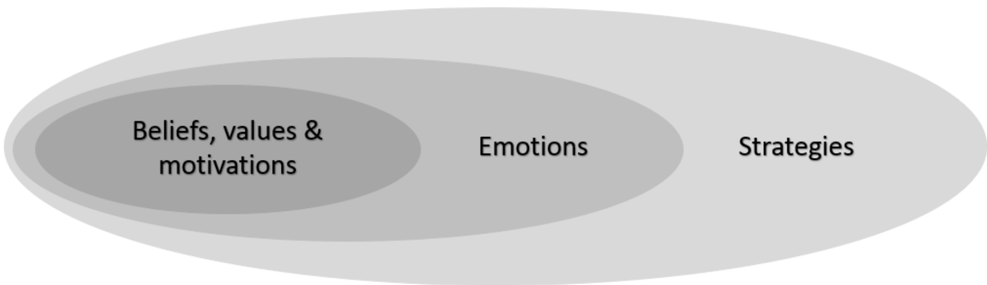

Figure 3 A representation of how beliefs, values & motivations are connected to emotions and strategies

Table 4 Summary of the result within the different categories and the impact of pictorial instructions

Beliefs, values and motivations	Emotions	Strategies

• Grades play a central role in students' education and are of highest importance. Learning is secondary.
• Actions such as reflection, taking on challenges or asking questions are under prioritized or avoided.
	• Many students are worried during the laboratory classes. They are worried of doing something wrong and how that will affect their grade.
	• For some students, the pictorial instructions helped ease that worry.
		• Used Strategies
		  • Many students use their teachers oral presentation as their main sorce of information.
		  • When unsure many students look at their clasmates for clues as how to precede.
		
		• Callenges
		  • Reading instructions is time consuming.
		  • Students often see the laboratory task as a number of separate tasks and find it difficult to see the task as a coherent process.
		
		• Benefits of pictorial instructions
		  • The pictorial helped some students see the task as a process
		  • The students felt inclined to work more together when using the pictorial instructions.

Beliefs, values and motivations	Emotions	Strategies

	• For some students the pictorial instructions resuced the stress of the laboratory class.	• Planning
		  • The pictorial instructions made it easier to relocate information for confirmation.
		• Collaboration
		  • The pictorial instructions could be used as a tool to pose more concreate questions.
		• Interactions
		  • Some students felt more cofidenc in thire own ability to figure out the task and less inclined to copy their clasmates.

6. Discussion

In this section, the result of the study will be discussed. The discussion is centered round the three research questions:

- How do the students approach their chemistry laboratory classes?
- How do students reflect upon their own approaches & strategies?
- What role can pictorial instructions play for students in chemistry laboratory classes?

6.1 How do Students Approach Their Chemistry Laboratory Classes?

Our results indicate that the students' first priority, in school in general as well as the chemistry laboratory classes, is to obtain as good grades as possible. This is sometimes at the expense of their learning as well as their well-being. In the laboratory work this is mainly visible as a fear of doing the wrong thing and as an unwillingness to turn to their teacher when they feel unsecure. The students are not sure of how they are being assessed during the laboratory work but they are fairly certain that asking questions would not be beneficial to their grade. This leaves the students with a sense of uncertainty and a notable amount of anxiousness. The main strategies to ease this anxiousness is to look at and ask their classmates. Other strategies the students use to manage the laboratory work include using the teacher's introductory presentation as their main source of information. From the results, we also learn that the students spend a large amount of time reading and understanding the instructions rather than preforming the experiments. The students experience that they do not have time to reflect on their work during the laboratory work classes. A situation that could be "pushing" the students towards a surface learning approach, as mentioned by Hofstein and Lunetta (2003).

As much as the students are focused on what and how they are being assessed, their apprehension of the very same, what and how they are being assessed, is at best unclear and at worst incorrect. One of the effects of this is the student's unwillingness to ask their teacher questions when they feel unsecure. Previous studies have showed similar unwillingness to ask questions (Ryan et al. 2001). In these studies, this has been linked to a fear of looking "dumb" in front of the other students and the effects that brings. In our study, this has not been prominent, the student prefers turning to their classmates as they think their grade will not be affected in the same way as exposing areas where they feel unsecure will.

On a more general level, the strong focus on grades is likely due to the perceived and real importance of grades. It diminishes schools to a place that prepares and evaluates students in order for them to be able to take the next step. For the students, it is not necessarily a place where learning itself is in focus.

6.2 How do Students Reflect upon Their Own Approaches and Strategies?

What the students consider to be satisfactory results from the laboratory work is closely related to the students' focus on how they are being assessed and on how their grades are affected. This witnessed of the students using a performance goal approach and gaining a surface learning. Some students express regret over this intense focus on grades instead of gaining deeper understanding. The interviews show that the students are not entirely happy or satisfied with this situation. They would rather like to focus on their actual learning, but they feel inhibited by the strong pressure to get good grades in order to be able to go to the universities they would like to go to. This behavior that the students' express correlates with that they are using a strategic approach, since the focus is on getting a good grade. This is also in line with the study results of that the students have learnt how to approach the curriculum (Cano 2005) to get as good grades as possible. However, as the students also expresses the regret regarding the strong focus on grades, they show that they would rather like to focus on the conceptions of learning 4-5 (learning as the abstraction of meaning, learning as an interpretative process aimed at the understanding of reality) but they are pushed towards conceptions 2-3 (learning as memorizing, learning as the acquisition of facts or procedures) since that is what's being rewarded with higher grades.

Earlier in this report we have addressed the effects of summative assessment in the form of high-stake testing. As we have mentioned both negative and positive effects of these tests have been addressed in studies. Among the negative aspects were the tendency of teachers to "teach to the test", to deprioritizes certain subject areas that will not be tested in order to achieve better test scores by putting more effort and time into areas that will be tested (Abrams 2004). We see similarities between the behavior and priorities the teachers in Abrams study express to the behavior and priorities of the students in our study. In both cases the students and teachers express that high consequences of achievement in certain areas form their approaches and strategies. In both cases the student and teachers express regret in the way their approaches and strategies have been effected by the high consequences. In Abrams study the teachers report teaching in ways contrary what they see as sound pedagogy (Abrams 2004). In our study, the students report that when faced with the choice between that they think will benefit their learning and what they think will benefit their grade they will choice their grade. It is our opinion that this is evidence of the importance of investing time and effort in to promoting alignment between the areas and skills that are deemed important and areas and skills where success and failure is connected to high-stakes or consequences. We also think that it is important to be aware of how high-stakes effect students and teachers approaches and strategies and how it effects their tendency to invest time and effort in areas that they themselves find important and interesting. We would also like to point out that since the students in our study have the approaches and strategies to let the high-stakes determine where they direct their attention and effort they have limited experience in letting their own judgment decide where they should direct their time and effort. We believe this is an aspect that is important to be aware of both for the universities where the students will attend in the future and for the decision makers imploring high-stake tests and grades.

6.3 What Role Can Pictorial Instructions Play for Students in Chemistry Laboratory Classes?

We gained the understanding that creating an overview of the task is sometimes problematic for the students. This is one of the areas where the pictorial instructions have showed themselves useful. In addition to helping the students create an overview of their task the instructions have also shown helpful in making the information-retrieval more efficient. This is in accordance to the findings by Zadina (2014b) that the students that had multiple sources of the information had a greater recall of the information. It has also shown to be useful as a tool for communication by offering opportunities to pose more concrete and clear questions. Pictorial instructions have potential to give the students better conditions to be able to reflect during the laboratory work classes and through that promoting deep-learning.

The modified instructions also helped many students to feel more secure in that they had understood the task correctly. They also perceived that the modified instructions helped them see the task more as a whole, which also improved their sense of control and eased their anxiousness. This is indicating that the pictures within the pictorial instructions where of the kind organizational and/or interpretational pictures (Carney & Levin 2002). Another benefit of the students' new-found sense of security and calm is that they now are less likely to suffer from the negative effects on learning resulting from anxiety and high level of stress (Zadina 2014a). However, as Carney and Levin (2002) mentioned, students are learning in different ways and have different preferences regarding what works best for them to gather the information. This was also mentioned by the students in our study, some of the students felt more secure with the pictorial instructions whereas others felt it was difficult to understand the new way the information was presented in.

7. Reflexivity

In the following section the benefits and challenges of the process of conducting the study will be discussed. The four areas that will be explored are the work with designing the modified instructions, conducting the observations, conducting the interviews and conducting the data analysis.

7.1 Designing Modified Instructions

When constructing the modified instructions Patric, our supervisor, acted as a critical friend and provided feedback and advice that were used to make additional changes and improvements. This method was very beneficial and provided a better product than would otherwise have been possible. However, including the teachers more in the process of constructing the modified instructions could have improved the study. This was not prioritized do to the limited time of the project. The laboratory classes observed in this study were held by the student's regular teacher. This was part of keeping the classes as close to their regular classes as possible, with the exception of the modified instructions. We did not expect the modification of the instructions to affect the teacher since only the form of the information and not the procedures the students were expected to preform were changed. During the study, however it became apparent that the changes sometimes affected the teachers' sense of security of the task. To avoid this, it would have been beneficial to involve the teachers more in the work of modifying the instructions.

7.2 Observations

As mentioned previously in this report unstructured observations can be used to understand and interpret cultural behavior (Mulhall 2003). This corresponds to our experience of the benefits of the unstructured observations. They helped us gain an understanding of the student's situation in the laboratory class. It is our perception that this made us more adapt at posing follow up questions that enhanced the student's reflections and discussion during the interviews. We are also under the impression that this improved the students trust in our ability to follow and understand their reflections. This in turn enhanced their reflections and discussions during the interviews. According to Kitzinger (1995) creating the right atmosphere is important to create a successful focus group session. Although we used tools suggested by Kitzinger such as refreshments and a conscious seating arrangement we also believe that the relationship we built together with the students were important in the creation of the "right atmosphere".

However, we did meet challenges regarding the observations. Some of the questions that were prepared as a support for the observations were not well matched with the observation situation we were in. The observations were conducted on a relatively large active group and the questions were relatively specific, such as "what type of questions does the students pose to the teacher?" or "how do the students use brakes?". We rotated our attention among the students but found it hard to be sure that we obtained an accurate representation to answer the specific questions. To answer the questions in appendix C the data collected in the videos might be a better source. However, in this data we only have students using the modified instructions.

We also noticed that the classroom set-up affected our observations. Observations in the classroom where the students conducted the class with their backs towards the center of the room were more challenging than the observations when the students conducted their class around tables in the center of the room.

7.3 Interviews

By changing one of the parameters of the laboratory classes we gained an access point in exploring and discussing the students' experience of their laboratory classes. When it comes to using the interviews to analyze the effects of pictorial instructions it must be considered that the students knew that we had constructed the modifications. The negative effects of the modifications could be under represented because of the students wanting to provide a positive image of the effects our effort had on their behalf.

Above we mention a negative effect of the students being familiar with us. We are however under the impression that the positive effects of this are greater than the negative. The students knew that we were familiar with their school situation but also that we did not have any influence on their grades. This combined with the stimuli (the cards, modified instructions, and video clips) provided us with rich conversations, reflections and discussions among the students. Our experience of the use of stimuli during the interview corresponds to the benefits described by Rowe (2009). In contrast, this also resulted in the interviews differing in content. The differences between the interviews makes it hard to use the data for meaningful quantitative analyses.

7.4 Data Analysis Method

As mentioned earlier, using an inductive approach allows the results to speak for itself, by allowing themes to appear from the raw textual data (Thomas 2006). Using this approach gave us the opportunity to let the students' voice tell the story on how they see their chemistry laboratory work classes and not only verify or reject our own preconceptions. Since the results in this study is focused on letting the students have the opportunity to tell their story, we can't say that what we found is what is happening in every class in Sweden. The result we presented is for these classes only and is not generalizable.

7.5 Future Research

In regard to finding out how students in general approach and feel about their chemistry laboratory classes, we would advise to do a larger study with a broader study group that expand over a longer period of time than just a couple of weeks. This since there seems to be a mismatch between the curriculum and how the students are approaching their chemistry laboratory classes at the moment.

Do to the students' strong focus on the assessment and uncertainty they expressed in regard to how they were being assessed during the laboratory classes. Further studies into how and what teachers assess during the laboratory classes and how this is communicated to the students is therefore of interest.

Another path to explore further, is regarding pictorial instructions as a tool to enhance learning. In this study, the students were not involved in creating the instructions. It would be interesting to explore how constructing pictorial instructions for themselves would affect the student's experience of their laboratory work. If this is done we would advise linking the task to the examination to help the students prioritize preparing themselves for the laboratory class by constructing the pictorial instructions.

8. Conclusion

Our results suggest that the students' every-day routine of the school day does not mainly revolve around learning but obtaining the best grade possible. In the laboratory work classes this is manifested both through a focus on obtaining notes and results that can be used for studying at a later time and through a concern on how the students' actions will affect the teacher's perception of them. The students were uncertain about how and on what they were being assessed during the laboratory classes. This uncertainty was larger during the laboratory classes in comparison to the other parts of their every-day routine of the school day.

The students in this study have developed thorough strategies to cope with the technical and complex details of the expository instructions. The main strategies found were; focusing on the teachers "run through" in the beginning of the class, reading through the instructions multiple times, as well as utilizing their fellow students to comprehend the task.

The impact of the pictorial instructions we have detected in this study is that students feel calmer when using them. This has been attributed to the instructions being helpful in: creating an understanding general outline of the task, posing more concrete questions to classmates and the teacher, enabling effective ways of checking information about the task and efficient ways to look back as previous parts of the task as well as up-coming.

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Appendix

Appendix A

Analys av den tillverkade produkten acetylsalicylsyra

Den produkt som du har framställt ska nu analyseras med några olika metoder. Bland annat ska renheten kontrolleras liksom att verkligen rätt produkt syntetiserats. Nedan hittar du det du ska göra. Principen är också att de handledare som finns visar den första gruppen och de för sedan kunskapen vidare till nästa grupp osv.

UPPGIFTER

1. Bestäm smältpunkten för ditt prov. Vad är den enligt litteraturen?
2. Undersöka renheten för ditt prov med TLC.

Se separat blad för utförande

1, SMÄLTPUNKTS-APPARAT

Smältpunkten för ditt prov bestäms i en speciell smältpunktsapparat. Den består i princip av en provhållare (för smältpunktsrör), en liten ugn samt ett förstoringsglas för att kunna studera provet när det smälter. Ett rent ämne smälter normalt vid en definierad temperatur.

2, UNDERSÖKNING AV RENHET MED TLC

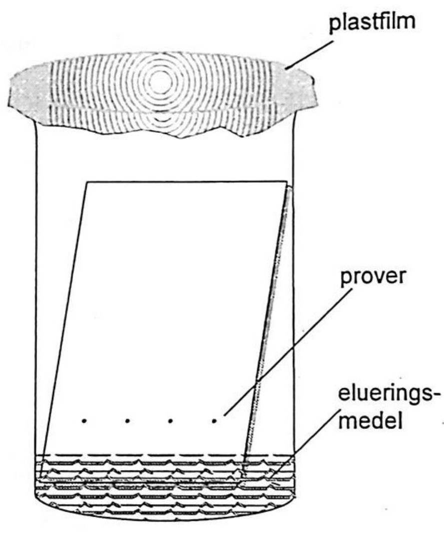
Riskbedömning
Måttligt riskfylld laboration. Allt arbete med lösningsmedel bör ske i dragskåp, eftersom lösningsmedlen är brandfarliga och avger irriterande ångor. Elueringsvätskan samlas upp i särskilt kärl. Provlösningar och referenslösningar kan spolas ut i vasken med mycket vatten.

Tunnskiktskromatografi – Teori
Tunnskiktskromatografi, TLC (**T**hin **L**ayer **C**hromatography), bygger på att olika ämnen fördelar sig på olika sätt mellan en stationär fas och en rörlig vätskefas. Fördelningen beror på att ämnena har olika löslighet i de båda faserna. Den rörliga vätskefasen brukar kallas *elueringsvätska*.
Eftersom olika ämnen har olika löslighet i de båda faserna kommer de att vandra fram över kromatografiplattan med olika hastighet. Varje ämne karakteriseras av sitt R_f-värde som definieras som kvoten mellan den sträcka som ämnet vandrat och den sträcka som vätskefronten – dvs. elueringsvätskan (lösningsmedlet) – vandrat:

$$R_f(\text{ämne } A) = \frac{den\ sträcka\ \text{ämne}\ A\ vandrat}{den\ sträcka\ vätskefronten\ vandrat}$$

Man använder ofta tunnskiktskromatografi för att separera och identifiera små joner och molekyler, t.ex. aminosyror. Några droppar av provlösningen appliceras ("fästs") på en plast- eller glasplatta som är täckt med ett inert, poröst material, t.ex. kiselgel (porösa korn av kiseldioxid). Plattan ställs sedan ner i en behållare med lite vätska, det s.k. *elueringsmedlet*, se figur på nästa sida. Elueringsmedlet är ofta en blandning av olika lösningsmedel. I denna laboration ska du använda ett elueringsmedel som innehåller etanol och etyletanoat (etylacetat).

Vätskeblandningen sugs in i det porösa skiktet på kromatografiplattan. Vätskan bildar där en *mobil (rörlig) fas* som sakta vandrar fram genom den *stationära (stillastående), fasta fasen*.



Lösningsmedlen väljs så att ett av dem absorberas starkare till den stationära fasen än de andra. På kornen bildas ett tunt vätskeskikt där det särskilt starkt adsorberade lösningsmedlet dominerar. Denna *adsorberade, stationära vätskefas* har alltså en annan sammansättning än den mobila vätskefasen. (Kiselgelen på de TLC-plattor som du ska använda adsorberar framför allt vatten).

När lösningsmedelsfronten kommer fram till startpunkten – den punkt där ett prov applicerats – löses de ämnen som igår i provet. Ämnen fördelas på olika sätt mellan den adsorberade, stationära faserna och den mobila vätskefasen alltefter ämnenas löslighet i de båda faserna. En viss del av ett ämne kommer att finnas i den stationära vätskefasen, resten i den mobila fasen. Varje ämne fördelas mellan de båda faserna så att följande jämvikt – en fördelningsjämvikt – ställer in sig:

$$\text{ämne } A\ (i\ \text{stationär vätskefas}) \leftrightarrows \text{ämne } A\ (i\ \text{mobil vätskefas})$$

för varje ämne kan man ange en jämviktskonstant

$$K = \frac{[A\ (mobil)]}{[A\ (stationär)]}$$

Man har valt elueringsmedel så att de ämnen som ingår i provet får olika värden på jämviktskonstanten. Därför kommer ämnena att föras framåt med olika hastighet: det ämne som har störst löslighet i den stationära vätskefasen (dvs. minst K) vandrar långsammast medan det ämne som är lösligast i den mobila vätskefasen (störst K) rör sig snabbast Ämnenas molekyler vandrar ständigt mellan den stationära fasen och den mobila fasen så att fördelningsjämvikten behålls under vandringen.

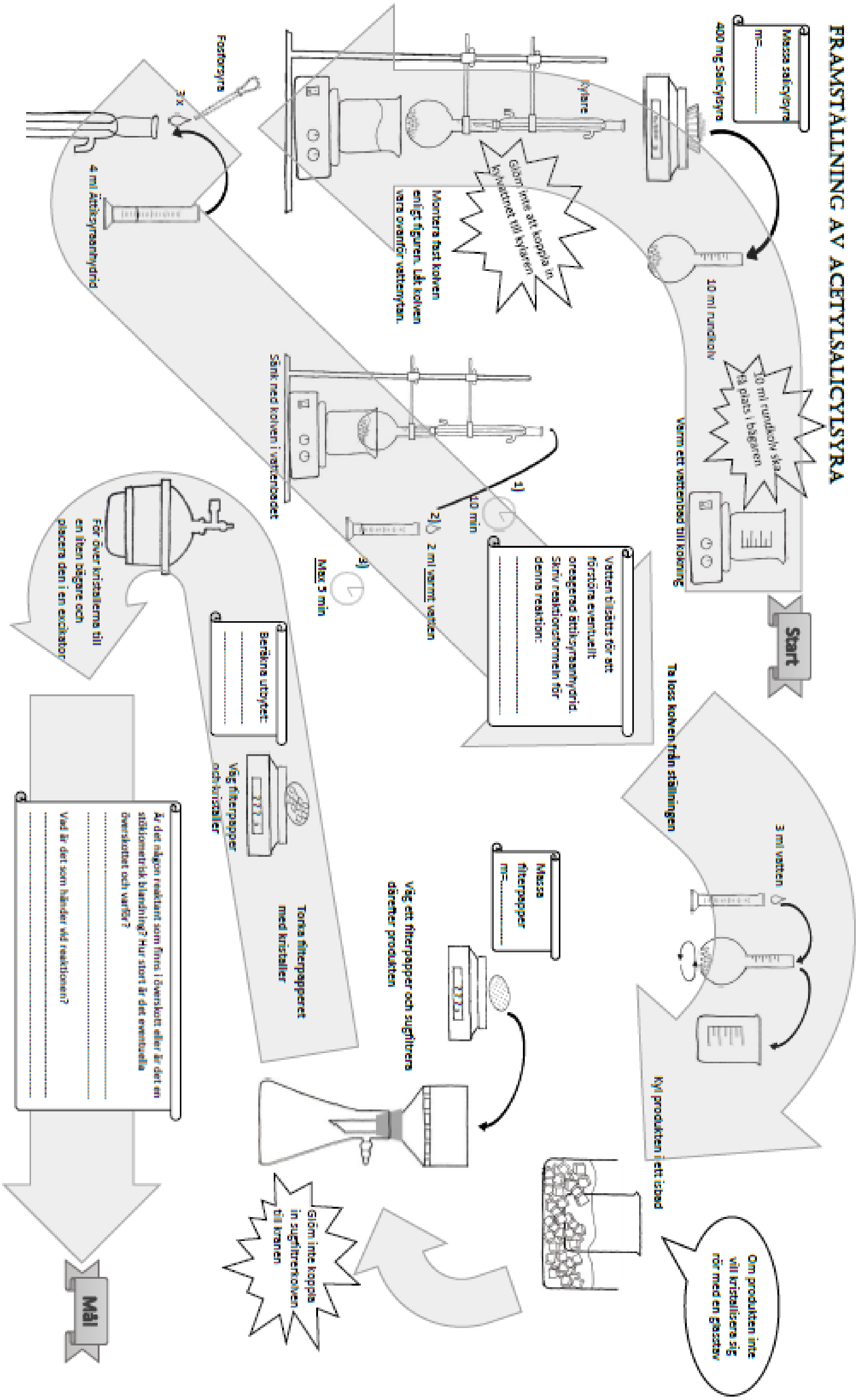
Kromatograferingen avbryts när vätskefronten närmar sig plattans övre kant. Innan man lokaliserar och identifierar de olika ämnena måste kromatogrammet torkas och ev. också framkallas med något färgreagens eller belysas med UV-ljus av lämplig våglängd. De olika ämnena kommer då att synas som färgade eller mörkare fläckar.

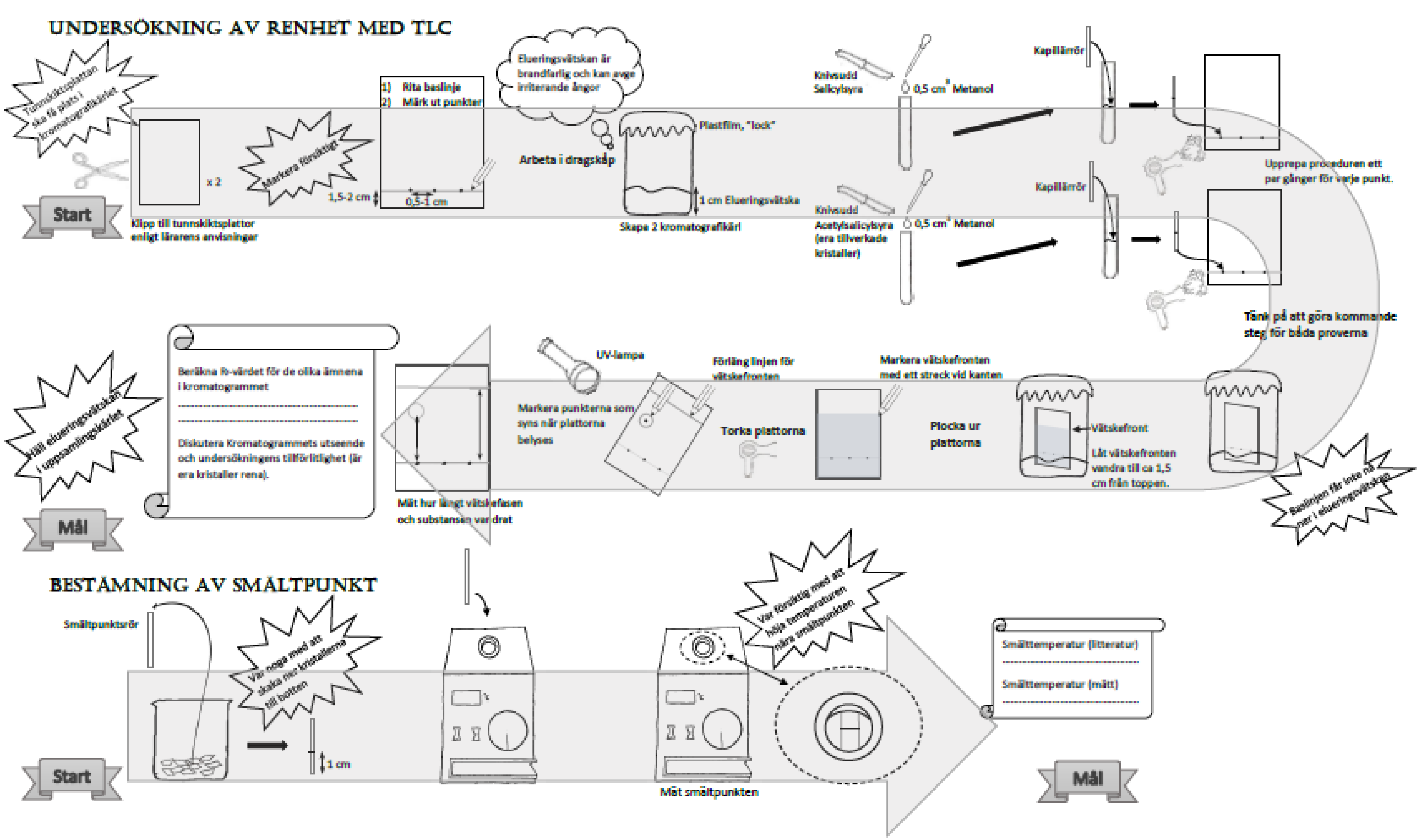
Utrustning

Små provrör (mikroskala eller liknande), 2 tunnskiktsplattor med kiselgel och fluorescerande beläggning, kromatografikärl med lock (vanna), kapillärrör (microcaps), glasstav, värmelampa eller hårtork, UV-lampa.

Kemikalier

Acetylsalicylsyra, salicylsyra, metanol, elueringsvätska (etanol och etylacetat i volymförhållande 1:9, finns färdiggjord)


FRAMSTÄLLNING AV ACETYLSALICYLSYRA
Massa salicylsyra
m=..........
400 mg Salicylsyra
10 ml rundkolv
10 ml rundkolv ska få plats i bägaren
Värm ett vattenbad till kokning
Start
Kylare
Glöm inte att koppla in kylvattnet till kylaren
Montera fast kolven enligt figuren. Låt kolven vara ovanför vattenytan.
Fosforsyra
3 x
4 ml ättiksyraanhydrid
Sänk ned kolven i vattenbadet
1)
10 min
2)
2 ml varmt vatten
3)
Max 5 min
Vatten tillsätts för att förstöra eventuellt oreagerad ättiksyraanhydrid. Skriv reaktionsformeln för denna reaktion:
Ta loss kolven från ställningen
3 ml vatten
Kyl produkten i ett isbad
Om produkten inte vill kristallisera sig rör med en glasstav
Massa filterpapper
m=..........
Väg ett filterpapper och sugfiltrera därefter produkten
Glöm inte koppla in sugfiltrerkolven till kranen
Torka filterpapperet med kristaller
Väg filterpapper och kristaller
Beräkna utbytet:
För över kristallerna till en liten bägare och placera den i en exsickator
Är det någon reaktant som finns i överskott eller är det en stökiometrisk blandning? Hur stort är det eventuella överskottet och varför?
Vad är det som händer vid reaktionen?
Mål


UNDERSÖKNING AV RENHET MED TLC
Tunnskiktsplattan ska få plats i kromatografikärlet
Start
Klipp till tunnskiktsplattor enligt lärarens anvisningar
x 2
Markera försiktigt
1,5-2 cm
1) Rita baslinje
2) Märk ut punkter
0,5-1 cm
Elueringsvätskan är brandfarlig och kan avge irriterande ångor
Arbeta i dragskåp
Plastfilm, "lock"
1 cm Elueringsvätska
Skapa 2 kromatografikärl
Knivsudd Salicylsyra
0,5 cm³ Metanol
Knivsudd Acetylsalicylsyra (era tillverkade kristaller)
0,5 cm³ Metanol
Kapillärrör
Kapillärrör
Upprepa proceduren ett par gånger för varje punkt.
Tänk på att göra kommande steg för båda proverna
Baslinjen får inte nå ner i elueringsvätskan
Vätskefront
Låt vätskefronten vandra till ca 1,5 cm från toppen.
Plocka ur plattorna
Markera vätskefronten med ett streck vid kanten
Torka plattorna
Förläng linjen för vätskefronten
UV-lampa
Markera punkterna som syns när plattorna belyses
Mät hur långt vätskefasen och substansen vandrat
Beräkna Rf-värdet för de olika ämnena i kromatogrammet
Diskutera Kromatogrammets utseende och undersökningens tillförlitlighet (är era kristaller rena).
Häll elueringsvätskan i uppsamlingskärlet
Mål
BESTÄMNING AV SMÄLTPUNKT
Smältpunktsrör
Var noga med att skaka ner kristallerna till botten
1 cm
Start
Mät smältpunkten
Var försiktig med att höja temperaturen nära smältpunkten
Smälttemperatur (litteratur)
Smälttemperatur (mätt)
Mål

Destillation

UPPGIFT Du ska undersöka brännbarheten hos 3 olika vattenlösningar av etanol med de ungefärliga halterna 15, 50 och 75 volymprocent denaturerad etanol. Sedan skall du undersöka hur halten etanol i ett rödvin ändras vid destillation.

TEORI Vid destillation förångar man en vätska genom att koka den. Därefter kondenserar man ångan genom att kyla ner den. Etanol förångas lättare än vatten. Halten av etanol är därför större i ångan än i den kokande vätskan. Destillatet utgörs av den kondenserade ångan. Även i destillatet är därför halten av etanol större än i den ursprungliga lösningen.

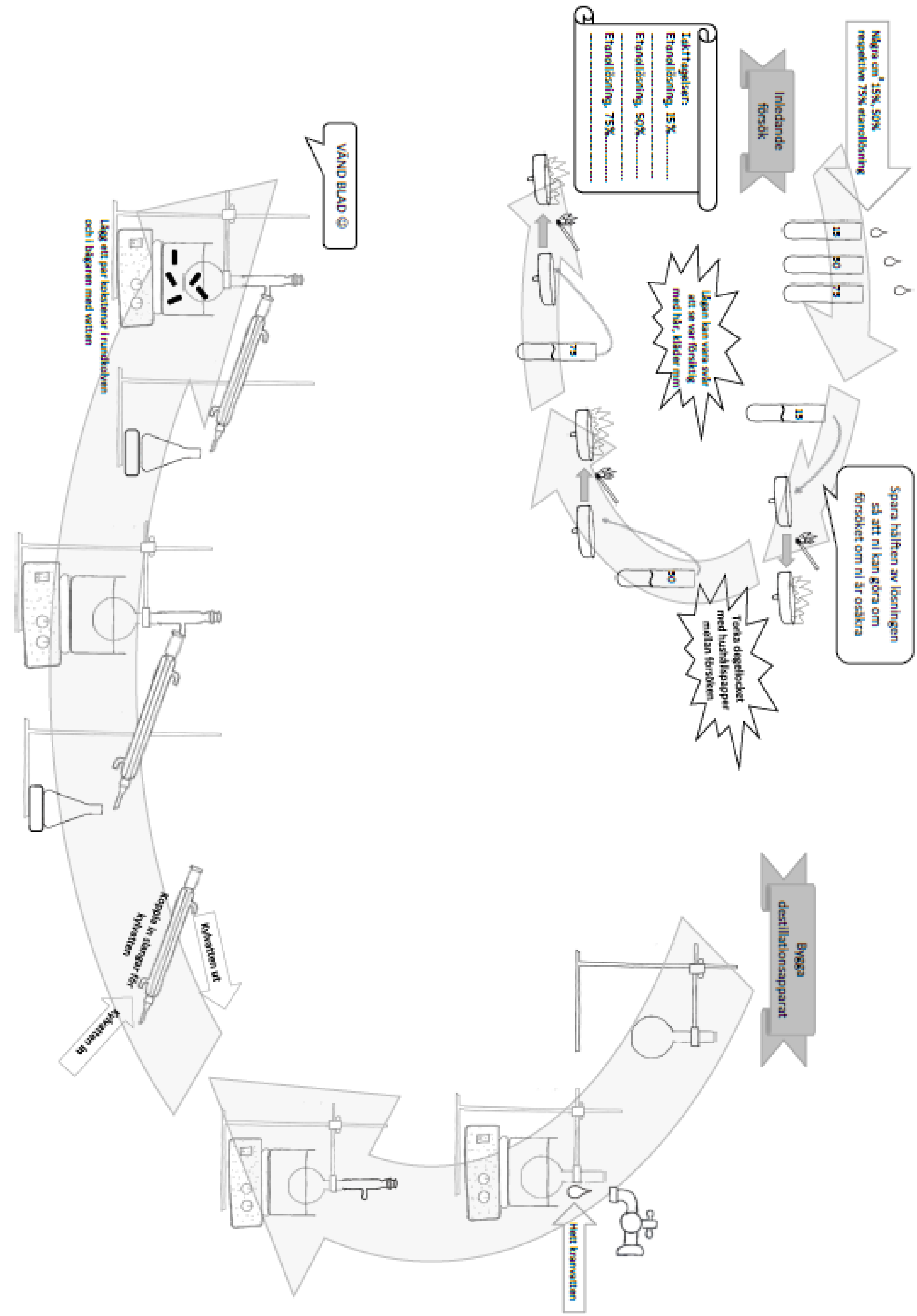
Kokpunkten för lösningen i kolven stiger, eftersom den flyktigaste beståndsdelen (etanol) lättare destillerar över och halten av vatten ökar.

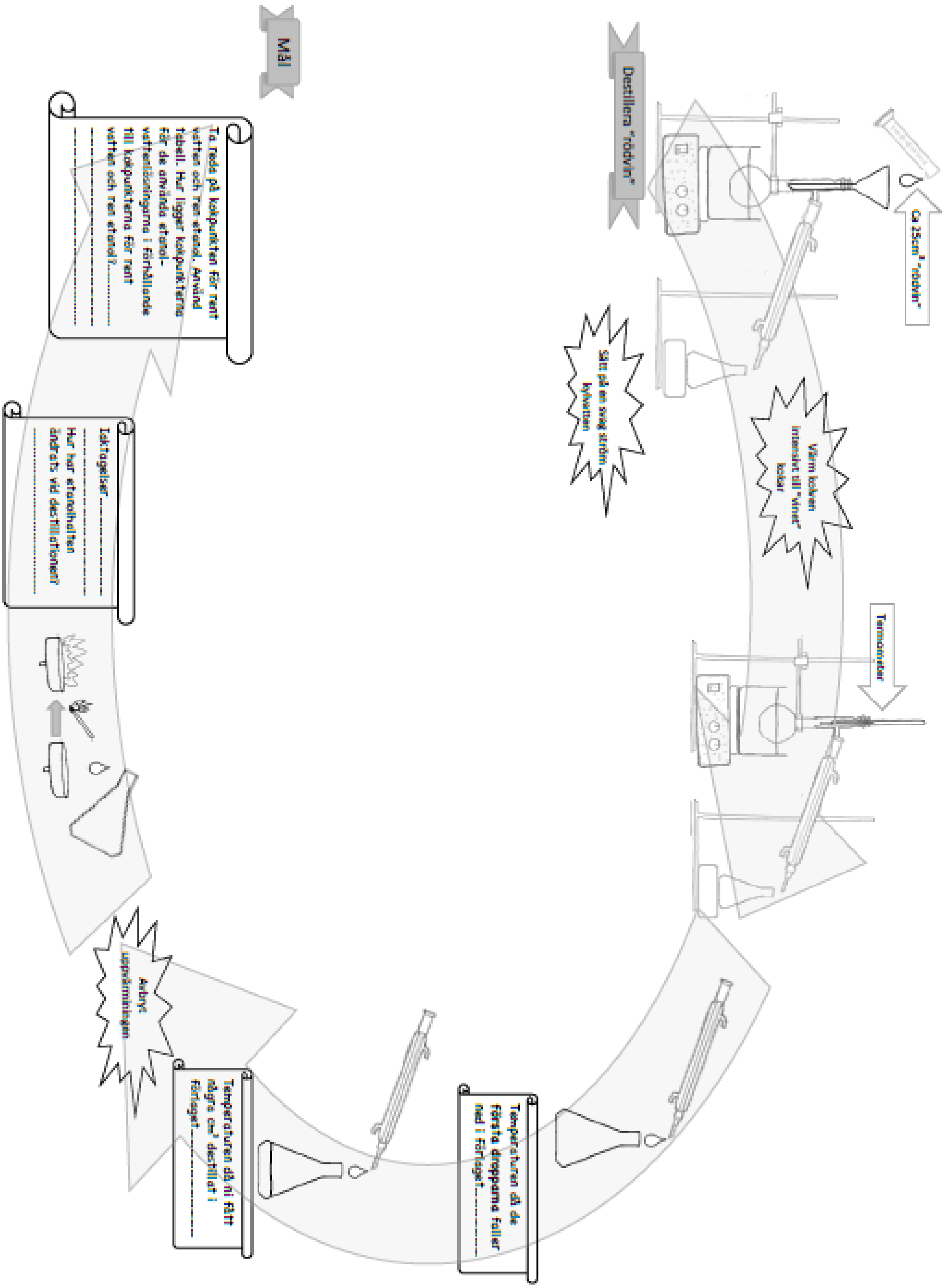
MATERIAL *GEMANSAMT MATERIAL:* 3 etanollösningar (15, 50 och 75 volymprocent), märkpennor, ”rödvin”, förhöjningsbord, 4 mätcylindrar, 4 trattar med lång pip och kokstenar.

MATERIAL FÖR VARJE LABORATIONSGRUPP: Provrörsställ med tre torra provrör, degel med lock, destillationsapparatur enligt fig., slangar och tändstickor.

RISKER Etanol är en lättantändlig vätska, lågan kan vara svår att se i starkt ljus. Iakttag försiktighet vid antändning och låt inte långt hår eller kläder befinna sig för nära. Ju högre volymprocent desto lättare antändning. Vår etanol är denaturerad och därför odrickbar. I denaturerad sprit har kräkmedel tillsatts. Lägg alltid kokstenar i glaskärl där vätskor upphettas för att undvika stötkokning. Se också till att sladden till kokplattan inte ligger an mot värmeplattan med risk för att sladden skadas.

FÖRSÖK Se separat blad.


Några cm³ 15%, 50% respektive 75% etanollösning
15
50
75
Inledande försök
Iakttagelser:
Etanollösning, 15%............
Etanollösning, 50%............
Etanollösning, 75%............
Lågan kan vara svår att se var försiktig med hår, kläder mm
Spara hälften av lösningen så att ni kan göra om försöket om ni är osäkra
Torka degellocket med hushållspapper mellan försöken
Bygga destillationsapparat
Hett kranvatten
Kylvatten ut
Koppla in slangar för kylvatten
Kylvatten in
Lägg ett par kokstenar i rundkolven och i bägaren med vatten
VÄND BLAD ☺


Mål
Destillera "rödvin"
Ca 25cm³ "rödvin"
Sätt på en svag ström kylvatten
Värm kolven intensivt till "vinet" kokar
Termometer
Temperaturen då de första dropparna faller ned i förlaget.........
Temperaturen då ni fått några cm³ destillat i förlaget.........
Avbryt uppvärmningen
Iakttagelser.........
Hur har etanolhalten ändrats vid destillationen?
Ta reda på kokpunkten för rent vatten och ren etanol. Använd tabell. Hur ligger kokpunkterna för de använda etanol-vattenblandningarna i förhållande till kokpunkterna för rent vatten och ren etanol?

Gelfiltrering

TEORI

Gelfiltrering är en kromatografisk metod att sortera partiklar i en lösning efter deras storlek. Lösningen får passera en kolonn som är packad med gelkulor. Gelen består av en kolhydratpolymer med ”nätverks-struktur” (jämför stärkelse). –Små partiklar i lösningen kan tränga in i gelkulornas porer (nätverk), och blir därmed fördröjda i sin vandring genom kolonnen. Stora partiklar passerar mer eller mindre ”utanför” gelkulorna, och kommer därför tidigare ut ur kolonnen ju större de är. –En separation efter storlek, enligt principen ”störst går först” erhålles.

I laborationen skall som ett inledande försök en blåfärgad polysackarid separeras från kaliumkromat, K_2CrO_4.
Huvudförsöket går ut på att separera kolhydrat (laktos) och protein (kasein) i lättmjölk. Laktos påvisas med ”Trommers prov”, kasein med ”Biuret-provet”. Samma reagens kan faktiskt användas i båda proven, nedan kallat ”Biuret-reagens”.

MATERIAL

Stativ med klämmare och muff, PD-10 kolonn (innehåller Sephadex G-25), 20 rena provrör i provrörsställ, 3 bägare 100cm^3, 1 bägare 250cm^3 (till vattenbad), dropp-pipett, kokrörsställ, kristallisationsskål, värmeplatta, bricka.

KEMIKALIER

Grön blandning av polysackarid och K_2CrO_4, lättmjölk (utspädd till hälften med vatten), 0,1 M NaCl-lösning, Biuretreagens, kasein, laktos (=mjölksocker). (Biuret-reagens: 0,30g $CuSO_4 \bullet 5H_2O$ + 1,2g NaK-tartrat löses i en bägare med 100 cm^3 vatten, 6,0g NaOH löses i en annan bägare med 100cm^3 vatten. Lösningarna blandas.)

RISK

Fast kaliumkromat, K_2CrO_4, är giftklassat. Den rena kaliumkromatlösning som droppar ut ur kolonnen i det inledande försöket skall hällas över i särskild uppsamlingsbägare enligt lärarens instruktion

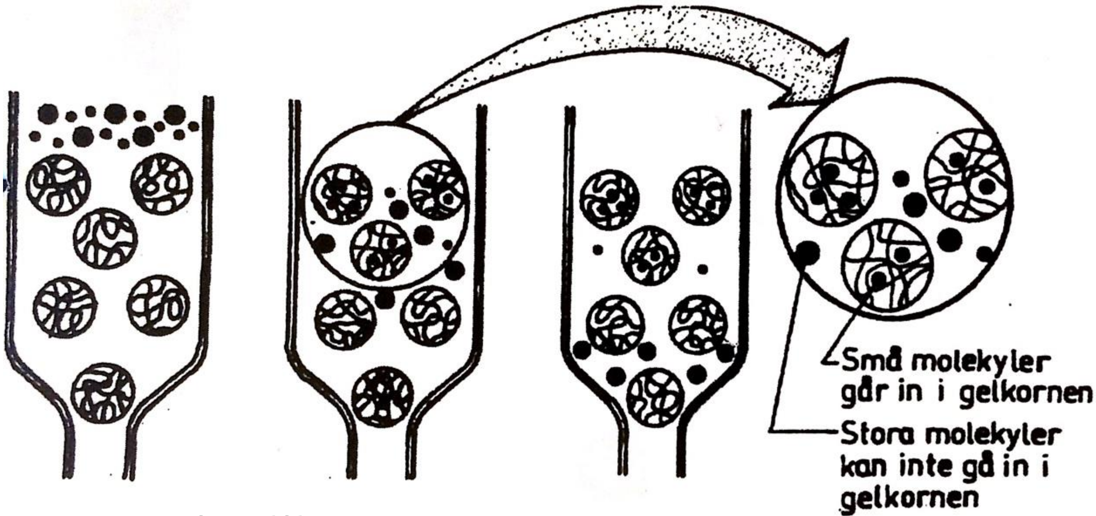
UTFÖRANDE

Se separat blad

.

Gelfiltrering (Utdrag från bok)

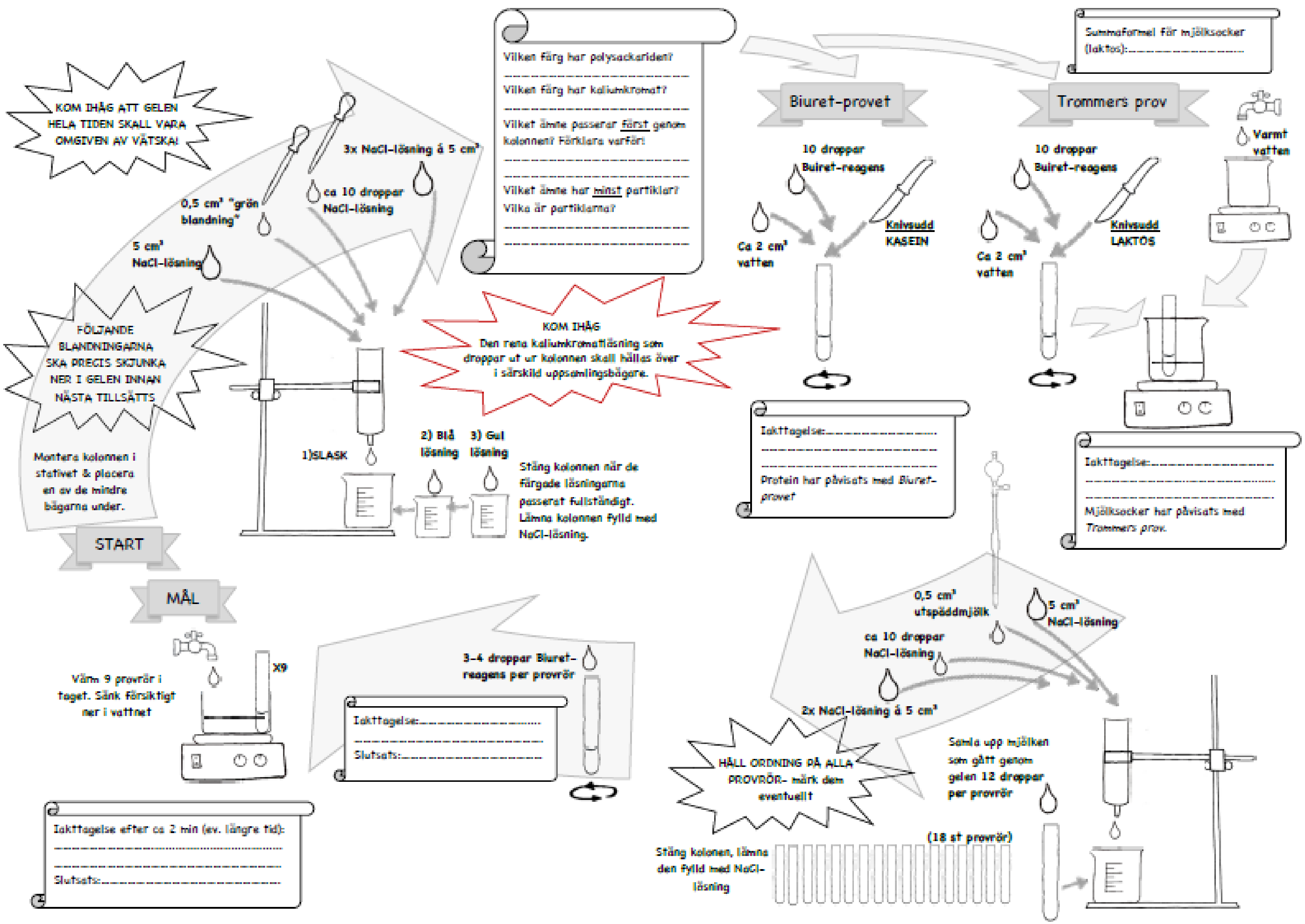
Vid gelfiltrering separeras föreningar efter storlek. I de kromatografiska metoder vi beskrivit ovan har separationen varit resultatet av en fördelning av de separerade ämnena mellan en stationär fas och en mobil fas. Vid gelfiltrering däremot förekommer inte någon interaktion (samverkan) mellan de komponenter som ska separeras och den stationära fasen. De är under hela förloppet lösta i den mobila fasen. Gelfiltrering utförs normalt i en kolonn. Den stationära fasen är uppbyggd av partiklar med väl definierad porstorlek. Man väljer porer så att de minsta molekylerna i provet kan penetrera samtliga porer medan de största inte kan ta sig igenom några porer alls. (se figur) Separationen fungerar så att om två partiklar av olika storlek appliceras på kolonnen så



Principen för gelfiltrering

kommer de stora molekylerna inte att kunna tränga in i porerna. De kommer då att röra sig med den mobila fasens hastighet mot kolonnens utlopp. Små molekyler kan diffundera in i porerna och måste sedan diffundera tillbaka för att åter transporteras av mobilfasen mot kolonnens utlopp. De stora molekylerna kommer därför ut först och de minsta molekylerna sist. Man kan likna processen med en omvänd sil. Stora partiklar slipper snabbt igenom medan mindre partiklar fastnar och tar längre tid på sig. Denna teknik utvecklades ursprungligen för makromolekyler, framför allt proteiner. Numera kan många typer av föreningar separeras och det finns kommersiella kolonner som lämpar sig för alla molekylstorlekar. Det är vanligt att man utnyttjar gelfiltrering för att avsalta proteiner. Proteiner och salterna kan separeras därför att salterna (t.ex. natriumklorid) består av små joner, medan proteiner däremot är makromolekyler. Salterna bromsas effektivt i en kolonn för gelfiltrering medan proteinerna snabbt vandrar genom kolonnen. Det svenska läkemedelsföretaget Pharmacia har varit världsledande då det gäller utveckling av teknik för gelfiltrering.

Retentionstid är en viktig faktor (parameter) även vid gelfiltrering. Egentligen är det molekylernas storlek som är av betydelse vid gelfiltrering. För ämnen som tillhör samma ämnesklass är molekylmassan proportionell mot molekylstorleken.


KOM IHÅG ATT GELEN HELA TIDEN SKALL VARA OMGIVEN AV VÄTSKA!
0,5 cm³ "grön blandning"
5 cm³ NaCl-lösning
ca 10 droppar NaCl-lösning
3x NaCl-lösning à 5 cm³
FÖLJANDE BLANDNINGARNA SKA PRECIS SKJUNKA NER I GELEN INNAN NÄSTA TILLSÄTTS
Montera kolonnen i stativet & placera en av de mindre bägarna under.
START
1)SLASK
2) Blå lösning
3) Gul lösning
Stäng kolonnen när de färgade lösningarna passerat fullständigt. Lämna kolonnen fylld med NaCl-lösning.
KOM IHÅG
Den rena kaliumkromatlösning som droppar ut ur kolonnen skall hållas över i särskild uppsamlingsbägare.
Vilken färg har polysackariden?
Vilken färg har kaliumkromat?
Vilket ämne passerar först genom kolonnen? Förklara varför!
Vilket ämne har minst partiklar?
Vilka är partiklarna?
Biuret-provet
10 droppar Buiret-reagens
Ca 2 cm³ vatten
Knivsudd KASEIN
Iakttagelse:
Protein har påvisats med Biuret-provet
Trommers prov
10 droppar Buiret-reagens
Ca 2 cm³ vatten
Knivsudd LAKTOS
Summaformel för mjölksocker (laktos):
Varmt vatten
Iakttagelse:
Mjölksocker har påvisats med Trommers prov.
MÅL
Värm 9 provrör i taget. Sänk försiktigt ner i vattnet
X9
Iakttagelse efter ca 2 min (ev. längre tid):
Slutsats:
3-4 droppar Biuret-reagens per provrör
Iakttagelse:
Slutsats:
0,5 cm³ utspäddmjölk
5 cm³ NaCl-lösning
ca 10 droppar NaCl-lösning
2x NaCl-lösning à 5 cm³
HÅLL ORDNING PÅ ALLA PROVRÖR- märk dem eventuellt
Samla upp mjölken som gått genom gelen 12 droppar per provrör
(18 st provrör)
Stäng kolonen, lämna den fylld med NaCl-lösning

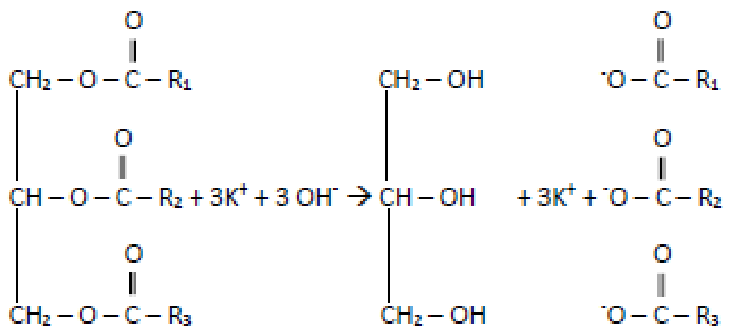
Matolja

UPPGIFT Att bestämma medelmolmassan för ett fett.

TEORI Ett fett är en blandning av olika fettmolekyler som har det gemensamt, att de är estrar av den trevärda alkoholen glycerol (1,2,3-propantriol), $CH_2 - CH_2 - CH_2$.
OH OH OH

Alkoholens tre hydroxidgrupper har förestrats med tre (vanligtvis olika) karboxylsyror. Ett naturligt fett kan innehålla ett stort antal olika karboxylsyror bundna till glycerol. Vi bestämning av molmassan får man därför ett medelvärde för de förekommande fettmolekylerna.

Vid förtvålning (= alkalisk esterhydrolys) sönderdelas fettet med hjälp av hydroxidjoner enligt:



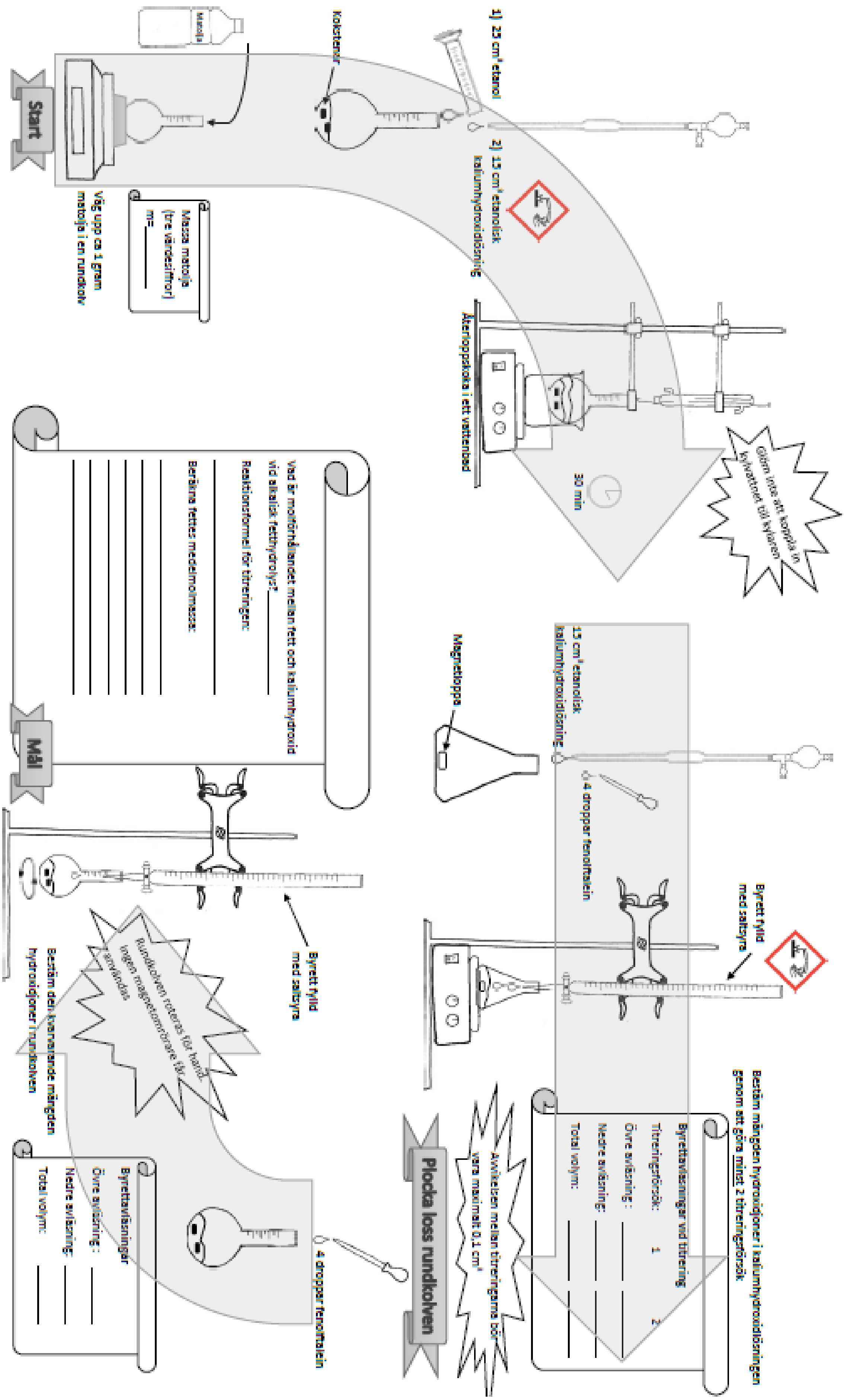
fett + kaliumhydroxid → glycerol + kaliumsalter

MATERIEL *Gemensamma kemikalier och materiel:*
Matolja (i droppflaska), etanolisk kaliumhydroxidlösning (ung. 0,5 M), etanol, mätglas (50 cm^3), 0,250 M saltsyra, fenolftalein, kokstenar, pipett (15 cm^3)

Egen materiel:
Rundkolv (100 cm^3), korkring, kylare, 2 slangar, bägare till vattenbad, värmeplatta, 2 st stativ, 2 st klämmare, 2 st muffar, byrett, tratt för byrettfyllning, byretthållare, slaskbägare, 2 st e-kolvar (100-150 cm^3), sprutflaska, magnetomrörare med loppa

RISKER Kaliumhydroxidlösningen är starkt frätande. Skydda ögon, hud och kläder. Även saltsyran är frätande. Torka upp stänk med fuktigt papper vid spill.

UTFÖRANDE Se separat blad


Start
Matolja
Väg upp ca 1 gram matolja i en rundkolv
Massa matolja (tre värdesiffror) m=________
Kokstenar
1) 25 cm³ etanol
2) 15 cm³ etanolisk kaliumhydroxidlösning
Återloppskoka i ett vattenbad
30 min
Glöm inte att koppla in kylvattnet till kylaren
15 cm³ etanolisk kaliumhydroxidlösning
Magnetloppa
4 droppar fenolftalein
Byrett fylld med saltsyra
Bestäm mängden hydroxidjoner i kaliumhydroxidlösningen genom att göra minst 2 titreringsförsök
Byrettavläsningar vid titrering
Titreringsförsök: 1 2
Övre avläsning : ________ ________
Nedre avläsning: ________ ________
Total volym: ________ ________
Avvikelsen mellan titreringarna bör vara maximalt 0,1 cm³
Plocka loss rundkolven
4 droppar fenolftalein
Byrettavläsningar
Övre avläsning : ________
Nedre avläsning: ________
Total volym: ________
Rundkolven roteras för hand. Ingen magnetomrörare får användas
Bestäm den kvarvarande mängden hydroxidjoner i rundkolven
Byrett fylld med saltsyra
Vad är molförhållandet mellan fett och kaliumhydroxid vid alkalisk fetthydrolys?________
Reaktionsformel för titreringen:
Beräkna fettes medelmolmassa:
Mål

PROPEN- FRAMSTÄLLNING, FÖRBRÄNNING OCH ADDITION

TEORI: Alkener är kolväten med dubbelbindning i molekylen. Skriv namn och strukturformel för de två enklaste alkenerna:

Om man leder propanolånga över upphettad aluminiumoxid, Al_2O_3, Bildas propen enligt reaktionsformeln:

$C_3H_7OH(g) \rightarrow C_3H_6(g) + H_2O(g)$

Skriv reaktionsformeln med tydliga strukturformler:

Reaktionen sker snabbt när propanolångan kommer i kontakt med fast aluminiumoxid, men oxiden förbrukas inte. Vad kallas ett ämne som påskyndar en reaktion utan att själv förbrukas?

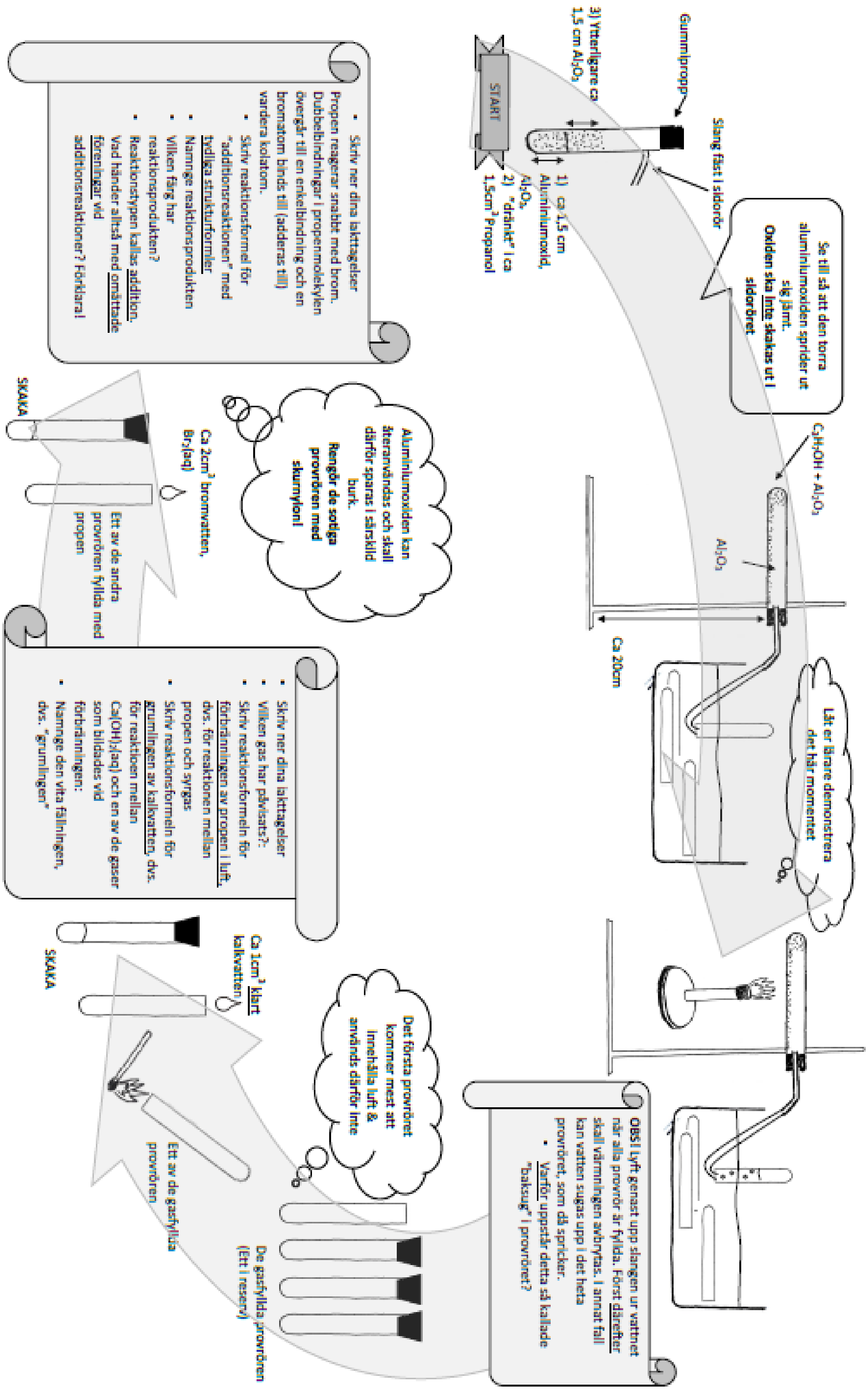
Propen är en gas som samlas upp över vatten.

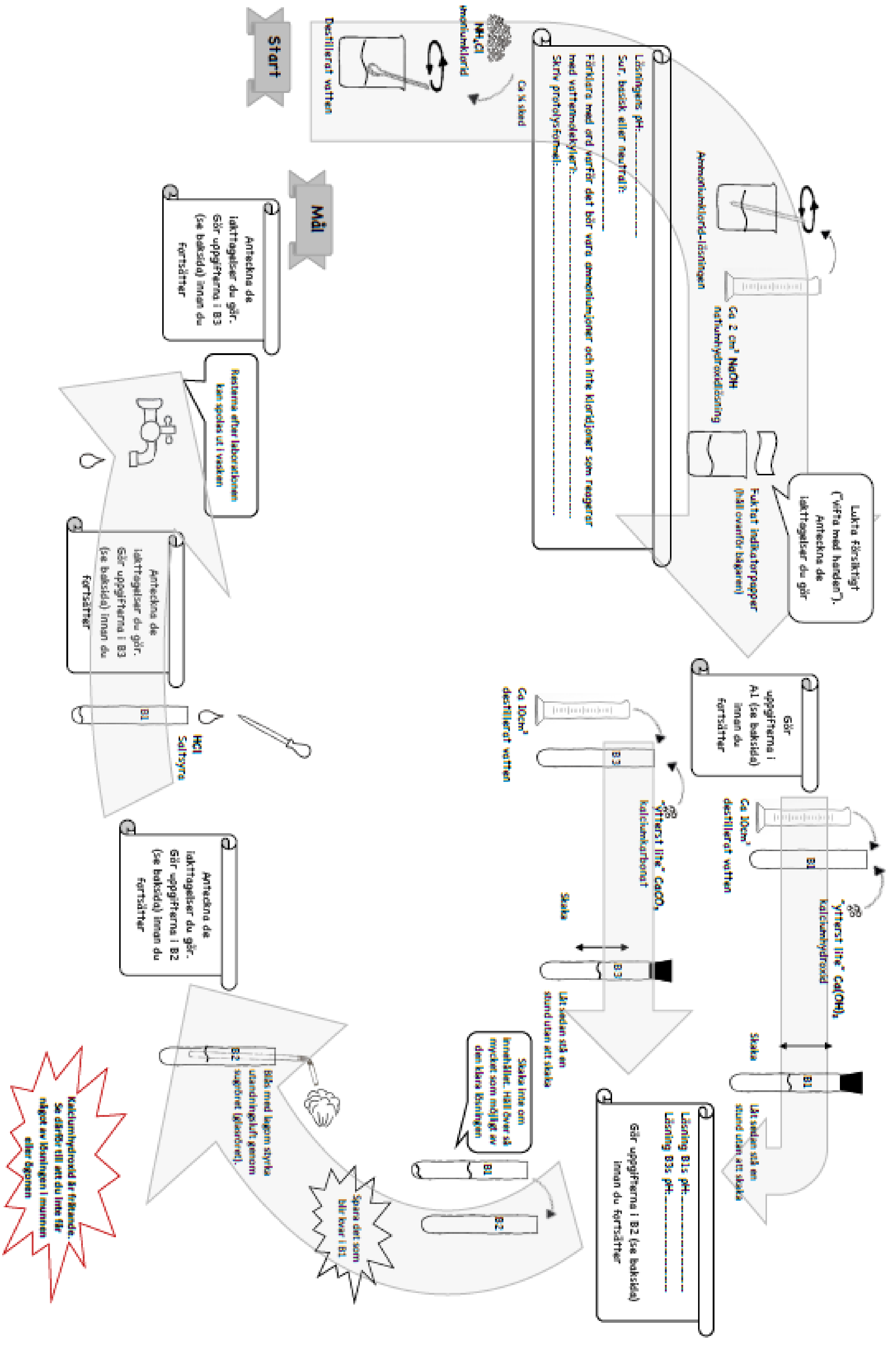
MATERIAL: 1 provrör med sidorör, passande gummipropp och gummislang ca 30 cm, stativ, klämmare, muff, brännare, stor kristallisationsskål eller plastlåda, provrörsställ med minst 4 provrör, 3 passande gummiproppar

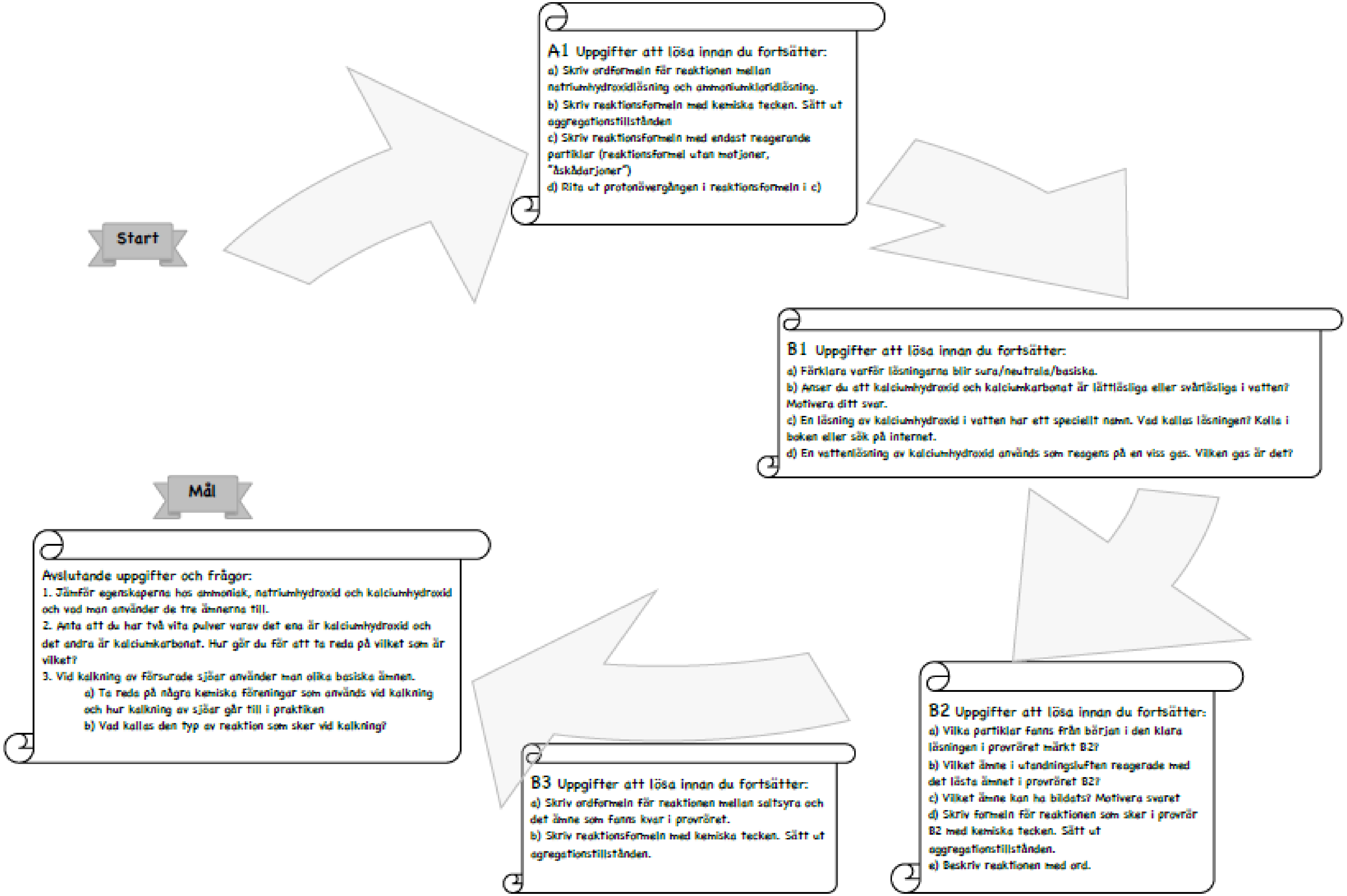
KEMIKALIER: Aluminiumoxid, 1-propanol, mättad kalciumhydroxidlösning (=kalkvatten), bromvatten.

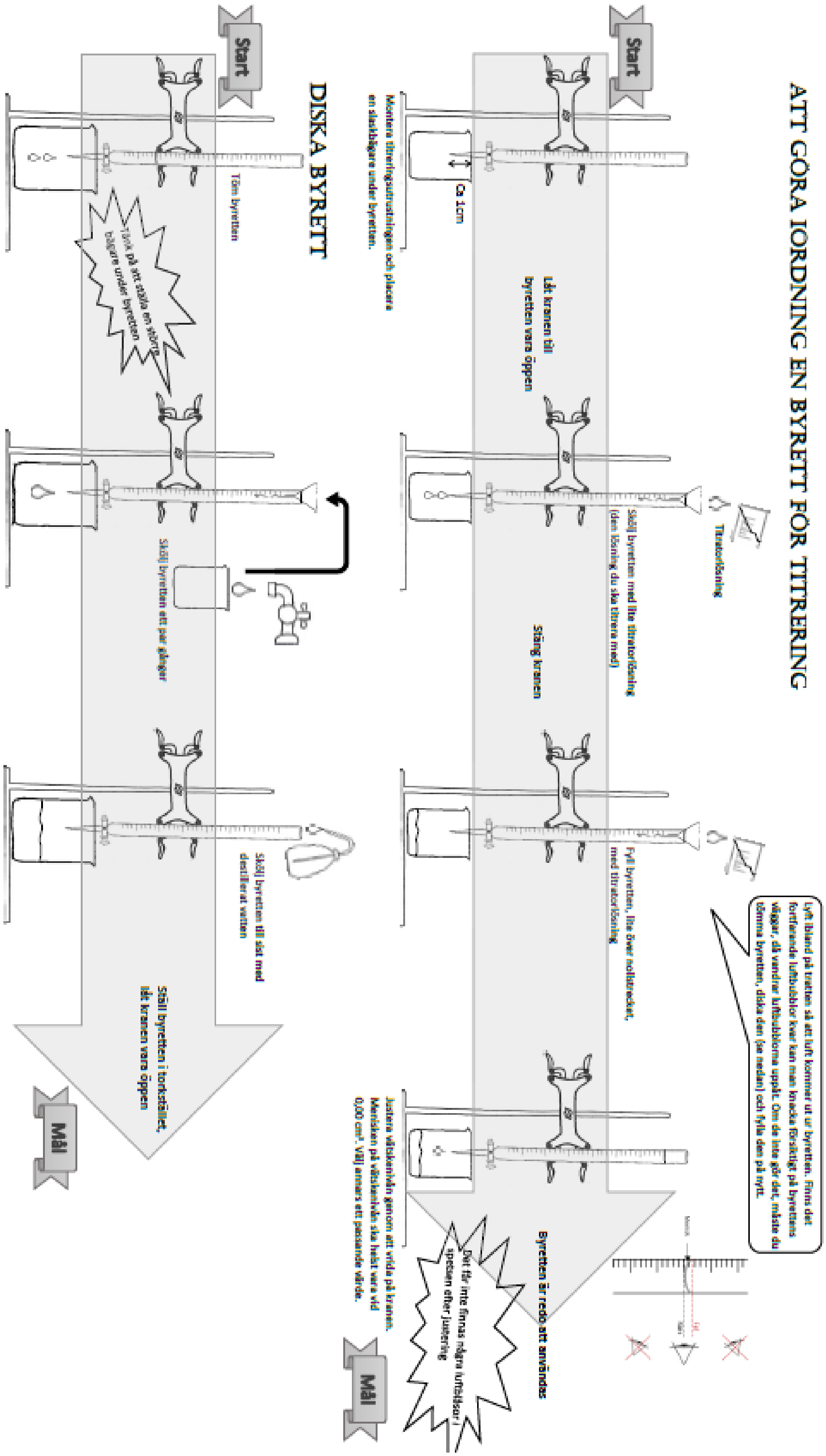
RISKER: Akta långt hår för lågan både när du använder brännaren och när du senare antänder den bildade gasen i provröret!
Förhindra ”baksug” i provröret (se nedan)!
Låt inte bromvatten komma i kontakt med huden. (Rent brom är synnerligen starkt frätande.)
Propen luktar obehagligt. Utför om möjligt försöket i dragskåpet och ”töm” all överbliven gas i dragskåpet!!

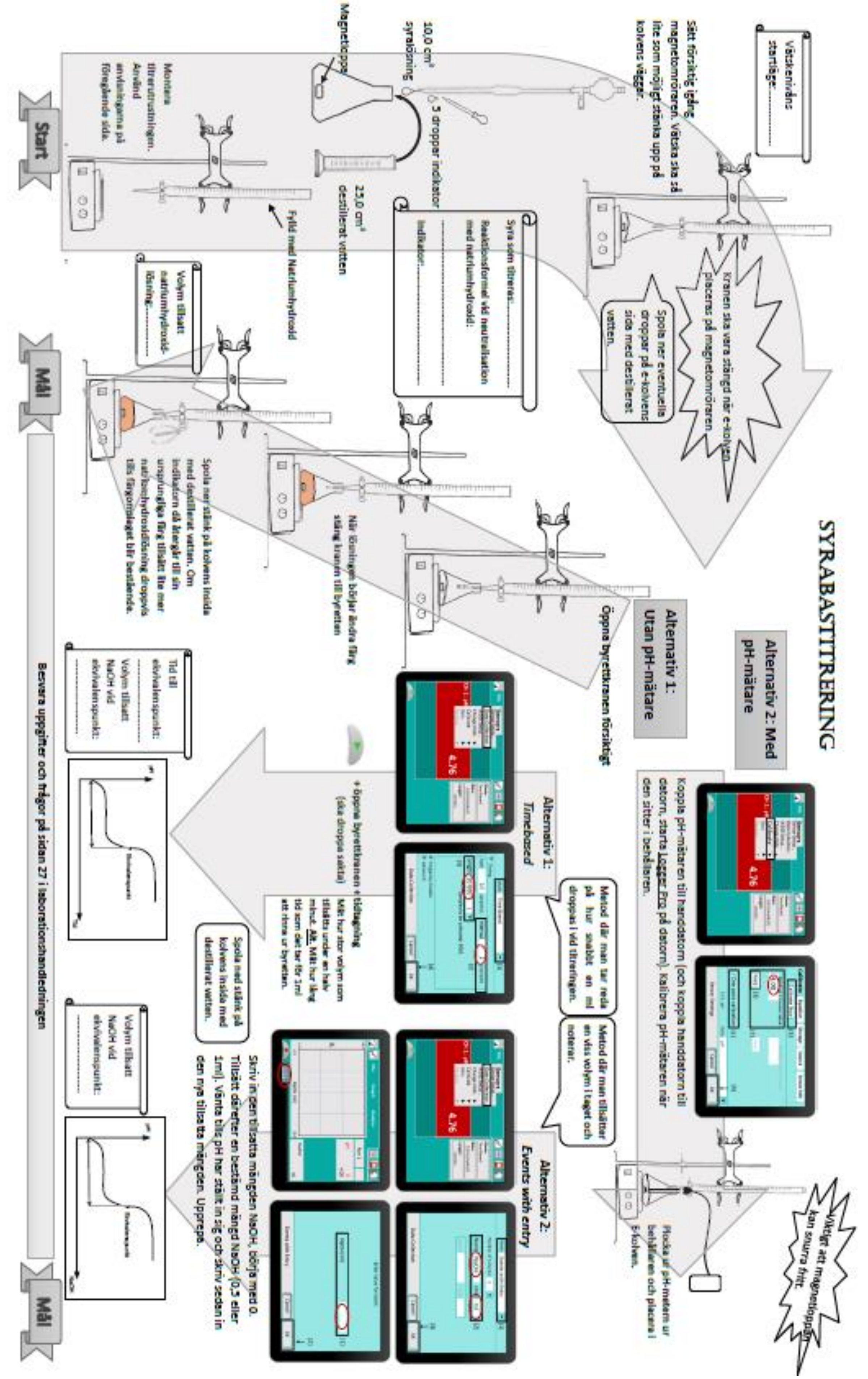
Utförande: Se separat blad


START
Gummipropp
Slang fäst i sidorör
3) Ytterligare ca 1,5 cm Al_2O_3
1) ca 1,5 cm Aluminiumoxid, Al_2O_3,
2) "dränkt" i ca $1{,}5 cm^3$ Propanol
Se till så att den torra aluminiumoxiden sprider ut sig jämt. Oxiden ska inte skakas ut i sidoröret
$C_3H_7OH + Al_2O_3$
Al_2O_3
Ca 20cm
Låt er lärare demonstrera det här momentet
OBS! Lyft genast upp slangen ur vattnet när alla provrör är fyllda. Först därefter skall värmningen avbrytas. I annat fall kan vatten sugas upp i det heta provröret, som då spricker.
Varför uppstår detta så kallade "baksug" i provröret?
Det första provröret kommer mest att innehålla luft & används därför inte
De gasfyllda provrören (Ett i reserv)
Ett av de gasfyllda provrören
Ca $1 cm^3$ klart kalkvatten
SKAKA
Skriv ner dina iakttagelser
Vilken gas har påvisats?:
Skriv reaktionsformeln för förbränningen av propen i luft, dvs. för reaktionen mellan propen och syrgas
Skriv reaktionsformeln för grumlingen av kalkvatten, dvs. för reaktioen mellan $Ca(OH)_2(aq)$ och en av de gaser som bildades vid förbränningen:
Namnge den vita fällningen, dvs. "grumlingen"
Ett av de andra provrören fyllda med propen
Ca $2 cm^3$ bromvatten, $Br_2(aq)$
SKAKA
Aluminiumoxiden kan återanvändas och skall därför sparas i särskild burk. Rengör de sotiga provrören med skurnylon!
Skriv ner dina iakttagelser
Propen reagerar snabbt med brom. Dubbelbindningar i propenmolekylen övergår till en enkelbindning och en bromatom binds till (adderas till) vardera kolatom.
Skriv reaktionsformel för "additionsreaktionen" med tydliga strukturformler
Namnge reaktionsprodukten
Vilken färg har reaktionsprodukten?
Reaktionstypen kallas addition. Vad händer alltså med omättade föreningar vid additionsreaktioner? Förklara!


Start
Destillerat vatten
NH_4Cl
Ca ½ sked
Ammoniumklorid-lösningen
Ca 2 cm³ NaOH
natiumhydroxidlösning
Fuktat indikatorpapper
(håll ovanför bägaren)
Lukta försiktigt ("vifta med handen"). Anteckna de iakttagelser du gör
Lösningens pH:……………
Sur, basisk eller neutral?:
……………
Förklara med ord varför det bör vara ammoniumjoner och inte kloridjoner som reagerar med vattenmolekyler?:……………
Skriv protolysformel:……………
Gör uppgifterna i A1 (se baksida) innan du fortsätter
Ca 10cm³ destillerat vatten
B1
"ytterst lite" $Ca(OH)_2$
Kalciumhydroxid
Skaka
Låt sedan stå en stund utan att skaka
B3
"ytterst lite" $CaCO_3$
Kalciumkarbonat
Lösning B1s pH:……………
Lösning B3s pH:……………
Gör uppgifterna i B2 (se baksida) innan du fortsätter
Skaka inte om innehållet. Häll över så mycket som möjligt av den klara lösningen
B2
Spara det som blir kvar i B1
Blås med lagom styrka utandningsluft genom sugröret (glasröret).
Kalciumhydroxid är frätande. Se därför till att du inte får något av lösningen i munnen eller ögonen
Anteckna de iakttagelser du gör. Gör uppgifterna i B2 (se baksida) innan du fortsätter
HCl
Saltsyra
Anteckna de iakttagelser du gör. Gör uppgifterna i B3 (se baksida) innan du fortsätter
Resterna efter laborationen kan spolas ut i vasken
Mål
Anteckna de iakttagelser du gör. Gör uppgifterna i B3 (se baksida) innan du fortsätter


Start
A1 Uppgifter att lösa innan du fortsätter:
a) Skriv ordformeln för reaktionen mellan natriumhydroxidlösning och ammoniumkloridlösning.
b) Skriv reaktionsformeln med kemiska tecken. Sätt ut aggregationstillstånden
c) Skriv reaktionsformeln med endast reagerande partiklar (reaktionsformel utan motjoner, "åskådarjoner")
d) Rita ut protonövergången i reaktionsformeln i c)
B1 Uppgifter att lösa innan du fortsätter:
a) Förklara varför lösningarna blir sura/neutrala/basiska.
b) Anser du att kalciumhydroxid och kalciumkarbonat är lättlösliga eller svårlösliga i vatten? Motivera ditt svar.
c) En lösning av kalciumhydroxid i vatten har ett speciellt namn. Vad kallas lösningen? Kolla i boken eller sök på internet.
d) En vattenlösning av kalciumhydroxid används som reagens på en viss gas. Vilken gas är det?
B2 Uppgifter att lösa innan du fortsätter:
a) Vilka partiklar fanns från början i den klara lösningen i provröret märkt B2?
b) Vilket ämne i utandningsluften reagerade med det lösta ämnet i provröret B2?
c) Vilket ämne kan ha bildats? Motivera svaret
d) Skriv formeln för reaktionen som sker i provrör B2 med kemiska tecken. Sätt ut aggregationstillstånden.
e) Beskriv reaktionen med ord.
B3 Uppgifter att lösa innan du fortsätter:
a) Skriv ordformeln för reaktionen mellan saltsyra och det ämne som fanns kvar i provröret.
b) Skriv reaktionsformeln med kemiska tecken. Sätt ut agregationstillstånden.
Mål
Avslutande uppgifter och frågor:
1. Jämför egenskaperna hos ammoniak, natriumhydroxid och kalciumhydroxid och vad man använder de tre ämnerna till.
2. Anta att du har två vita pulver varav det ena är kalciumhydroxid och det andra är kalciumkarbonat. Hur gör du för att ta reda på vilket som är vilket?
3. Vid kalkning av försurade sjöar använder man olika basiska ämnen.
a) Ta reda på några kemiska föreningar som används vid kalkning och hur kalkning av sjöar går till i praktiken
b) Vad kallas den typ av reaktion som sker vid kalkning?


ATT GÖRA IORDNING EN BYRETT FÖR TITRERING
Start
Mål
DISKA BYRETT
Start
Mål


SYRABASTITRERING
Alternativ 2: Med pH-mätare
Alternativ 1: Utan pH-mätare
Start
Mål
Mål
Vätskenivåns startläge:
Sätt försiktigt igång magnetomröraren. Vätska ska så lite som möjligt stänka upp på kolvens väggar.
10,0 cm³ syralösning
Magnetloppa
3 droppar indikator
25,0 cm³ destillerat vatten
Fyll med Natriumhydroxid
Montera titrerutrustningen. Använd anvisningarna på föregående sida.
Syra som titreras:
Reaktionsformel vid neutralisation med natriumhydroxid:
Indikator:
Kranen ska vara stängd när e-kolven placeras på magnetomröraren.
Spola ner eventuella droppar på e-kolvens sida med destillerat vatten.
Volym tillsatt natriumhydroxid-lösning:
Öppna byrettkranen försiktigt
När lösningen börjar ändra färg stäng kranen till byretten
Alternativ 1: Timebased
Alternativ 2: Events with entry
Tid till ekvivalenspunkt:
Volym tillsatt NaOH vid ekvivalenspunkt:
Besvara uppgifter och frågor på sidan 27 i laborationshandledningen
Viktigt att magnetloppan kan snurra fritt.

Appendix B

Kunskapskrav

Betyget E

Eleven redogör **översiktligt** för innebörden av begrepp, modeller, teorier och arbetsmetoder från vart och ett av kursens olika områden. Eleven använder dessa **med viss säkerhet** för att söka svar på frågor samt för att beskriva och **exemplifiera** kemiska förlopp och företeelser. Utifrån **något** exempel redogör eleven **översiktligt** för hur kemins modeller och teorier utvecklas. Eleven värderar också modellers och teoriers giltighet och begränsningar med **enkla** omdömen.

Eleven analyserar och söker svar på **enkla** frågor i **bekanta situationer** med **tillfredsställande** resultat. Detta gäller såväl i det teoretiska som i det praktiska arbetet. I arbetet formulerar eleven relevanta hypoteser och formulerar **med viss säkerhet enkla** egna frågor. Eleven planerar och genomför **i samråd** med handledare experiment och observationer på ett tillfredsställande sätt. Dessutom hanterar eleven kemikalier och utrustning på ett säkert sätt. Vidare tolkar eleven sina resultat, utvärderar sina metoder med **enkla** omdömen och motiverar sina slutsatser med **enkla** resonemang.

Eleven diskuterar **översiktligt** frågor som rör kemins betydelse för individ och samhälle. I diskussionerna för eleven fram **enkla** argument och redogör **översiktligt** för konsekvenser av **något** tänkbart ställningstagande.

Eleven använder **med viss säkerhet** ett naturvetenskapligt språk och anpassar **till viss del** sin kommunikation till syfte och sammanhang. Dessutom använder eleven olika typer av källor och gör **enkla** bedömningar av informationens och källornas trovärdighet och relevans.

När eleven samråder med handledare bedömer hon eller han **med viss säkerhet** den egna förmågan och situationens krav.

Betyget D

Betyget D innebär att kunskapskraven för E och till övervägande del för C är uppfyllda.

Betyget C

Eleven redogör **utförligt** för innebörden av begrepp, modeller, teorier och arbetsmetoder från vart och ett av kursens olika områden. Eleven använder dessa **med viss säkerhet** för att söka svar på frågor samt för att beskriva och **exemplifiera** kemiska förlopp och företeelser. Utifrån **några** exempel redogör eleven **utförligt** för hur kemins modeller och teorier utvecklas. Eleven värderar också modellers och teoriers giltighet och begränsningar med **enkla** omdömen.

Eleven analyserar och söker svar på **komplexa** frågor i **bekanta situationer** med **tillfredsställande** resultat. Detta gäller såväl i det teoretiska som i det praktiska arbetet. I arbetet formulerar eleven relevanta hypoteser och formulerar **med viss säkerhet** egna frågor. Eleven planerar och genomför **efter samråd** med handledare experiment och observationer på ett tillfredsställande sätt. Dessutom hanterar eleven kemikalier och utrustning på ett säkert sätt.

Vidare tolkar eleven sina resultat, utvärderar sina metoder med **enkla** omdömen och motiverar sina slutsatser med **välgrundade** resonemang.

Eleven diskuterar **utförligt** frågor som rör kemins betydelse för individ och samhälle. I diskussionerna för eleven fram **välgrundade** argument och redogör **utförligt** för konsekvenser av **något** tänkbart ställningstagande.

Eleven använder **med viss säkerhet** ett naturvetenskapligt språk och anpassar **till stor del** sin kommunikation till syfte och sammanhang. Dessutom använder eleven olika typer av källor och gör **välgrundade** bedömningar av informationens och källornas trovärdighet och relevans.

När eleven samråder med handledare bedömer hon eller han **med viss säkerhet** den egna förmågan och situationens krav.

Betyget B

Betyget B innebär att kunskapskraven för C och till övervägande del för A är uppfyllda.

Betyget A

Eleven redogör **utförligt och nyanserat** för innebörden av begrepp, modeller, teorier och arbetsmetoder från vart och ett av kursens olika områden. Eleven använder dessa **med säkerhet** för att söka svar på frågor samt för att beskriva och **generalisera kring** kemiska förlopp och företeelser. Utifrån **några** exempel redogör eleven **utförligt och nyanserat** för hur kemins modeller och teorier utvecklas. Eleven värderar också modellers och teoriers giltighet och begränsningar med **nyanserade** omdömen.

Eleven analyserar och söker svar på **komplexa** frågor i **bekanta och nya situationer** med **gott** resultat. Detta gäller såväl i det teoretiska som i det praktiska arbetet. I arbetet formulerar eleven relevanta hypoteser och formulerar **med säkerhet komplexa** egna frågor. Eleven planerar och genomför **efter samråd** med handledare experiment och observationer på ett tillfredsställande sätt. Dessutom hanterar eleven kemikalier och utrustning på ett säkert sätt. Vidare tolkar eleven sina resultat, utvärderar sina metoder med **nyanserade** omdömen och motiverar sina slutsatser med **välgrundade och nyanserade** resonemang. **Vid behov föreslår eleven också förändringar**.

Eleven diskuterar **utförligt och nyanserat komplexa** frågor som rör kemins betydelse för individ och samhälle. I diskussionerna för eleven fram **välgrundade och nyanserade** argument och redogör **utförligt och nyanserat** för konsekvenser av **flera** tänkbara ställningstaganden. **Eleven föreslår också nya frågeställningar att diskutera**.

Eleven använder **med säkerhet** ett naturvetenskapligt språk och anpassar **till stor del** sin kommunikation till syfte och sammanhang. Dessutom använder eleven olika typer av källor och gör **välgrundade och nyanserade** bedömningar av informationens och källornas trovärdighet och relevans.

När eleven samråder med handledare bedömer hon eller han **med säkerhet** den egna förmågan och situationens krav.

Appendix C

Support for the class observations (in Swedish)

Här följer exempel på frågor som kan användas som stöd under observationerna av helklass. Frågorna är uppdelade på de fyra olika fokusområdena som valts ut i projektet.

Tid

- Verkar eleverna stressade eller jäktade?
  - Hur uttrycks detta?

Utmaningar

- Uppstår konflikter?
  - Hur uppstår de? Hur hanteras de?
- Bildas gruppidentitet/Team känsla i labbparen?
  - Hur uttrycks detta? (förekommer till exempel uttryck som "vi är bäst/snabbast/vi får bäst resultat?)
  - Går det att se några följder på det beteendet i form av reaktioner från övriga klasskamrater?
- Uttrycks känslor som frustration eller upprymdhet?
  - På vilket sätt?
  - Går det att se några följder i form av reaktioner från andra klasskamrater?

Angreppssätt till arbetet

- I vilken ordning utförs momenten?
  - Utförs de endast i den ordning de står i laborationshandledningen eller görs det anpassningar när tillexempel utrustningen är upptagen?
- Hur utnyttjas pauser som uppstår?
  - Tittar elever tillexempel på vad andra gör eller utför de uträkningar, läser eller tittar i laborationshandledningen eller i läroboken?
  - Diskuterar de laborationen, annat skolrelaterat eller icke skolrelaterat?
- Hur delar eleverna upp arbetet mellan sig?
  - Verkar någon i paren ha ansvar för att läsa/tolka laborationshandledningen?
  - Verkar paren turas om med att utföra olika moment?

Diskussioner

- Vilken typ av frågor ställer eleverna till läraren?
  - Finns frågor kring syftet eller målet med laborationen?
  - Är dessa kring vad som ska göras i termer av vilken utrustning eller kemikalier som ska användas, eller kring begrepp och teorier som man gått igenom under tidigare lektioner?

Kommer eleverna med nya frågeställningar eller hypoteser till läraren?

Appendix D

Support for the interviews (in Swedish)

Nedan följer exempel på frågor som kan ställas i par-intervjuerna uppdelade i projektets fyra fokusområden.

Utmaningar

- Var det svårt att förstå laborationshandledningen?
- Var det något som ni uppfattade som problematiskt eller som en utmaning under laborationen?

Tid

- Hur upplevde ni tidstillgången till laborationen?
    - Var det för lite tid eller kanske gott om tid?
- Hur brukar ni uppleva att tidstillgången till laborationerna brukar vara?
    - Skiljde sig detta?
    - Hur tror ni det kommer sig?
- Vad upplever ni att ni la som mest tid på, under laborationen?
    - Hur kommer det sig att ni la tid på det?
    - Skiljer det sig från vad ni brukar lägga tid på?

Angreppssätt till arbetet

- Var det lätt/svårt att få grepp om vad som skulle göras på laborationen, bilda sig en helhetsbild av laborationen och förstå vad syftet eller målet med laborationen var?
    - Hur gjorde ni för att bilda er en uppfattning om vad som skulle göras?
    - Skiljde det sig ifrån hur ni brukar göra för att bilda er en uppfattning av vad som ska göras under laborationstillfället?
    - Var ni hela tiden säkra på vad som skulle göras och vad som var nästa steg?
- Hur delade ni upp arbetet mellan er?
    - Vad fick er att dela upp arbetet på just det sättet?
    - Diskuterade ni vem som skulle göra vad?
- Hur brukar arbetet vara uppdelat under laborationerna?

Diskussion

- Hur mycket diskuterade ni under laborationen?
- Hur mycket brukar ni diskutera?
- Om vad diskuterade ni?
- Vad var det som fick er att börja diskutera?
    - Hur kom det sig att det var just detta ni diskuterade?

Appendix E

Students' unfair struggle to choose between learning, grades and their future

Patric Wallin, Lisa Rundberg, and Erica Sandström

Introduction

In response to a rise in neoliberal ideology and practices, educational landscapes all over the world have changed in profound ways during the last few decades, (Connell, 2013). The emphasis on markets and businesses has greatly changed the language used in education, and as Giroux (2002) pointed out "one consequence is that civic discourse has given way to the language of commercialism, privatization, and deregulation." It is through the emphasis of the free market and market driven agendas that neoliberalism reshapes education with the aim to increase its efficiency, and promote individualism, competition, and consumption in society (Harvey, 2005).

Concrete examples of this change are the conceptualization of students as consumers of higher education institutions (Molesworth, Nixon, & Scullion, 2009), the increasing importance of rankings (Hazelkorn, 2011), and the emphasis of university branding (Chapleo, 2010). These changes, together with the high number of students applying for higher education, have strong effects on university admission processes. University admission has become a double-sided competition where students compete to be accepted into prestigious universities, and universities compete for the "best" students (Olssen & Peters, 2005).

In Sweden, neoliberalism had a tremendous impact on education in general and upper secondary schools in particular (Symeonidis, 2014). From a strong tradition of a welfare state with a centralized education build on democratic and egalitarian values, the Swedish education has since the late '90s become one of the most decentralized and market-orientated education systems in the world (Lundahl, Arreman, Holm, & Lundström, 2013). The stronger emphasis on free school choice and the individual that is responsible for their own success and failure, together with a focus on testing, has created a difficult situation for students to appreciate learning as having value on its own. Lund (2008) showed through critical discourse analysis how these changes have influenced students' choices of schools and programs in upper secondary education, and the underlying discourses of these choice paths. In more general terms, upper secondary education has become mainly a stepping stone into higher education, and eventually the job marked for many students (Molesworth et al., 2009).

At the same time, there is a move towards student-centered education, where students are actively engaged in developing an answer to the problem, rather than finding the right answer (Sjöberg, 2011). An increasingly desired outcome in education is the ability of students to engage in lifelong learning (Ambrose et al., 2010). Based on the argument that "only lifelong learners will be able to keep up with the explosive growth of knowledge and skills in their career and to retool into a new career after their previous one runs its course" (Nilson, 2013).

In the light of these changes in the educational landscape, it is very interesting to take a closer look at how young adults cope with the transition between upper secondary school and higher education. The departure point for this study is the chemistry laboratory and the use of pictorial instructions, and it is within this context that we start to see glimpses of more general and fundamental aspects of the education system that influence students. From seeing the students in class and talking to them, it becomes clear that neoliberal discourses in education influence students, and here we start to explore in what ways this affects students' views on education and approach to learning.

Background

University admission in Sweden

In order to be eligible for admission in higher education in Sweden, one needs to first fulfill the general requirements by completing upper secondary education with a certain amount of passing grades, and second needs to go through a selection process (Universitets- och högskolerådet, 2017). The selection process matches the fixed number of place for undergraduate students in Sweden to the applying students. There are two main selection criteria: grade point average (GPA) from upper secondary education and the results from the Swedish Scholastic Assessment Test (sweSAT) (Löfgren, 2005). The GPA is calculated from all grades in upper secondary school (three years) and ranges from 1-20, in addition up to 2.5 additional points can be earned by reading qualifying courses (Universitets- och högskolerådet, 2017). The sweSAT is a standardized multiple choice test given twice a year to allow people to improve their chances to be admitted to the university program of their choice. The number of places assigned through each selection criteria differs from university to university, but at least 1/3 should be distributed by GPA and 1/3 by sweSAT. The remaining places can be distributed through selection criteria designed by each institution, or by extending the places for GPA and sweSAT based selection (Universitets- och högskolerådet, 2017).

In 2016, 57% of all undergraduate programs in Sweden had more than one application per available place. However, there are large variations in popularity and number of applications amongst different disciplines, programs, and universities. This leads to large differences in what results applicants need in their GPA or sweSAT in order to be accepted. One example is the engineering program "industrial economy", where applicants in 2016 needed a GPA of 14.02 at Mittuniversity, 15.89 at Mälardalens university, 20.78 at Linköpings university, and 21.88 at Lunds university (Universitets- och högskolerådets, 2016). In more general terms, there are certain universities that are much more prestigious than others and with much higher entry requirements, even though the degree is the same at the end.

Chemistry laboratory exercises

Laboratory exercises in the natural science subjects have a long tradition in upper secondary schools, and are often described to help students to gain practical experience in the laboratory (Elliott, Stewart, & Lagowski, 2008). However, often laboratory exercises are reduced to expository lessons that require the students only to follow a specific set of instructions without much reflection and independent inquiry. During laboratory work, students' and teachers' time for "meaningful, conceptually driven inquiry" is often seriously limited because the technical and inflexible details of the task consume most of their time and energy (Hofstein & Lunetta, 2004).

One way to enable student driven inquiry and promote meaningful learning experiences in laboratory exercises is to focus on student centred approaches and use instructions that are designed to promote students' own ideas and strategies (Wolf & Fraser, 2008). Pictorial instructions in particular can enhance student collaboration and provide them with multiple cognitive pathways to grasp the information (Zadina, 2014).

There is strong support in the literature that instructions that focus on students' ability to ask their own questions and develop their own inquiry approaches can greatly support students in coupling theory and practice, as well as build deeper and more holistic conceptual models of the subject area (English & Kitsantas, 2013; Hmelo-Silver, 2004; Madhuri, Kantamreddi, & Prakash Goteti, 2012; Zacharia, 2003). Despite the positive research findings, adaptation rates are low and according to a review of laboratory instructions styles by Domin in 1999, the most common instruction style, at that time, remained the expository instruction that leaves little room for the students own ideas.

Recent reforms of upper secondary education in Sweden aim at overcoming this problem and highlight the importance of student driven inquiry (Skolverket, 2016). For chemistry education, this reform means both changes in the curriculum, as well as the way chemistry is taught and assessed in schools. The aim is to create a stronger alignment between the students' laboratory and theoretical work, as well as promote student centred inquiries during the laboratory work. To achieve this aim, five important areas are highlighted that chemistry education shall provide student development opportunities in:

1. Knowledge of concepts, models, theories and practices in chemistry and understanding of how these evolve.
2. Ability to analyse and answer questions related to the subject as well as to identify, formulate and solve problems. Ability to reflect on and evaluate the chosen strategies, methods and results.
3. Ability to plan, implement, interpret and present experiments and observations as well as the ability to handle chemicals and equipment.
4. Knowledge of the importance of chemistry for the individual and society.
5. Ability to use knowledge in chemistry to communicate as well as to examine and use the information.

It needs, however, to be seen how this reform will be perceived by students and teachers, and how it will impact classroom practices in an education landscape that focuses strongly on grades and assessment. One of the central problems is, as Symeonidis (2014) pointed out: "Students are learning how to pass exams and not how to work together or how to appreciate learning in itself."

Research context and approach

The research context for this study are two municipal upper secondary schools in the Gothenburg area (Sweden). Both schools have relatively high minimum entry qualification requirements and similar student populations, with a majority of students aiming to continue their education at universities afterwards.

Empirical data was collected through classroom observations (6 classes) and focus group interviews (12 groups) over five weeks during the spring 2016. For the observations, a qualitative unstructured approach was used that focused on the whole class, the overall impression of the students work in the laboratory and their social interactions. The aim was to better understand and interpret students’ cultural behaviour and their everyday routines during the laboratory exercises as they occur by focusing on emerging patterns situated in the students’ own actions (Mulhall, 2003). All the individual notes from the observations were written as a storyline soon after the event to fully profit from the immersive experience of observing the students in action.

Using the observations as a starting point to define areas of interests, the focus group interviews were used to gain more in-depth information about students’ experiences and viewpoints regarding the emerging topics (Ritchie & Lewis, 2003). The aim with the interviews was to better understand why different types of phenomenon occur, to explore the students’ reasoning, and to see school life from their perspective (Legard, Keegan, & Ward, 2003). The reason to choose focus group interviews was to capitalize on communication between students in order to stimulate memories and reflections on experiences, as well as to explore cultural values and procedures that are shared by the members of the group (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Interviews lasted between 45 and 70 minutes, and were all audio recorded and transcript soon after the event.

All material was analyzed together using an inductive data analysis approach to capture emergent categories (Ritchie & Lewis, 2003). In the first step, the data was read and listened to multiple times, before it was deconstructed into units of meaning by pulling out quotes and passages of interest. Afterwards, units of meaning were used to construct categories that captured emergent topics of importance in the data. At later stages of this iterative process of deconstruction and construction, literature was used to provide an additional perspective and departure point for analysis of the data. The aim was to let the data speak for itself and explore the situation from the students’ perspective. In this way, it was possible to discover underlying reasons and actual effects, not only anticipated ones.

Results

The initial classroom observations allow us to see how students act and interact in class during their chemistry laboratory exercises. It is through these observations that we can better understand and interpret the students’ cultural behaviour and their everyday routines. From the observations, it becomes clear that the students’ actions, interactions, and foci are not bounded by the chemistry laboratory exercises. One aspect that plays a strong role for the students are upcoming tests and exams in any of their courses:

(25 min)	Group 3 worries about a test that they will have later today and talk about it for a long time. They look into their books – not their chemistry books, but the book needed for the test later.
(45 min)	After working a little bit more on their chemistry laboratory exercise, group 3 has returned to talk about the upcoming test.
(60 min)	Group 3 is rehearsing and try to prepare as good as possible for the test.

(Observations Class 1)

Upcoming tests play an important role for the students and greatly influences the way that these young adults work on their chemistry exercise. It takes away focus from engaging and learning from the class that they are in right now, and instead the students think ahead to the next test that they need to perform.

The prominent role of test and exams is further illustrated by the way students not only talk about the content of a test and what they need to know, but by engaging in more general discussions about exams and testing practices:

(35 min)	Group 4 starts to talk about a biology exam, which they will have later today. They start to involve some other groups and soon the discussion is about oral and written exams in more general terms.

(Observations Class 5)

These observations serve as a starting point for the focus groups interviews that allow us to better understand the students and see glimpses of which underlying reasons and discourses influence young adults and their daily school life.

We wanted to explore why grades play a central role in how these young adults approach different learning situations and education as a whole, and what consequences this might have. When asked directly why grades play such an important role for them, the single most important factor that students talk about is the importance of grades to be able to freely choose a university and study program after school:

Lisa:	Why do you think you are focusing so much on the exams?
Anders:	One wants to have good grades or so…
Maria:	Yes that’s the way it is.
Lisa:	Why do you want to have good grades?
Maria:	Because… because we want to come in [at the university] where we want and… and there is a lot of pressure in our class as well…

It is not necessarily that the students exactly know what they want to do after school, but they want to have high grades in order to be able to choose without restrictions. They do not want to be the only ones not being able to choose.

While grades play a central role for the students, they are not really sure about how they are formed. The students know that tests have a big influence on their grade, but that also their performance in class plays an important role. It is this second aspect that students are most unsure about. This uncertainty on how their work in class is assessed creates an environment where the students become afraid to ask the teacher questions, because they do not want to show when they do not understand something. They believe that this could influence their grade negatively:

> Peter: I do not really know how we are assessed on the laboratory work [...] You do not want to ask to much because then you might show that you do not understand [...] You do not want to do the wrong thing because the practical work is being assessed as well.

In this way, the students see the laboratory work not first and fore most as a place for them to gain understanding, but a place to show the teacher what they are already able to do:

> Clara: I know that the teacher assesses this, the laboratory work is still a part of the grade. [...] [For] me it’s important that the execution is right because that’s what I know the teacher is assessing. I also think that it is important for me to do the right thing and to think right because I know the teacher might not tell you “Now I’m assessing you” but I know they still do it.

For some students, this becomes an internal conflict, where they are unsure when and what to ask, and what questions to avoid. On the one hand, they could learn something new from asking, on the other hand they believe it could affect the teacher’s perception of them negatively. The students are unsure of what they are supposed to learn and what they should know already. They do not want to risk the teacher finding out that they do not know something that they already should be familiar with by asking a wrong question:

> Anna: I get a little bit like this “should I ask the teacher, will he think that it is good that I ask or will he just, oh she really does not understand”.

Not knowing how they are assessed and on what grounds creates an environment where the students become afraid to ask and to do something wrong, which greatly limits their opportunities to learn. This is something that the students are completely aware about and it is something that troubles them. They know that some of their approaches are focusing only on grades and tests, and that they actively choose these strategies over the once that they belief would help them to learn better:

> Tim: It is a bit sad that all our focus is on what we need to learn for the test, but that is what always happens. We have to [learn it], not because it is part of the course or the topic that we are exploring at the moment but because "we have to know this exercise because it will be on the test".

One of the students even explained that gaining a greater understanding was one of the things she looked forward to when she moved up to upper secondary school, but now when she is here she feels as though it still is not what she is spending her time developing:

> Isabella: Before I started upper secondary school, I thought "once I am in high school I will work in the chemistry laboratory and run experiments, but I will not only see and do stuff, but I will understand why". However now that I am here, it feels like I still do not understand why, I still just do it without really understanding what really happens when I do it, but that would be the interesting part.

Situations that could have been exiting challenges instead become a source of stress because of the thought of how it will affect the grades:

> Daniel: On one hand you think that it is a little bit fun. At least I think that problems are fun to solve. So in that regard it can be fun but on the other hand you get really stressed by the situation. Maybe not by the laboratory work by itself but by everything thing around it, like if a teacher walks past and thinks "what ARE you doing?".

The group pressure that students talk about should not be misinterpreted as being overly competitive amongst each other and the desire to be better than the others. The students help each other through out the laboratory classes, ask each other questions, and explain things to each other:

> Julia: [When work at the same table as other groups,] one can always discuss fairly easy with each other without having to run around the room in order to find someone who knows what you want to know.

In some way, the students stick together and help each other out, in order to avoid asking the teacher too much in fear to lower their grade. The pressure has to do with gaining the privilege to freely choose a higher education through good grades, and not being left out.

Discussion

The interviews with the students, as well as the observations, allow us to better understand how students approach school and what shapes their learning experiences. By seeing them and listening to them, it becomes possible to unveil the side effects of the current system of university entry requirements and admission processes, as well as the struggles neoliberal ideology has created in education.

These young adults explain how they focus on grades and assessment, and how they sometimes feel that they prioritized grades over learning. This in itself is not so surprising, and many studies have looked at students' approaches to learning in different contexts and situations after Marton's and Säljö's (1976a, 1976b) seminal work in the area. What is interesting though is to explore what influences and shapes these approaches. It is interesting to learn from the students that the main reason for the focus on grades is to be accepted at the "right" university, and the possibility to choose. These young adults want to be prepared for the transition from school to university. It is not only previous classroom experiences on local and personal level that will shape students approaches and strategies for learning, but the way society and institutions describe, communicate, and incentivize learning on a more systematic and general level (Giroux, 2002).

In the current education system, there is a paradox, where learning is assessed through high stakes testing, and grades are used to select students, but at the same time reforms aim to emphasis student-centered learning and focus on developing self-regulated learners that value learning and education (Shepard, 2000). Young adults are left alone to figure out how to best navigate through this system, and what priorities to choose (Symeonidis, 2014).

The departure point for this study was the chemistry laboratory and the use of pictorial instructions that were prepared for eight different chemistry laboratory exercises (Rundberg & Sandström, 2016). However, it quickly became clear that the change in instructional design had very little immediate effect on students, and is overshadowed by the omnipresent of grades and assessment. In the interviews, the students explained how they are aware of that focusing on tests and grades is not necessarily helping their learning, but at the same time grades are important for their future. Being in the center of this paradox made the students sad and feeling helpless, as they do not know how to balance both aspects. While the pictorial instruction might not have had a strong direct effect on the students, they serve as a trigger to stimulate students to evaluate, access, and think about their deeper beliefs and values (Ling & Marton, 2012).

The young adults in this study are struggling, but they lack the necessary tools to critique the system and boundary conditions itself that creates the situation that they are in. The way neoliberal ideology has influenced education has reduced the ability of students to critique the system itself by emphasizing individualism, competition, and consumption (Harvey, 2005). Neoliberal discourse maintains, as Fischman (2009) pointed out, that “schools should be apolitical institutions, implementing scientifically verified ‘best practices’ which will be assessed through standardized testing”. Instead of educating critical and democratic citizen, the focus has shifted towards educating consumers that function in the work place (Giroux, 2002).

Listening to these young adults and understanding their struggles in the education system in more detail is an important step to be able to better help students in the transition from schools to universities and provide them with the tools to look beyond the current way education works. The current education system leads students to perceive learning as a stepping-stone to be able to get a good job, and schools become a place of preparation for a world, where grades are used as a selection filter (Schommer & Walker, 1997). The emphasis on grades, test scores, and merit in society and in the university admission process is a strong influence for young adults (Alon & Tienda, 2007), especially in the population of high performing students that were part of this study. It means that everyone is responsible for their own success, but also that the ones that do not succeed are failures and responsible themselves (Symeonidis, 2014). This creates a lot of stress for all students, the ones that are later accepted to their chosen university and program, as well as the ones that are not.

In this study, we capture glimpses of young adults at the transition between upper secondary school and higher education. More studies are clearly needed to better understand how this life phase is influenced by predominant neoliberal discourses, and to make sure that the voices from these young adults are heard and listened to. It is in the students’ struggles, learning opportunities are lost and the joy for learning is damaged, at a time when lifelong learning, critical citizenship, and democratic values are needed more than ever.

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Appendix F

How to help first year students to appreciate learning

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Short summary

The learning approaches and strategies many students arrive with at the university might not be suitable for the new teaching methods in engineering education. Therefore, it is crucial for educators to help students to advance their approaches and strategies towards learning through active discussions and open dialogues.

Keywords: Learning strategies, dialogue, first-year students, university admission

Introduction

Over the last two decades, teaching in engineering education has changed more and more towards placing students and their experiences in the center and focusing on their learning (Prince & Felder, 2006). This becomes particular clear in problem- and project-based learning that begin with practical application that students can easily relate to before moving more into theoretical aspects. These teaching methods have in common that students need to regulate and take responsibility for their own learning – the teacher should focus on helping students to become self-regulated learners (Kuh, 2008) using some of the many different techniques discussed in the literature (e.g. Lindner & Harris, 1993; Zimmerman, 2002). It is however important to note that teaching concrete strategies alone is not enough, as students' overall approaches to learning that they carry with them from school might hinder them from becoming selfregulated learners. Students need to be encouraged to take a deep approach to learning that focus on generating meaning rather than memorize and recall information for exams (Marton & Säljö, 1976). English and Kitsantas (2013) point out that "for many students, [the self-regulated learning] role conflicts with deeply ingrained habits they have developed through more familiar classroom experiences, in which they have been passive recipients of knowledge."

Besides previous classroom experiences on local and personal level, the way society and institutions describe, communicate, and incentivize learning will shape students approaches and strategies for learning on a more systematic and general level (Giroux, 2002). This leads to the first research questions that this study will try to answer using an inductive qualitative research approach:

1) *What shapes students' approach to learning in schools?*

Using the findings from the first question as a starting point, we will critically discuss the empirical data together with relevant ideas from the literature. The discussion will focus around the boundary conditions universities create in students' transition processes from school to university. It is through this discussion that we will approach the second research question:

2) *How can educators at the university help first year students to become self-regulated learners?*

Study context, design and research approach

The study presented here is part of a larger project (Rundberg & Sandström, 2016), which originally aimed at exploring the effect of new instruction methods on students' learning experiences and social interactions chemistry laboratory classes.
Empirical data was collected through focus group interviews and in-class observations at two upper secondary schools in the Gothenburg area. Focus group interviews capitalise on communication between students in order to stimulate memories and reflections on experiences (Ritchie & Lewis, 2003). Furthermore, they are particular useful to explore cultural values and procedures that are shared by the members of the group (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). A total of six classes were selected for observations and 12 focus group interviews were collected. All students that were involved in the study were informed and able to ask questions about the research. Students who were interviewed signed informed consent forms. Interviews were audio recorded and transcript, and observations were written down directly after classes.
All material was analyzed together using a general inductive data analysis approach to capture emergent themes (Thomas, 2006). The aim was to let the data speak for itself and explore the situation from the students' perspective. In this way, it was possible to discover underlying reasons and actual effects, not only anticipated ones. The pool of data was read repetitively to ensure that all aspects and details were captured. In an iterative process of reading, tagging, and classifying, the data was first deconstructed into units of meaning before overarching themes were reconstructed.

Results

From the interviews with the students, as well as the observations, it quickly became clear that grades and grading play a central role for students. While this in itself is not surprising, it is interesting to see why students focus so much on grades and how it influences students' approaches during class. Students recognize that their grades are based on their test results, as well as their performance during classes, but at the same time they do not know how their performances are assessed during laboratory classes. This uncertainty makes the students unwilling to ask the teachers questions, because they are afraid it will influence their grade negatively:

Peter: I do not really know how we are assessed on the laboratory work [...] You do not want to ask to much because then you might show that you do not understand [...] You do not want to do the wrong thing because the practical work is being assessed as well.

Not knowing how they are assessed and on what grounds, creates an environment where the students become afraid to do something wrong and ask, which greatly limits their opportunities to learn. This is something that the students are completely aware about and it is something that troubles them. They know that some of their approaches are focusing only on grades and tests, and that they actively choose these strategies over the once that they belief would help them to learn better:

Anna: It is a bit sad that all our focus is on what we need to learn for the test, but that is what always happens. We have to [learn it], not because it is part of the course or *the topic that we are exploring at the moment but because "we have to know this exercise because it will be on the test".*

It is disturbing to see how these students know that they are missing out on their learning and regret their approaches, but at the same time do not know how to change the situation. In order to fully understand the students and their decisions, it is important to know why grades play such an important role for them. When asked about it, the single most important factor that students talk about is the importance of grades to be able to freely choose a university and study program after school:

Lisa: Why do you think you are focusing so much on the exams?

Anders: One wants to have good grades or so…

Maria: Yes that's the way it is.

Lisa: Why do you want to have good grades?

Maria: Because… because we want to come in [at the university] where we want and… and there is a lot of pressure in our class as well…

It is not necessarily that the students exactly know what they want to do after school, but they want to have high grades in order to be able to choose without restrictions. The group pressure that students talk about should not be misinterpreted as being overly competitive amongst each other and the desire to be better than the others. The students help each other through out the laboratory classes, ask each other questions, and explain things to each other:

Julia: [When work at the same table as other groups,] one can always discuss fairly easy with each other without having to run around the room in order to find someone who knows what you want to know.

In some way, the students stick together and help each other out, in order to avoid asking the teacher too much in fear to lower their grade. The pressure has more likely to do with gaining the privilege to freely choose a higher education through good grades, and not being left out.

Discussion

Grades and grading emerge as a central theme from the data, where students choose grades over learning, because they want to be able to enter the university and study program of their choice. This situation is unsettling for the students, they feel sad about their own choices and regret that they do not focus more on learning. Rather than separating the students from each other, this situation encourages them to stick together and help each other.

In order to understand these findings, it is important to remember the way university admission processes and entry requirements are designed. At Chalmers, there is a strong emphasis on grades and results from high stakes testing, when it comes to student admission. Students that want to study engineering programs (civilingenjörsutbildningar) at Chalmers needed to have between 18.09 and 22.40 points (avg. 20.22) on a 20+2.5 points scale in 2016 to be accepted (Chalmers University of Technology Admission Office, 2016). This means that students not only need to have top grades in nearly all subjects in secondary school, but for some programs also need to have the right courses that give extra merit points (up to 2.5).

It is through their admission policies that universities strongly influence student behavior and approaches to learning and education in upper secondary schools. This creates a difficult situation for the teachers in schools, as they cannot deny the importance of grades, but still want to encourage students to learn for gaining a deeper understanding. The strong reliance on grades and test results is not unproblematic (Kerr, 1975), and as Schwartz (2015) has pointed out it is impossible to design incentives and rules that cannot be exploited. We will not discuss the usefulness of test and grades further here, but rather focus on the consequences of the university admission process.

Students entering university, especially universities and programs with very high entry requirements like Chalmers, will often see grades as the most important part of their learning; interest and deeper understanding become secondary. Asking these students all of a sudden to focus on their own learning and understanding rather than grades will potentially alienate them, as their studying techniques are simply not adopted for this. At the same time, using teaching methods like problem- and project-based learning offers an opportunity to help students develop new studying strategies and adopt deeper approach to learning. However, it is important to realize that students will need help during this process and that teachers need to explicitly discuss these issues (English & Kitsantas, 2013). It is simply not enough to tell students to become self-regulated learners without providing help and support (Bråten & Strømsø, 2005). Central for helping the students is to openly and explicitly discuss study techniques, approaches to learning, expectations, and reasons for teaching in particular ways. For example when using *flipped classrooms* or *project-based learning*, it is important to tell the students the ideas behind this approach, what is expected form them, and provide them with reasons why this will help their learning. It is through the dialogue between students and teachers that self-regulated learning can become meaningful and desirable. As a starting point for discussing study techniques, Dunlosky et al. (2013) provide a comprehensive overview of ten easy-to-use study and learning techniques that help students become self-regulated learners. In addition, it is crucial that the assessment is aligned with the teaching methods (Shepard, 2000) – emphasizing the importance of self-regulated learning and at the same time using common fact checking exams will only further strength students believes that grades are more important than learning (Clark, 2012).

Conclusions

The learning approaches and strategies many students arrive with at the university are shaped by the university admission system that uses grades as a central selection criterion for admission. The students' focus on grades becomes problematic in combination with teaching methods in engineering education that places the student in the center and demand them to focus more on their learning than grades. Universities have created a mismatch between the way students are admitted and the way they are taught and encouraged to learn. It is therefore crucial for educators to help students to advance their approaches and strategies towards learning. Educators cannot assume that students possess the right mindset to become self-regulated learners directly, but need to actively discuss with students study strategies and learning approaches.

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