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Development of Furniture Concept

- To meet the user needs in future learning environments

Bachelor thesis in Design and Product Development

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Cover:
Rendering of final concept.

Preface

This bachelor thesis of 15 credits is performed at the bachelor program of Design and Product Development at Chalmers University of Technology, within the Department of Design and Human factors at the institution of Product- and Production development. The project was assigned by Kinnarps AB.

We would like to thank Olof Wranne, our supervisor at Chalmers who has helped us during the work and given us valuable advice. We would also like to thank all participating schools, teachers, and students who have allowed us into their environment providing us with important user information.

Special thanks also to our supervisors at Kinnarps AB: Mikael Sjöberg and Stefan Liljedahl who have been a great support during this bachelor thesis. Also, great thanks to Anders Larsson for all of your support and cheering along the way.

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Elin Karlsson, Ida Larsen

Abstract

Kinnarps AB is a Swedish furniture manufacturing company with interior workspace solutions for offices and learning environments. During the last year, Kinnarps AB has started to work with a new concept called Next Education, which will include furniture for the creation of future learning environments. The purpose of this project is to search for and analyse what user needs are not met in today's learning environment with the existing furniture. Furthermore, the purpose is to investigate how these needs can be met through the development of new school furniture. The research will mainly include upper schools and high schools. The most important delimitation is that the final concept will be delivered as sketches and visualisations but will not include specific construction data.

The aim of this project was to answer the research questions: What needs in today's learning environment cannot be satisfied with today's existing furniture? How can a furniture be developed within Kinnarps AB, in order meet the identified user needs in the school environment?

The user studies show which requirements that are the most important for the users regarding furniture in a learning environment. "Good quality and durability", "Enable various working postures", and "Enable various types of teaching situations" are the prioritised requirements according to the compiled result from pupils, teachers, and experts from furniture business. On the basis of these requirements, in combination with the other demands that were found during the research, development of a furniture concept for Kinnarps AB was done.

The result is a concept of a student chair on wheels where the backrest can be turned 90 degrees to a horizontal position, in order to be used as a work surface. Moreover, the concept enables various working postures and teaching situations. Wheels and the base of the chair have not been developed in this particular project. The resulting concept, a chair that becomes a workstation which offers both a sitting area and a work surface is one step forward in order to make the classroom environment more flexible.

Keywords: Future learning environment, school furniture, Kinnarps AB, product development, workstation, chair.

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1

Introduction

1.1 Background

Kinnarps AB is a Swedish furniture manufacturing company that develops and produces furniture for public environments, offices and educational environments. Their range of products includes work tables, desk chairs, screen systems and storage, which all have a high standard in ergonomics together with a genuine combination of shape and function. A concept called Next Office™ was introduced in its latest version in 2012 and includes collections of activity based furniture, developed for modern office environments (A. Larsson, personal communication 1 Feb 2017). The concept has had great success, therefore Kinnarps AB has an interest in creating a similar concept for school environments, Next Education.

A survey done by Demoskop (2016) on behalf of Kinnarps AB, shows that the physical and psychical school environment are important for how well pupils and teachers perform and enjoy school. Open answers also show that if they had the chance to change or improve something in the physical school environment, they majority wished for new, modern, sustainable and ergonomic furniture. This result is strengthening Kinnarps AB intention of continuing to develop furniture for school environments, with the company's core values in mind: ergonomics and sustainable development.

Since the way of teaching is developing, there is a possible change in user needs and demands concerning the learning environment. Therefore, it is necessary to investigate this in order to design furniture and equipment suitable for the modern learning environment.

1.2 Purpose

The purpose of this project is to search for and analyse what user needs that are not met in today's classroom environment with the existing furniture. Furthermore, the purpose is to investigate how these needs can be met through the development of new school furniture.

The aim of this project is to develop a furniture in order to enable a more flexible learning environment that meet the needs in today's and future schools.

1.3 Delimitations

Target areas within the research are upper schools and high schools but will also involve university environments. The research will include both youths and teachers working in these areas but will not include youths in lower classes than upper school. Within the sample of schools, no socioeconomic factors will be considered.

The project team will investigate which user requirements that are not met in today's learning environment and research future teaching techniques. Within the research, there will be a geographic focus on the Scandinavian market.

Choice of colours and materials will be done within the existing availability at Kinnarps AB and with respect to sustainability aspects. Costs of material and manufacturing methods will not be considered. The concept will be delivered as sketches and visualisations but not include construction data.

1.4 Research questions

For this project, following research questions are stated:

- What needs in today's learning environment cannot be satisfied with the existing furniture?
- How can a furniture be developed within Kinnarps AB, in order to meet the identified user needs in the school environment?

2

Theory

This chapter contains theories associated with the project and aims to give a greater knowledge regarding the various areas that are concerned, such as theories about ergonomics, pedagogy, and sustainability.

2.1 Ergonomics

In general, ergonomics can be described as the interaction between human and technology. According to the International Ergonomics Association, (IEA), the definition of ergonomics is:

"Ergonomics (or Human Factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory principles, data and methods to design in order to optimise human well-being and overall system performance" (Bohgard et al., 2015, p. 11).

Ergonomics can be divided into different areas; Physical, Cognitive and Organisational ergonomics. There are various subjects of concern, some parts which are important for further understanding of this project are described below.

2.1.1 Psycho-social environment

One discipline in ergonomics is organisational psychology which is the collaboration between the organisation and the individual with the focus and aim to improve well-being, create good learning situations and promote personal development. The psycho-social aspects of the environment have a strong impact on the well-being. Some important factors for positive development are the opportunity for individuals to influence their working situation, both physical and psychical, good working community and the work itself should be stimulating and engaging. Also, the leadership has an important influence, where a good relationship between the team leader and the employees are significant to create trust, and an overall positive psychosocial working environment (Thylefors, 2015).

2.1.2 Physical environment

Physical strain is one part in the definition of ergonomics and concerns the mechanical work and forces that humans are being exposed to in the working environment.

2. Theory

To establish a good working environment, the conformation of furniture and devices after physical needs and requirements, are crucial factors for well-being and efficiency. The physical limitations of a human being are important to take in consideration when designing a work area. Human dimensions and other factors such as postures, proportions, reach and ability to move are to be found in anthropometric data (Hägg, Ericson and Odenrick, 2015, p. 173-175).

Anthropometry is the science and knowledge about the human dimensions, strength and work capacity (Högskolan i Skövde, 2011). There are standard measurements that are to be used in product development and these vary between men and women. Hägg et al. (2015, p. 173-175) declare standards for the Swedish population and in the figure 2.1 below the most important measurements for this project can be found. The measurements are for adults, which has to be taken into consideration when designing products for youths. The measurements are given in the 5, 50 and 95 percentile as well as median and standard deviation. The 95 percentile means that 5% of the population have taller and larger dimensions than the measurements given in that column and the measurements for the 5 percentile shows that only 5% of the population has smaller dimensions than given in that specific column (Hägg et al. 2015, p. 172). Further description regarding the measurements is to be found in figure 2.2.

Dimensions (mm)	Men				
	5%	50%	95%	M	s
1. Body lenght	1669	1779	1902	1792	70
2. Elbow height	1020	1108	1181	1104	56
3. Sitting height	883	946	1006	944	36
4. Shoulder height sitting	557	607	668	608	33
5. Elbow height sitting	195	238	292	240	28
6. Loin-hock	451	493	545	496	29
7. Hock height	437	491	534	486	32
8. Hip width sitting	326	387	445	391	35
Dimensions (mm)	Women				
	5%	50%	95%	M	s
1. Body lenght	1562	1673	1789	1674	68
2. Elbow height	957	1044	1130	1042	52
3. Sitting height	832	892	949	892	35
4. Shoulder height sitting	521	577	624	575	29
5. Elbow height sitting	192	238	285	238	27
6. Loin-hock	431	477	522	478	30
7. Hock height	397	444	500	447	28
8. Hip width sitting	367	416	463	414	30

Figure 2.1: The data in the table are for adults and are given as 5, 50, 95 percentile as well as median and standard deviation.

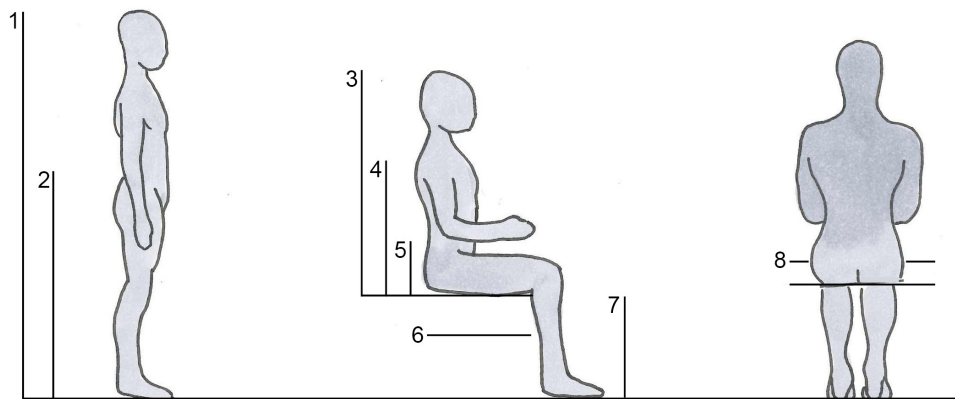


Figure 2.2: Anthropometric measurements for standing and sitting positions. (Picture created by the authors)

Further recommendations given by Hägg et al. (2015, p. 177) regarding the height of the work surface are:

- If the work requires precision: 50-100 mm over the height of the elbow.
- If the work requires easy manual work: 50-100 mm below the height of the elbow.

In the product development at Kinnarps AB, standard measurements are used. According to S. Liljedal (personal communication 17 May 2017) the standards used for sitting and standing are following:

- Sitting/standing tables are adjustable between 620-1280 mm in height.
- Normal height (fixed) sitting: 740 mm.
- Medium height (active height) sitting: 900 mm
- Standing height: 1050 mm

Today, a common working posture in industrialised countries is sitting, which is one contributing factor to spine problems. In order to obtain a good ergonomic working situation, the possibility to change position occasionally is necessary (Hägg et al., 2015, p. 177).

2.2 Physical learning environments

According to a report published by the Swedish Education Administration [Skolverket], there is a lack of research and knowledge about how the physical working environment is affecting pupils ability to perform in elementary schools (Gustafsson et al., 2009, p. 246-249). However, it is stated that the physical environment is an important research area and that it may affect the student's opportunities to perform. *How* it is affected is not concluded by the report.

Even though it is stated that more research regarding how physical environment and pupils learning are related is needed, there are existing theories about the design of physical learning environments. Pia Björklid, a professor in pedagogics, is the author of "Lärande och fysisk miljö", in which research regarding factors in the interaction between pupil and learning environment is gathered.

Björklid (2005, p. 27-28) suggest that individuals interact with their environment - the environment is affecting the individual but the individual is also affecting the surroundings. The process of learning is a result from interaction, both physical, social and cultural. The learning takes place in a specific context, but this context is not limited to a classroom. The learning in school is called "formal learning" [formellt lärande] and the "informal learning" [informellt lärande] takes place in all other environments. The physical school environment is not just an environment for learning and working, several scientists believe that it is also a milieu for children's development and socialisation.

One conclusion stated by Björklid (2005, p. 101-102) is that research show classrooms should have the characteristics of a workshop, with different areas intended for different activities. The environment should inspire actions. Furthermore, it is important to give the pupil opportunity to move and stimulate senses to help the pupil to be active.

A factor that stimulates pupils willingness to learn is the teacher's ability to lead and perform a variation in teaching techniques (Johansson, 2010). This may indicate that the physical environment must allow this variation in teaching techniques. Notes from a seminar held in 2010 at Arkitektmuseet, which was arranged by Lärarförbundet and Sveriges Arkitekter with pedagogues, architects, scientists and representatives from Lärarförbundet and Education Administration [Skolverket] participating, emphasises that the physical environment is very important for pupils. It should provide the opportunity for social interaction, but also privacy (de Laval, 2010).

In a project at Stockholm Institute of Education, a "Classroom of the Future" has been designed in 2008, which is a physical and virtual learning and teaching environment. The initiators identified that teachers often faced challenges in using ICT-tools (Information Communication Technology-tools) in learning, due to lack of proper competence. They created this environment with the intention to make the physical learning environment more flexible, designing the room in a way that furniture easily can be rearranged in order to meet different needs. Other aims were to support the use of ICT-tools, making it easy to work digitally and support co-creation work (Koroma, 2012). The "Classroom of the Future" contains café tables, sofas, larger tables and extra chairs, all equipped with wheels. It also provides technical tools as laptops, web cameras, a smartboard, sound, and projectors. The environment is intended to have a wide target group, not just schools but also teachers, students at a higher level and researchers for example and "hope to inspire to new thoughts about teaching methods and co-operations" (Koroma, 2012). This is

an early example of how a future learning environment may be designed, regarding the use of ICT-tools.

The physical learning environment is briefly considered in the Swedish curriculum (Skolverket, 2016a, p. 14-15). It is stated that everyone who works in school shall cooperate towards creating a good environment for development and learning. It is also stated that everyone that works in school shall promote pupils will to take responsibility and influence the social, cultural and physical school environment.

A traditional classroom in Sweden is 60 square meters large, although this may vary and classrooms in newer built schools might have other dimensions (Björklid, 2005 p. 74, 89). The layouts of schools have traditionally consisted of long corridors, classrooms with teacher's desk at the front, with no smaller areas for temporary group-work (Wallin, 2000).

2.2.1 Future learning environment

Already in 2000, there were thoughts about school development and how schools could be designed in the future. "Skola 2000" was a concept of how pedagogics, work organisation and physical environment should be integrated into a new modern school (Wallin, 2000). The concept is an idea of how these areas together can create a modern education that is in line with the modern curriculum. "Since children shall be co-participants in the education and not just recipients, there is a need for new facility solutions, besides the ones that have been dominant through centuries" (Björklid, 2005, p. 88).

A research done by Demoskop (2016) on behalf of Kinnarps AB identifies problem areas and shows opinions of pupils, teachers, and principals, a total of 1233 respondents. The survey indicates what should be focused when creating future learning environments.

According to Demoskop (2016) 4 out of 10 pupils feel uninspired by the physical environment when going to school every day. A good physical environment is also an essential factor, where 9 out of 10 pupils think the environment is crucial for the well-being. If the students got the opportunity to change something in the physical environment, almost 40% would prioritise to replace chairs and tables. Every second pupil in elementary school feels that their chair is uncomfortable. The research done by Demoskop (2016) also shows that the pedagogues agree with the pupils regarding what should be changed in the physical environment, where 25% would prioritise to have new, sustainable and ergonomic furniture.

Today's classrooms are often very stationary, something that can be seen in the same report from Demoskop (2016) where every second student remarks that the furnishing in the classrooms rarely is adapted for their studies. The flexibility, or the absence of flexibility, in today's classrooms is something that one-third of the pedagogues are critical to.

2.3 Pedagogy, didactics and teaching in future

According to the Swedish National Encyclopedia, pedagogy is "the knowledge and methods applied in education and training" (NE, 2017). One part of pedagogy is didactics, which is described as the science of teaching that includes the analysis and understanding of factors that are important for learning. Didactics aim to answer the questions of what, how and why someone, e.g. a pupil, shall learn (Skolverket, 2016b).

When teachers were asked about what they think will characterise future learning in 2031, this was the result (Larsson, 2015):

- 95% believe that IT will be a natural part of all pedagogics.
- 80% thinks a big part of pupils learning is to be able to handle a large amount of information.
- 77 % thinks it will be important to make learning a strong experience.
- 71 % thinks it will be important to teach students about the social interaction between people.

The result is commented by a researcher in pedagogics, who in contrast to the result, believes that the teacher will continue to be an important co-creator with students and provide them with basic knowledge, not just a coach as the report concludes (Larsson, 2015). The opinions go apart since other agree and mean that teachers can become more of a coach in class - adapting the teaching to the pupil's way of learning (Stridsman, 2015). One thing is agreed - the teacher is important and the role is likely to change as the world around is in rapid change.

There are many theories regarding teaching, which describes different approaches. In the book "Utmärkt undervisning", the authors and researchers in pedagogics Jan Håkansson and Daniel Sundberg, have gathered two decades of Swedish and international research regarding school. The book aims to serve as guidance for teachers creating "education with good quality". Lozic (2016) highlights some of the author's conclusions on the Education Administration's website, where teachers competence development is pointed out as very important. Lozic (2016) also highlights the conclusion that education high in quality is characterised by collaborative learning [kollektivt lärande]. Collaborative learning is explained as a learning process where you learn from each other - the knowledge is gained during the interaction with other people (Cornell University, n.d.). The learning environment must be communicative, where pupils can exchange experiences, and teachers shall support this interaction (Lozic, 2016).

Through technology, new ways of teaching and learning are possible. A few examples of different new teaching phenomena are described below.

Flipped classroom

The "Flipped classroom" is a phenomenon that switches or "flips" the way of how ordinary teaching is done. What the students usually are supposed to do as homework, like solving problems or writing essays, are done in the classroom and the preparations such as listening to lectures or reading about a subject are done prior the lesson by the student (Freeman, Herreid and Schiller, 2013). This method requires that the pupils are engaged in their own studies, but it also gives the pupils time to move forward in their own pace. Freeman et al. (2013) also mean that "Flipped classroom" gives the teachers more quality time with the students, when the pupils are already known to the subject when the lesson starts. It is also easier for the teacher to understand how different pupils are learning in the best way, and because of that be able to customise the assignments and schedule. The "Flipped classroom" phenomenon requires an efficient communication between the teacher and the pupils, it is also essential that all students and the teachers have a good experience in and access to computers and other digital devices in order to pursue the education.

Gamification

The education concept "Gamification" is a theory about how functions from the gaming world can be used in educational purpose. There are suggestions about that environment from common games can be used in order to create educational assignments for various subjects. Furthermore, "Gamification" means that the mechanisms in games, such as scoring systems, competitions, direct feedback and the opportunity to reach new levels are to be used in order to motivate pupils in the education (Wahlgren, 2012).

Connected learning

Connected learning is a type of learning in higher education that "puts students at the center of the educational experience, offering the ability to connect courses, people, and resources to develop unique personalized learning pathways" (EDUCASE Learning Initiative, 2013, p. 2) and refers to students who use their connections in resources and technology to accomplish their goals. The key elements are students personal interest, support from peers and pedagogues as well as the use of IT-tools (EDUCASE Learning Initiative, 2013). The Connected Learning Alliance (n.d.) describes it as follows: "the "connected" in connected learning is about human connection as well as tapping the power of connected technologies".

The EDUCASE Learning Initiative (2013, p. 2) also highlights that universities may need to support connected learning to remain competitive. The Moffitt Library at the University of California has created an environment that supports connected learning. They use some of their library floors not for books but for creative spaces open for collaboration and sharing knowledge in IT, and the use of IT-technology in learning. They emphasises that the library shall provide expert guidance for students regarding the massive flow of information and provide new

IT-tools, for example, 3D-printers, data visualisation and multimedia editing (UC Berkeley Library, 2016).

MOOC - Massive Open Online Courses

A new type of education on a higher level that has attracted a lot of students all over the world during the past years. Massive Open Online Courses, MOOC, are free of charge and can be attended by thousands of students. The education can consist of recorded lessons on video and interactive assignments (Boussard, 2015).

The universities offering a MOOC often collaborate with edX, an "online learning destination and MOOC provider" (edX, 2017) founded by Harvard University and MIT in 2012. In 2014, the first MOOC was offered by a Swedish University and the courses attracted over 70 000 students (AllaStudier.se, 2015). Chalmers University of Technology has introduced a new campus: ChalmersX, which is a platform that offers courses about the material grafen, sustainable development, and logistics for example (Chalmers University of Technology, 2016).

2.4 The labelling Möbelfakta

Möbelfakta is a reference and labelling system that concerns three different areas of requirements:

- Quality
- Environment
- Social responsibility

The purpose of Möbelfakta is to help buyers and others who work with various parts in the furniture business to determine the quality and also create a link between producers and the customer (Möbelfakta, 2011). A furniture that is labelled with Möbelfakta fulfills the criteria for ethical aspects and have passed environmental requirements as well as technical testing for quality assurance. The technical requirements regarding quality are based on European (EN)- and International (ISO)-standards. Concerning the social responsibility, the criteria originate in the UN's "Code of conduct" where "The Global Compact"- ten principles of ethical enterprising can be found (Möbelfakta, 2017).

Regarding quality aspects, there are several "use classes" where school environment is one of the categories for which a furniture can be tested and marked with Möbelfakta. To be approved in a use class the furniture must stand tests for following criteria: Safety/Behavior, Dimensions, Surface resistance, Fire/Flammability, Upholstery covering, Acoustics, Glass (Möbelfakta 2015).

3

Methods

In this chapter, the methods used in the project are described in chronological order, however, some iteration between methods has been necessary. The product development process is shown in figure 3.1 below and is created by the project team.

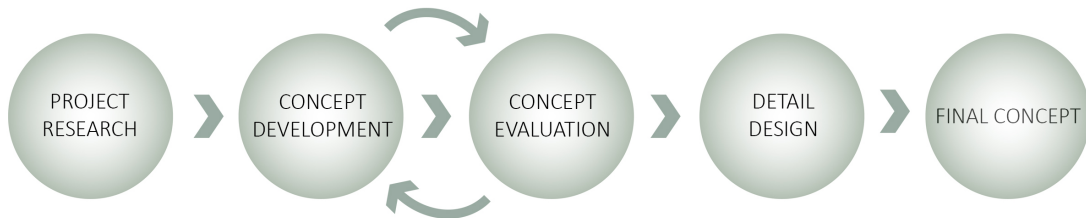


Figure 3.1: Product development process (Picture created by the authors).

3.1 Project planning

In order to work in a structured project process, a plan was made to specify project goals and important activities. The project plan is stated in the following section Gantt-chart, and the purpose is to make sure that no activities are missed out and that the project follows the timeline.

3.1.1 Gantt-chart

A Gantt-chart is an appropriate tool when creating a general project time plan, as it quickly declares the main activities from the project's start to end (Johannesson, Persson and Pettersson, 2013, p. 659). The time is represented by the x-axis and the activities are listed on the y-axis. A horizontal line represents each activity and its estimated time.

In this project, a Gantt-chart was created in order to state all the important activities in relation to the available time. To see the Gantt-chart, go to Appendix A.

3.2 Methods for research

An important part of this project is to identify user needs in a classroom environment. Therefore, methods for user studies are presented in this section, together with methods regarding literature studies.

3.2.1 Literature studies

Literature studies are in general used in order to collect information about current knowledge in a field (Osvalder, Rose and Karlsson, 2015, p. 491). In this project, literature studies were used in order to collect the needed information to background theory. The research includes information regarding ergonomics and sustainability in furniture design, physical working and learning environments, pedagogy and future teaching techniques.

3.2.2 Semi-structured interviews

Among the various types of interview structures, the semi-structured form can be used to be able to get both qualitative and quantitative data. There is a preset structure with questions but it is also possible to add attendant questions during the interview (Osvalder et al., 2015, p. 487).

Interviews with semi-structured form were conducted in order to investigate what teachers and people working in the furniture business area think, feel and what values and experiences they have regarding learning environments today, and also what they are expecting in the future. All interviews were conducted in Swedish, due to an assumption that the interview persons would be able to express feelings and thoughts better in their native language. The interview guides can be found in Appendix C.

3.2.3 Observations

The purpose of using observations in a research phase is to gain knowledge about the users in a real and specific situation. Observations can be used to see how people interact with the surrounding or with specific equipment and can also show what problems that occur in the interaction (Osvalder et al., 2015, p. 484). Observations can be direct, where something that happens at the moment is observed. Observations can also be participating, where the observer interacts in the situation that he or she observes. Moreover, an observation can be open or hidden where the in a case of an open the observed people are aware of the observer (Karlsson, n.d, p. 1-2). Before an observation is performed the project team should decide: "What" should be observed? "Where" - in what surrounding? "Who"- should be observed? "How" - should there be a present structure or not? and "Who should perform the observation" (Karlsson, n.d, p. 1-2).

In this project, observations in classroom environments were done in order to obtain knowledge about how students use the furniture and devices that are available. The purpose was also to observe how students interact with each other and how the physical environment encourages or prevents that. The observations were direct, open and semi-structured where some areas that should be considered during the observations were decided in advance.

3.2.4 KJ-analysis

The purpose of the method KJ-analysis is to compile a large amount of qualitative data in order to categorise and present the result easily (Karlsson, 2007b, p. A10). The method is based on collecting details and statements and write these on post-IT notes or similar. The notes should then be placed on a big paper or a wall, where different groups of statements and details that are somehow connected to each other should be put together (Karlsson, 2007b, p. A10).

This method was used in order to gather interesting statements and feelings from the interviews and observations.

3.2.5 Kano-model

The Kano-model is used to categorise customer needs into three categories: "Basic needs", "Performance needs/satisfiers" and "Unexpected needs/delighters" (Karlsson, 2007a, p. 19-20). The model, which can be seen in figure 3.2 shows how these requirements influence the customer satisfaction if they are fulfilled.

The basic needs are usually never mentioned by the user/customer because they seem to be obvious. The Performance needs/satisfiers are the requirements that are mentioned by the customer and important for the main performance of the product. These requirements have to be accomplished in order to deliver a product that will satisfy the customer. The unexpected needs/delighters are requirements that are not mentioned by the customer, but neither obvious. These are needs and problems that the customer might not know they have before the product helps to solve them. This will give the customer/user extra satisfaction when using the product (Karlsson, 2007a, p. 19-20).

In this project, the Kano-model was used to categorise the requirements that were identified through the KJ-analysis, in order to find which requirements need to be satisfied for a concept to work properly and which are delighters that will improve the user experience.

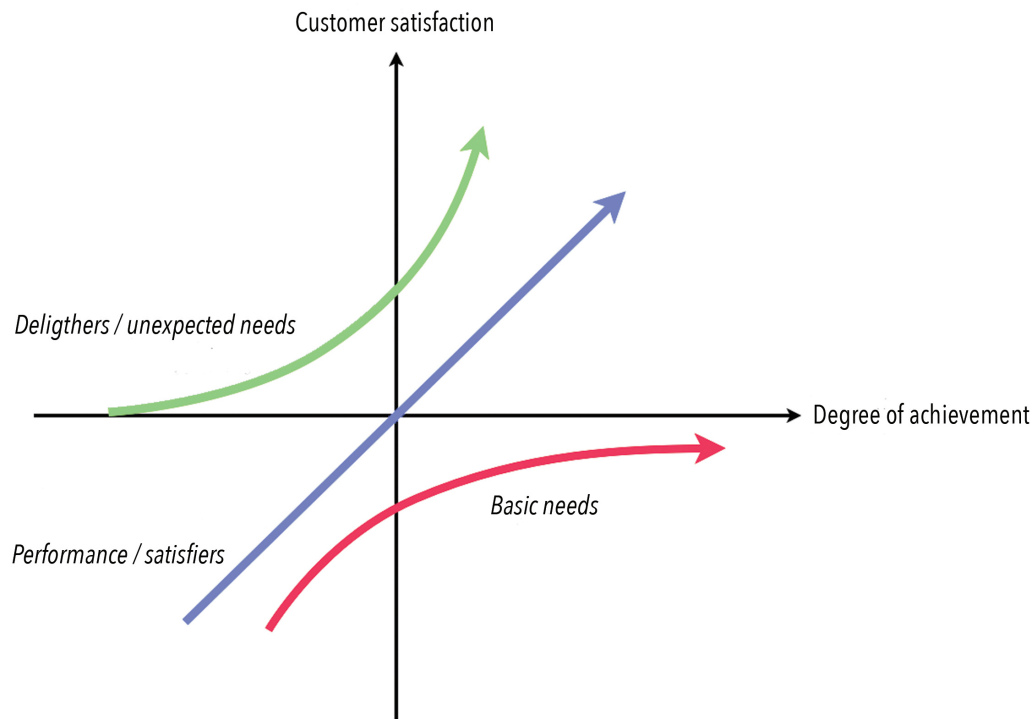


Figure 3.2: The Kano-model that shows the relation between the customer satisfaction and how well the requirements are fulfilled. The model also shows three levels of user requirements that are visualised through the arrows. (Picture created by the authors).

3.2.6 Scenario

The use of scenarios in product development processes can illustrate a situation and how a user interact with the surrounding or with other people. Scenarios are fictive stories that describe an everyday situation and should include details in the surrounding and feelings that occur (Johannesson et al., 2013, p.270). User scenarios were made in this project in order to create an impressionistic description about the everyday life of the users, pupils, and teachers in learning environments.

3.2.7 Survey

To use a survey is according to Bryman & Bell (2013, p. 245) in some ways similar to a structured interview but there is no interviewer present to ask the questions. Surveys are an efficient way to reach many people in a short time compared to reach the same amount of people through interviews.

In this project, a survey was used to retrieve a weighting of customer requirements. The customer requirements, that were defined and categorised in affinity-charts, were put together in a survey in order to be prioritised by the users.

3.2.8 QFD - Quality Function Deployment

QFD, Quality Function Deployment, is a method to systematically translate qualitative customer requirements into measurable criteria for construction (Johannesson et al., 2013, p. 159, 296-301). The method also includes a competitor analysis, a benchmarking. The outcome of the method QFD is a weighted specification of technical requirements, which serve as a guideline for further development.

The process of QFD, described by Johannesson et al.(2013, p. 160-161) and Österlin (2011, p. 70-72) starts with identifying customer requirements. It is essential to systematically analyse customer needs, in order to be able to specify these in the QFD-matrix. This could be done by a market analysis (Johannesson et al., 2013, p. 297). In this step, requirements also need to be weighted from a customer perspective.

The next step is to define how these customer requirements should be accomplished. This is done by defining design requirements, the different functions of the product. For each function, a measurable limit or target value is defined, to enable test and verification.

The following activity is to investigate the correlation between every customer requirement with every product function and answer how strong the relation is between them. This is also done regarding the relation between each product function. The relation shows if the different functions are supporting each other or if they are counteracting.

To complete the QFD, the next step is to conduct a competitor analysis and analyse how existing solutions meet the customer needs. One perspective of the competitor analysis is how the solution meet the identified needs, but in addition to this, a competitor analysis also should be done regarding the technical parameters in order to investigate how well the solutions meet these criteria.

All of this information is structured in a QFD-matrix, which summarises:

- What is needed (Customer requirements).
- How this can be provided (Product functions).
- Correlations between customer requirements and product functions.
- Correlations between different product functions.
- Competitor analysis from both customer and technical perspective.
- Technical target values, level of difficulty and final weighted score.

The final weighted score indicates how important the different functions ("hows") are in order to achieve the customer requirements ("whats").

3.3 Methods for concept generation

In order to come up with concept ideas, various creative methods are used. In this section, the methods are presented and special modifications for this project are described.

3.3.1 Function analysis

A function analysis should answer why the product should exist, what is the main function and what should the product accomplish (Österlin, 2011, p. 42). The main function describes the primary purpose, and functions that contribute to the main function to work is called part functions. If there are functions that clarify the superior functions these are called supportive functions, which could be for example a labelling or expressing identity. The supportive functions are not required in order to fulfill the main function (Österlin, 2011, p.43). In this project, the method was used to identify which functions should be included in the concepts during the idea generation.

3.3.2 Brainstorming

The purpose with brainstorming is to come up with as many ideas as possible during a session. All ideas should be considered and no criticism are allowed in this stage of the idea generation process (Osvalder et al., 2015, p. 502). The method is often used in a group of 5-15 people and there are according to Johannesson et al. (2013, p.166) four rules to consider during the session:

- No criticism are allowed
- Try to obtain quality
- Think outside the box
- Combine ideas

In this project, the method had to be modified regarding the number of participants, where the project group consists only of two persons.

3.3.3 Idéskiftesmetoden

"Idéskiftesmetoden" is a creative method where the group members sketch on a couple of ideas each, regarding a predefined problem, before they exchange paper with each other. When the group members have switched their ideas the task is to further develop the ideas on the new paper in order to take a new approach to the problem (Johannesson et al., 2013, p. 170).

The session in this project was done by the two project members and the papers were exchanged twice.

3.3.4 Katalogmetoden

"Katalogmetoden" for idea generation is a common method in order to get inspired by other existing ways to solve the same or similar problem. For example, newspapers, magazines, and other literature can be used to find associations and inspiration to sketch new ideas (Johannesson et al., 2013, p. 172)

In this specific project, furniture and interior design magazines were used, together with papers about nature and art. The method was made individually in the group where the members sketched as many ideas as possible during the session.

3.4 Methods for concept evaluation

In the following phase, methods for concept evaluation and elimination are presented. The evaluation considers opinions from both customers/users and people in furniture business together with the voice of the project team.

3.4.1 Elimination matrix

In order to evaluate the four developed concepts that passed through the last step of the idea generation, an elimination matrix was used. An elimination matrix is used to identify which concepts that should be further developed or which should be eliminated from the process. Osvalder et al. (2015, p. 506-507) describe one form of elimination matrix where the concepts get rated in different categories with (+/Yes) (-/No) (?/More information is required). The categories used in that matrix is: Solving the main problem, Satisfies requirements, realisable, Safe and ergonomic and Suitable for the company.

Some modifications of the original matrix were made for this specific project where the earlier identified customer requirements were used as categories in the elimination matrix and every concept was evaluated with (Yes) (No) and (Possible). The purpose of this method was to take care of "The voice of the user" where the weight of the requirements are done by the users and the estimation regarding if or if not the different concepts meet the user requirements are made by the project team.

3.4.2 PNI-analys

The method called PNI that aims to find positive, negative and interesting aspects of concepts in an elimination process. One purpose is to find this interesting parts that should be considered in further product development (Österlin, 2011, p. 66).

The project group had a session of discussion with base in the PNI method. All concepts were careful analysed and evaluated with (+) for positive aspects, (-) for negative and (?) for interesting parts that for example could be transferred and applied to other concepts as well. The purpose of this part was to visualise the project group's own opinion regarding which concept should be further developed.

3.5 Methods for visualisations

In order to visualise the concepts during the product development process, some different methods and tools were used.

3.5.1 Sketches

The early stages in the process contained mostly sketching by pen and paper, and further on Photoshop was used in the visualisation process.

3.5.2 Prototyping

Prototypes can be made with various methods with different purposes. According to Johannesson et al. (2013, p. 124) CAD (Computer Aided Design) can be used in order to create virtual prototypes where dimensions can be tested. Also, it is possible to make simulations considering moving mechanisms. Mock-ups is a kind of prototype that express shape and colour. Both of these methods are used in this project and further description can be found below.

Mock-up

Mock-up is a full-scale model where for example dimensions and accessibility can be tested in a real environment (Österlin, 2011, p. 82, 112). In order to try the concept in terms of dimensions, proportions, and shape before the phase of 3D modelling, a mock-up was made. The base of the chair was taken from a Kinnarps AB's chair Xact where the star-base with gas-spring and wheels were kept in its original performance. The mock-up was made in scale 1:1 and built of foam board and paperboard.

Computer Aided Design (CAD)

The program used for 3D modelling was Catia V5, which is a program where both surface- and solid-modelling can be made. STEP-files, which are 3D-files, was created and used as basic data for prototyping. The same program was also used in order to do renderings.

4

Project Research

In this chapter, results from interviews and observations are analysed and user requirements are identified. The aim of the user studies is to gain knowledge about the users in the context of classrooms. The outcome of the study is requirements which will be the base and guidelines for the product development.

4.1 User studies

In the following section, the outcome from the interviews and observations are summarised and presented.

4.1.1 Interviews

During the pre-study, interviews with teachers and experts working in furniture business were conducted. During the observations, some pupils were spoken to as well regarding their education environment. Below, the input from the different interviews is summarised in different user groups and a table of interviewees are presented.

Table of interviewees

The following people were interviewed during the project research phase. The sample of interviewees was made to cover different areas within the fields school and furniture business. Regarding the sample of teachers and students, the geographic area is Gothenburg and its surroundings. The teachers tutor different subjects and have varied years of experience in school. In the furniture business, people who have direct contact with the customer and users in learning environment were interviewed in order to get information about their perspective of the business and user needs.

Occupation /Title	Company
Next Education Manager	Kinnarps AB
Consultant in school- and business development	Åke Westh Konsult AB
Interior designer/Sales representative	Kinnarps AB
International Product Manager - Chairs	Kinnarps AB
Software engineer (former teacher)	Engineer consultant company
Teacher student, year F-3	Gothenburg University
Teacher gymnasium 1-3 (Art/Swedish)	Polhem gymnasium
Teacher, year 6 (Science)	Fridaskolan Mölnlycke
Teacher gymnasium 1-3 and adjunct principal	Donner gymnasium
International Product Manager - 3rd Space	Kinnarps AB
Teacher gymnasium 1-3 (Mathematics)	Donner gymnasium
Special pedagogue	Utvecklings/Stödenheten Härryda

Figure 4.1: Table of interviewees.

Teachers

In Swedish schools today, most pupils in secondary school and higher grades do not have a set home classroom, but switches between different classrooms depending on which subject that is current on the schedule. The teachers tutoring subjects such as art or science have lessons in specific classrooms adapted for these subjects. Other teachers, tutoring subjects that are not depending on special equipment may change classrooms more often.

A common opinion among interviewed teachers is that furniture in classrooms is lacking in flexibility. *"We would really need chairs with wheels, now it is a lot of dragging back and forth"* (Teacher year 6, personal communication, 23rd of February 2017). Another teacher says: *"The teacher often has a lot of things that should fit into the ordinary schedule, and then you don't want to spend ten minutes to rearrange the furniture in the classroom. Then you just run with it, but the pupils do not sit in an optimal, pedagogical, formation"* (Teacher gymnasium 1-3/adjunct principal, personal communication, 24th of February 2017). The lessons are often divided into several parts, for example, lecture, discussion or individual work and one part with a summary of the lesson. Another teacher also expresses that there is not enough time in between the activities to rearrange the furniture. This, even though it might be more suitable with another form of arrangement in the environment.

Teachers also mention that all pupils have different needs, some of them more special, that has to be satisfied to enable the pupil to learn. During interviews with teachers, there was an expressed need of a flexible classroom environment to meet these different requisites - for example, the need of shielding for a private area.

One situation that is common in school is when pupils have tests or exams. Tables and chairs must then be rearranged into single working spaces, due to minimising the risk of cheating. This process could be tricky and time-consuming. Another specific situation exemplified by a teacher is when pupils move chairs into a formation suitable for group discussion, they often have their laptops in their lap. In this situation, the teacher could see the need of a smaller close-by working surface.

There is an awareness among teachers of an economic limitation - they might want a new interior design but often there is no budget for this in school. Nevertheless, they would gladly change the environment if they could.

In future, interviewed teachers think that a major part of the education is going to be digitised. According to a newly graduated teacher, it becomes more and more common with 1-to-1, (one laptop to one student). Some subjects in school, for example mathematics, is often taught in a traditional way, writing with pen and paper even if there is a lot of pedagogical programs available for computers. Moreover, the newly graduated teacher expresses that there have been a lot of discussions regarding the negative aspects of the use of digital devices in school. The teachers loose control over what the students really are doing with their computers, are they listening during the lessons or are they spending time on social medias? Also, mobile phones are often prohibited for students to use during the lessons, in order to be able to concentrate. This is mainly something that has to do with students behaviour and maturity, why one teacher says that they are talking a lot to the students about this and tell them that it is their time, their education. According to this teacher, it is also important to bring up questions regarding Internet behaviour and bullying.

Today there are still some problems to solve when the schools become more and more digitised, but there is a good side as well with computers and mobile phones. For an example, there are some great programs for students with writing- and reading disabilities to use in their education. According to a newly graduated teacher, there is a part missing in the teacher-training program regarding how to use computers in the education in order to make it a good resource instead of an obstacle.

One teacher also talks about today's limitations in the physical environment, such as access to a power supply connected to the pupil's work area which is necessary if the digital education should work without a problem. When using digital tools you are also very dependent on a good Internet connection, something that one teacher find often does not work properly today.

Mentioned in Theory, see section 2.2, there is a lack of research about how physical environment is affecting students results. Although, there are teachers that have

personal experience of how physical environment affect study results. A special pedagogue who has a long experience of working in schools, currently working with supporting schools in Gothenburg municipality regarding both inclusive learning environment, physical environment, social environment and the didactic environment. She sees a connection between these different aspects and the physical environment - for example, that the layout in schools affects the ability to concentrate. This may have an effect on students results in turn.

Students

During the observations, some semi-structured, spontaneous, group interviews were done with pupils in order to find out what they thought about their learning environment.

In many classrooms today, the interior is very stationary, and according to some pupils in the 9th grade, it is unusual that they move around furniture in order to adapt the layout for the teaching situation. They say that they often arrive just a few minutes before the lecture starts, and so does the teacher, which leaves no time for rearranging the furniture. Because of the placement of the tables in the classroom, some pupils sit with their back against the teacher and the whiteboard. This makes the students twist their backs when the teacher gives instructions, which is not an optimal sitting position.

Functions in furniture, such as adjustable footrests at a chair, are good, but not used in higher grades where the students change classrooms for the various subjects. This leads to that a chair which should be good when the footrest is at the right height are not good at all when it is not adjusted after the student who sits there. In this case, the students say that they easily slide of the seating area when they do not reach the footrest.

Both students and teachers talk about the network connection that is often bad, especially in some classrooms. The students think it is really slow compared to what they are used to at home and think they lose a lot of time just waiting for the Internet to work properly. The second problem connected to this, in classes where all pupils have one laptop each is the limited access to a power supply when everyone has to charge their laptops. Some student express that they would rather work at home where they have a high-speed Internet and want to have web-based instructions for the school assignments.

Many students express that they are having trouble concentrating when there are a high noise level and discussions in the classroom. They talk about that it would be great to have small group rooms in connection to the classroom to use during group work, and also if you want to sit alone to concentrate on individual work. Moreover, the pupils talk about the light, that classrooms with windows and daylight are much better for the concentration and the energy. They also mention that there should be some more varied lighting to make the environment more pleasant.

Also, the overall physical environment engages students when they are asked. *"Think of an office", one student say, "they have a lot of different colours, indoor plants, textiles and so on. Everything in school is very white and plain which makes the classrooms boring".*

Some student talk about that sitting for long times during school hours makes them tired. When they are asked if they would like to have the opportunity to work while standing at lectures, some think that would be great while others express their doubtfulness for this. But they all agree that it would be great to be more physically active during the lessons.

When the students were asked how they would like the classroom to be furnished if they could choose, there are a lot of various thoughts. Some students would like to have tables paired in two, some in long rows turned against the whiteboard, others want separate desks and some want to sit in groups. This makes is very clear that people are different and have various needs in a school environment. It is also obvious that one style of furnishing does not suit everyone and that the flexibility in many classrooms today are very low.

Insights from furniture business

In one interview with the International Product Manager at the department "Chairs" at Kinnarps AB, he was asked about what needs he would say are not satisfied in today's school environment. The answer that follows describes very well the overall situation, which is also strengthened by the other interviews. *"There are no solutions that are flexible and good enough, there are still very simple chairs made by wood, stationary tables, stationary chairs and very little focus on activity, movement and ergonomics. No one really states any demands on these parts. Prior everything it is very low flexibility in the furniture, four fixed legs with a work surface and a chair with four legs and a wooden seat. These are not furniture that is able to adjust when the pupil grows older, very often it is not even possible to adjust the height. So there is an obvious need of more flexible furniture, the opportunity to rebuild or rearrange the classrooms. More movement, chairs that can be adapted with easy adjustments. The best thing with good ergonomics is to move. The next sitting position is the best one, and that concerns youths as well."* (International Product Manager - Chairs, personal communication, 16th of February 2017).

In the development of schools today, there is one important factor to take into consideration, according to the Next Education Manager at Kinnarps AB 8 out of 10 schools are old schools that need to be renovated and 2 out of 10 are newly built schools. The limitations in the physical environment in old schools such as the classroom structure and long corridors, make it a challenge to do a total reconstruction and may limit the development to implement new furniture and interior design. In the making of new schools, there is a greater opportunity to transform the overall learning environment in order to meet the needs of today and tomorrow.

Moreover, changes in the education, mainly the digitising creates new demands

in the learning environments. According to the International Product Manager 3rd space at Kinnarps AB, programming will be a very important subject in school where all students have to be able to encode in future. The technology and availability are consequently the main challenges for today's school in the adaption to future education. This is also according to an Interior Designer/Sales Representative at Kinnarps Interior, one main reason to try to implement a more flexible and activity base furniture concept in schools today, to meet the new ways of teaching, where teamwork becomes a greater part of education.

There is according to a consultant in school- and business development, another limitation besides the physical environment in school, and that is the organisation which is based on time planning and scheduling of activities rather than planning how the teaching should be performed or what should be taught. The organisation spends a lot of time to ensure that the teachers are occupied and what classroom should be used at what time, but there is no focus on the content.

In order to achieve knowledge about the users (student and teachers) and to be able to interact with the customers (often principals), employees at Kinnarps AB visit different schools and other learning institutions. Something that according to the Next Education Manager at Kinnarps AB is one big challenge is the limitations in the physical working space which also makes the whole environment very stationary and non-flexible. According to an Interior Designer/Sales Representative at Kinnarps Interior, schools are sometimes afraid of investing in a new furniture concept which include student chairs with wheels and areas based on different activities, it often ends up with traditional furniture in the order after all. The same representative at Kinnarps Interior believes that school managements probably think that it will be messy and a high noise level if all students will ride around with the chairs to different areas in the classroom. After all, the flexibility seems to have two sides, one positive and one that might bring more trouble to the learning environment, this probably also depends on which grade the students are in, older pupils might handle the situation better.

The occupancy of areas in schools today such as classrooms, dining rooms, and gymnastics room is today very low, according to a consultant in school- and business development, about 40 % during the semesters and 20% rest of the year. With a more flexible interior design, the usage of theses areas could be more efficient and open for other activities outside education hours.

It is not only the limitations in the physical classroom area that has a negative influence on the learning situation today, it is also other factors such as ventilation and lighting. The lighting in schools today are often just a wide ocean of light from fluorescent without any focus points at all, according to the consultant in school- and business development, this makes it harder for pupils to concentrate. Also, the absence of daylight in classrooms has a negative influence of the focus and energy.

4.1.2 Observations

During the observations, the learning situations in classrooms were the main focus area. Students and teacher in different grades and schools were observed during various types of lessons, such as language, biology, art & design, and science. In this research, four schools were visited in Gothenburg and its surrounding areas.

One main difference that was identified was the working space required for the various school subjects. The art & design classroom had large tables put together and all space was occupied by A3-papers, pens, acrylic paint, computers and digital sketching notepads. This in comparison with the class in Swedish, where the students only brought one fiction book each and some of them also computers, requires a significant smaller working area. The most common things to bring into class was: computers/notepads, pencil cases, notebooks, and textbooks.

In almost all classrooms there is a more ergonomic chair intended for the teacher, but during the observations, none of the teachers really used this chair. They all stood while having their lectures. There are some situations where the teacher interacts with the pupils giving supervision or similar, in that instance, the teachers often grab a student-chair and sit beside. This situation also shows that while the teacher sits down giving a supervision to a group of student he or she often put the laptop in the knee to be able to move on to next group quickly.

Most of the lectures that were observed, included situations where the students should work together in pairs or in small groups after the teacher's briefing. This required the students to move around in the classroom, sometimes also move some of the furniture (chairs and sometimes tables) in order to form the groups. A higher noise level occurred in these situations and difficulties with lack of space when moving around furniture were observed in these moments.

All schools that were included in the observation offered every student either an iPad or a laptop to use in their education. This requires the opportunity to charge the units, which otherwise becomes useless. The observations show that the classrooms today are not adapted for this digitisation and sometimes there are about five wall sockets available for 30 students with laptops.

According to theories in pedagogy, see section 2.3, it becomes more common to collaborate and work in groups, which is something that also could be seen during the observations. In this situation, it becomes even clearer that today's classroom environment is not really adapted for the education. The noise level becomes high and some students seem to find it hard to concentrate in the groups. Smaller areas (group rooms or similar connected to the classroom) is something that seems to be missing in all schools that were observed.

Jackets and other outdoor clothes are often left outside the classroom in personal lockers or just hooks at the wall. Sometimes the students bring jackets inside and put them on the back of the chair. Bags and other personal belonging were the

same scenario, sometimes even put in big humps on the floor in absence of available storage.

Students with special needs are often challenging for the schools to include in the education in the way the students are in need of. One school had built a small area with portable walls, a better ergonomic chair and an own table where one student stayed for all lessons in order to manage the studies. There seems to be no other logic way for the schools to handle these situations apart from being creative and solve situations when they occur.

The types of furniture found during the observations are mostly classic school-furniture: chairs made of wood/steel and simple tables. The furniture is very static and not equipped with wheels. None of them seem to be adjustable in height, or if they were, no one changed them because it took too much time and effort.

Various learning situations

During the observations, notes were taken regarding what activities that takes place in class and how pupils and teachers use the classroom. Following figures in this section illustrates some of these different learning situations.

Figure 4.2 shows three different situations during a lesson with pupils in grade 9. The current subject was technology based science and the left side of figure 4.2 shows how pupils (coloured dots) take their place when the lecture is supposed to start. Soon, the two teachers (purple dots) asked pupils to form a ring. Chairs were dragged on the floor and the procedure took a few minutes before everyone fitted in the created half moon ring. The teachers led the discussion, started by checking in with the students, re-capping the last work and what is to come. The assignment of this lesson was to work in groups solving a construction problem, and students moved back to the tables, seated in small groups. One group chose to move a table to get a more separated and private working area, illustrated to the right in figure 4.2.



Figure 4.2: Illustration of how pupils and teachers move around in classroom during a lesson in technology based science. Purple dots represents teachers. Yellow, red, green and blue dots represents pupils and grey dots represents the observers. (Picture created by the authors).

As can be seen in the middle section of figure 4.2 some pupils sits on top of the table during group discussion, an example of when the physical environment is used in an unexpected way. A sketch, illustrating the pupils, was made in this moment and shown in 4.3.



Figure 4.3: Pupils using furniture in unexpected ways. (Picture created by the authors).

Another learning situation is illustrated in figure 4.4 and show pupils in 3rd year in high school, having a lesson in science. In this particular school, the furniture is consciously arranged in a way that is supposed to promote interaction between students, in line with Collaborative Learning (see chapter 2.3). The way tables and chairs are placed, students are facing each other while sitting down in class. During observations, it becomes clear that this is followed by some difficulties. During the lesson's first 20 minutes, several pupils were forced to have a twisted working posture in order to see the teacher, because of the furniture arrangement. This part of the lesson is shown to the left in figure 4.4. The latter part of the lessons consisted of project group work and supervision by the teacher, one group at a time. The students moved around, chose a seat close to their group members. In this part of the lesson, the furniture arrangement seems to work well, as it became natural to form groups around the tables. Although, some students chose to move outside the classroom since they needed a more private area.



Figure 4.4: Illustration of how pupils and teachers move around in classroom during a lesson in science. Purple dots represents teachers. Yellow, red, green and blue dots represents pupils and grey dots represents the observers. (Picture created by the authors).

The following figure, 4.5 illustrates another class in their 3rd year of high school, having a lesson in Swedish. The lesson starts with a short briefing, where the teacher went through some planning and instructions. As can be seen in the illustration, the teacher (purple dot) then leaves the classroom together with one student, for a one to one feedback session in private. The assignment for the rest was to 1. read their book or 2. discuss the read chapter with a colleague. At first, there was a calm working environment, pupils concentrating on their books. Just a few minutes later, one pupil who was finished reading chose to use the teacher's chair with wheels and interact with students at another table. Soon, more students finished reading and started to discuss their chapters, hence the sound level was raised. Some students might have acted on the fact the teacher was not in the classroom, as they joined a more relaxed discussion with some of their classmates. At this point, shown to the right in figure 4.5, some students are reading, some are discussing their books, some are chatting about other events - altogether, there was a variety of activities.



Figure 4.5: Illustration of how pupils and teachers move around in classroom during a lesson in Swedish. Purple dots represents teachers. Yellow, red, green and blue dots represents pupils and grey dots represents the observers. (Picture created by the authors).

By the observations, it is clear that the need of work space is depending on the subject and the activity. In creative and practical subjects such as art, and in the specific technology based science class described above, there seems to be a need for a somewhat large working area. In all other observed subjects and situations, the used working area is smaller. During almost all observations, the activities in classroom caused pupils to move or to move furniture in order to adjust the environment to their needs.

Different layouts in classrooms were identified through the observations. One interesting note is that one classroom suitably designed for group work was not very suitable for lectures or teacher's briefings, and one classroom designed to fit ordinary lectures was not optimal regarding group work.

The observations also confirm that many different activities take place in a classroom, several of them occurring during one lesson. Examples of teaching situations are:

- Lecture/briefing
- Group work
- Group discussion/seminar
- Individual work
- Test/Examination
- Workshop
- Presentations

4.1.3 User scenarios

The result from the user studies, with observations and interviews, can be summarised in two different fictive user scenarios, which illustrates how a classroom environment may be used today.

The teacher

Science is on class 9's schedule. The pupils take their seats and the lecture begins. First, teacher Marie holds a presentation about climate changes and the global goals for sustainability, then she tells the pupils to group up for discussion about what they can do in their everyday life, in order to act sustainable. They should discuss for 15 minutes and then present their result for the rest of the class. As usual in these situations, sound level rises since some pupils drag tables and chairs on the floor with the aim to get a more private area for group work. Some pupils assemble around a table, taking their chairs with them. When it is time for presentations they arrange the furniture in a half circle around the whiteboard. The rearrangement takes a few minutes but Marie believes it is important for everyone's participation during the presentation.

After the science lesson, Marie is in a hurry. The time between lessons are short and next class on the schedule is supposed to have a test. Therefore, she needs to rearrange the tables that usually are placed in a row, into separate stations with enough spacing in between them. It is a noisy and somewhat heavy process, she feels stressed when the pupils arrive. A few pupils arriving early helps her with the last tables.

The pupil

Sara has just started her second semester in high school together with 27 other students in her class. She is an active person that loves to play football and perform gymnastics in her spare time. The favourite subjects in school are mathematics and art because it enables you to try completely different skills. When she arrives at school every day she goes to her locker in the corridor and brings the books she needs for the first lecture, along with her laptop. She leaves the jacket, bag and everything else because there is no room to store that in the classrooms which is rather small.

English is the first subject on today's schedule and Sara enters the classroom and chooses a place in one of the front rows, where she can be sure to see the whiteboard because she is quite short for her age. She tries to put her feet on the footrest on the chair, but she can not reach it. Sara does not know how to adjust it so she just put one leg over the other instead and does not care about the footrest. When the teacher is done with describing the assignment, the pupils should work individually, a few pupils start talking and Sara finds it hard to concentrate. She thinks of going out in the corridor to find a quiet place, but she stays in class so she can easily ask the teacher for help when necessary.

4.2 Identification of user requirements

In this chapter, the needs and demands existing in the studied context are presented, as well as the process of identifying them. Furthermore, the identified user requirements are explained and weighted through a survey. In the end of this chapter, a benchmarking is done and finally, all information is compiled in a QFD analysis and a list of requirements.

4.2.1 Categorising of requirements

By analysing the documented information from observations and interviews, different needs in a classroom environment were detected. In order to categorise these statements and requirements, a KJ-analysis was made. The analysis resulted in following groups of concerns: flexibility/mobility, concentration in class, individual work/groupwork, storage, ergonomics, and technology. This resulted in a list of needs that exists in a school environment.

After the categorising in groups, the identified user requirements were translated from Swedish into English before they were put in the Kano-model and affinity charts. The different needs were divided into basic needs, wanted needs/satisfiers and unexpected needs/delighters and presented in a Kano-model below:

Basic needs

- Have a surface to work on with room for books, papers, pens, notebook, laptop/iPad, water bottle.
- Have a work surface in direct connection to sitting/standing opportunity.
- Opportunity to store belongings (books, pens, laptop and more).
- Storage and opportunity to hang outdoor clothes and bags.
- Be able to see the whiteboard from all places in the classroom regardless of the height of a person.
- The seating area must be adapted for people with various body dimensions.
- Free floor space where the teacher can move between the pupils in the classroom in order to help and give instructions.

- Sustainable furniture (meet the requirements to be labelled according to the standards of "Möbelfakta").

Performance/satisfiers

- Be able to keep the noise level low during discussion exercise.
- Access to group rooms in connection to the classroom. (In order to be able to concentrate and shielding during group work or individual work).
- More mobile interior and furniture that can be moved around depending on the current needs and activities in the classroom.
- Be able to quickly switch places along with the change between individual work and group studies.
- Enable individual adjustments for pupils with special needs.
- Various types of classrooms depending on the purpose and activity.
- Prevent misuse of furniture and interior (riding around on chairs with wheels for example).
- Low noise level in the learning environment.
- Ergonomic furniture.
- Enable collaborative learning.
- The environment should enable practical exercises and offer degrees of freedom, variety, and access to work material.
- The environment should be well adapted for digital devices and tools.
- Enable interaction and communication between pupils and teachers in a good, ergonomic working height.
- The opportunity to use a projector and a whiteboard at the same time.
- The environment should be compatible with various technology (chrome books, iPads, projectors, smart boards).
- Be able to charge digital devices in connection to the work area.
- Affordable.

Unexpected needs/delighthers

- More efficient lighting solutions, offer focus-lighting.
- Ease the informal learning situations.
- Innovative furniture that can be adapted for the situation and different subjects in existing classrooms with respect to the limitations in the physical area.
- Enable various working postures (e.g. be able to stand up during the lectures).
- Increase the efficiency (furniture that eases concentration, communication and working undisturbed).
- Inspirational environment (colour, shape)
- Safety storage for digital devices.
- Furniture that encourages micro-movements.

From the Kano-model, all requirements except from "Basic needs" are used as input in the affinity diagrams below. The "basic needs" have to always be fulfilled in order to make a product that should work the way that the user expect.

4.2.2 Affinity diagram

By using the affinity diagram the different needs from the Kano-model were broken down into product-focused demands.

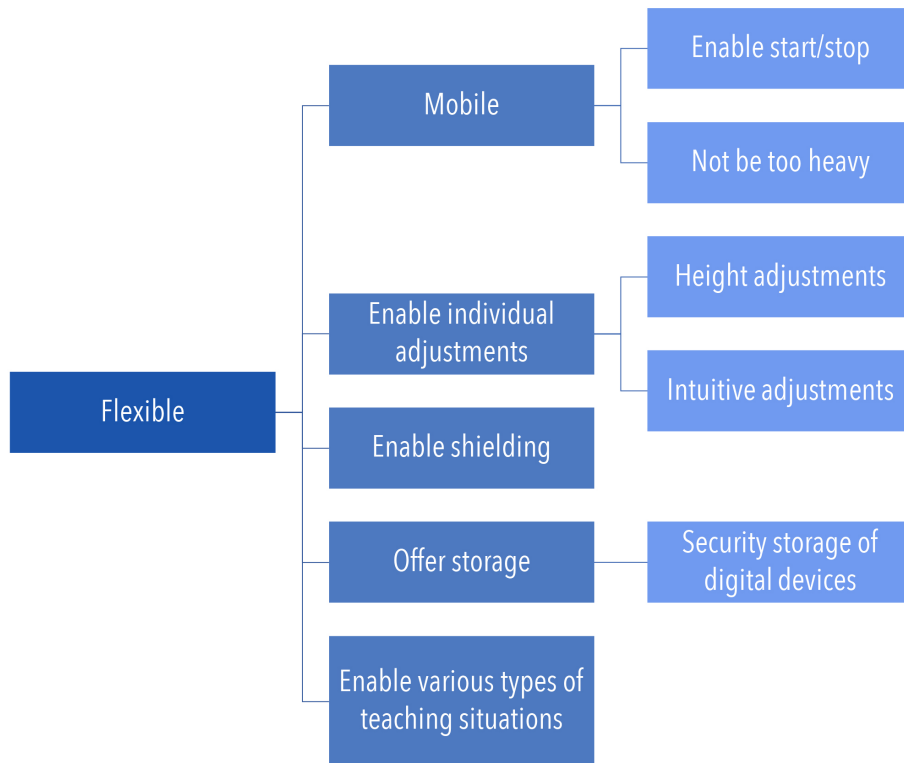


Figure 4.6: The user requirement "Flexible" broken down in three levels.



Figure 4.7: The user requirement "Security" broken down in three levels.

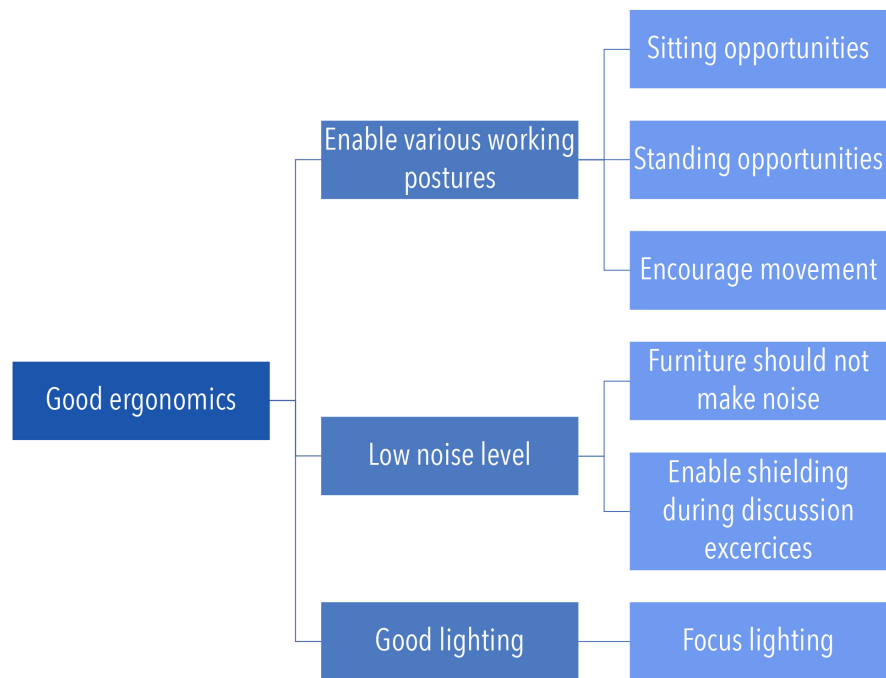


Figure 4.8: The user requirement "Good ergonomics" broken down in three levels.

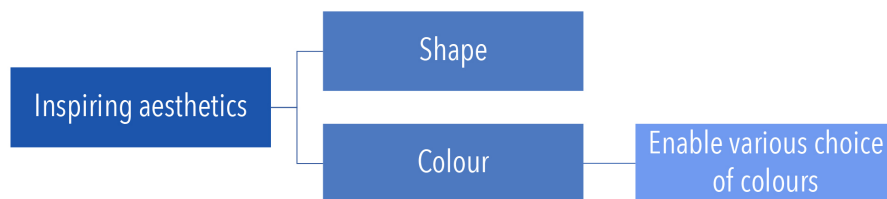


Figure 4.9: The user requirement "Inspiring aesthetics" broken down in three levels.

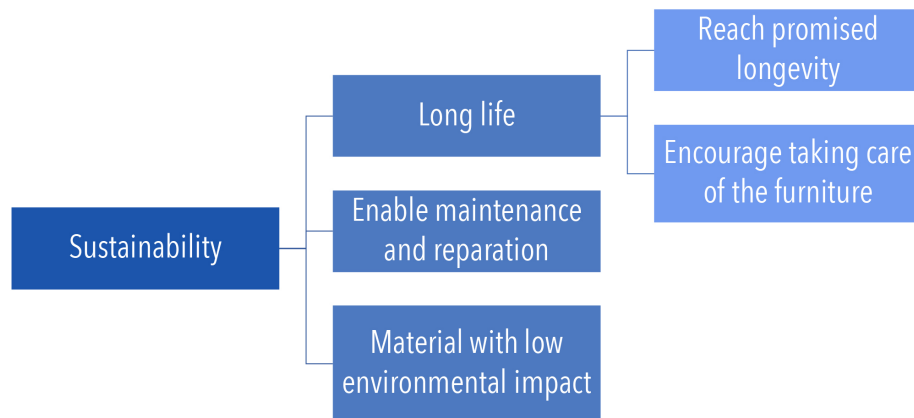


Figure 4.10: The user requirement "Sustainability" broken down in three levels.



Figure 4.11: The user requirement "Customer/user value" broken down in three levels.

The affinity diagrams show three levels of the user requirements and there are 17 requirements in the secondary hierarchy, which is the level of requirements that should be input to the QFD-analysis. These user needs are general in a learning environment and do not consider a specific product yet. In order to let the users weigh the requirements against each other, 12 requirements were chosen to take into further consideration. The requirements that did not go through to the weighting process were those which were not directly applicable on furniture or were so important that they would be considered in further product development anyway. The requirement regarding shielding could be applicable on a furniture but was in a discussion with Kinnarps AB not chosen to be focused on in this project. The 12 chosen requirements are described in the next section.

4.2.3 Definition of user requirements

The following section explains the substance of the user requirements of the second hierarchy from the affinity diagrams, which will be taken further into weighting by the users and input in the QFD-analysis.

Good quality and durability:

The product should have a good quality, which is important since furniture in schools often is used for many years. It also requires that furniture should be durable, as wear and some damage are common in the school environment.

Enable various working postures:

According to Theory, see section 2.1.2, it is important to be able to change working posture during the day. This includes the ability to change a sitting position but also to be able to stand up.

Enable various types of teaching situations:

During a day in school, the students work in various formations with different tasks. For some time they need to sit and listen to a briefing where a whiteboard or power point is used, the other minute they are supposed to work in small groups or with an individual task that might require other classroom formations.

Enable individual adjustments:

To be able to concentrate and also according to ergonomic and well-being aspects, it is important to be able to adjust furniture to individuals with various lengths and various body dimensions overall.

Be stable:

Stability is important for the safety in the school environment and is a factor in perceived quality as well.

Low noise level:

Regular classrooms today have an approximate area of approximately 60 m² and between 20-30 students are studying there at the same time. It is very common that the noise level is too high and, both from speaking loud but also from furniture that is moved around in the classroom. It is therefore, an important factor to consider in the development of furniture for a learning environment.

Material with low environmental impact:

Kinnarps AB works very actively with sustainability in the overall product development and manufacturing process. They call their work "The better effect" and they use the labelling system Möbelfakta as a proof of quality and sustainability. This is an unexpected (non-spoken) requirement that the project team believes that the user finds important and lies in the line with what Kinnarps AB stand for.

Mobile:

According to today's pedagogy, there is a tendency in a more variable learning situation where there are quick changes in the formations of students, from group-work to individual studies, to briefing for all students. Therefore, it is important to consider mobility in the furniture designed for learning environments.

Offer storage:

The observations, see section 4.1.2, shows that most of the students today carries both books, computers, papers, pens, mobile phones and bags to the lectures. Consequently, this requires space to store these belongings during the class.

Shape:

To feel inspired and according to well-being aspects, it is important to have a good physical environment, which includes the design of the furniture. The shape is therefore, an important factor to achieve this, which also interacts with ergonomic aspects in the development regarding for example angles and dimensions.

Colour:

Colour is a complementary factor to shape and may have an effect on how the product is perceived and how inspiring the total environment is.

Price:

The price has an effect of how "affordable" a product is and is one factor of customer value.

4.2.4 Weight of requirements

In order to find a priority of requirements for further product development, users (pupils in various grades and teachers) along with some people working in furniture business were asked to answer a survey. In the survey, all chosen requirements from the affinity diagrams were rated against each other and evaluated through the question: "Regarding furniture in school environments, what value is the most important for you?" All answers in the survey were analysed and later organised in a matrix, see figure 4.13, which shows in what order the users find the requirements most important. The weighting of the requirements is further input in the method QFD in next step of the research.

55 responses from students, teachers, and people in furniture business resulted in following weighting of requirements that can be seen in figure 4.12. Each requirement is given a letter from a to l and all the requirements are weighted against each other. The mid section shows the letters of the winning requirements in every weighting.

4. Project Research

User requirements												
a Enable various types of teaching situations												
b Low noise level	a											
c Mobile	a	b										
d Material with low environmental impact	a	b	d									
e Enable individual adjustments	a	e	e	e								
f Offer storage	a	b	c	d	e							
g Good quality and durability	g	g	g	g	g	g						
h Price	a	b	c	d	e	f	g					
i Shape	a	b	i	d	e	f	g	i				
j Be stable	a	j	j	j	j	j	g	j	j			
k Colour	a	b	c	d	e	f	g	h	i	j		
l Enable various working postures	l	l	l	l	e	l	l	l	l	l	l	
	a Enable various types of teaching situations	b Low noise level	c Mobile	d Material with low environmental impact	e Enable individual adjustments	f Offer storage	g Good quality and durability	h Price	i Shape	j Be stable	k Colour	l Enable various working postures

Figure 4.12: The result of the weighting by the users.

Some of the requirements had almost the same amount of votes why this weighting should be seen as a support in the further development and gives a hint of what demands that are important for users. It should not be taken as a definite result, but as one part of defining what needs that should be focused on in the concept development. The result is put into the QFD-matrix, go to Appendix B to see the full diagram.

The requirements that had almost the same votes were:

- Enable various types of teaching situations / Good quality and durability
- Price / Colour
- Enable individual adjustments / Enable various types of teaching styles
- Offer storage / Shape
- Enable various working postures / Good quality and durability

Those requirements differed less than one percentage point between them, but they also end up with almost the same amount of votes among them. For example, the requirements "Enable various working postures" and "Good quality and durability" ends up at the same place, which can be seen in figure 4.13 and that is somehow a proof that the last percentage point should not make a major difference for the result.

User requirements	Result	Weight
Good quality and durability	10	5
Enable various working postures	10	5
Enable various types of teaching situations	9	4,5
Enable individual adjustments	8	4
Be stable	8	4
Low noise level	6	3
Material with low environmental impact	5	2,5
Mobile	3	1,5
Offer storage	3	1,5
Shape	3	1,5
Price	1	0,5
Colour	0	0

Figure 4.13: Results compiled from the survey that gives the requirements a weight for further input in QFD analysis.

In this table, the resulting point from the survey are divided by two which gives each requirement a weight. From the same table, the ten requirements with the most votes from the users are further input in the QFD analysis, which excludes "Price" and "Colour" from further research. Price is of course always important, in order to create profitable products for the company, and affordable products for the buyer/user but will not affect the first phases of the product development. Colour will be considered in the later parts of the product development process and will be a part of the final composition of the concept.

4.2.5 Conclusion of the user requirement identification

Some of the user requirements that have occurred during the user studies are already satisfied for some of the users, but not for others. For example, the access to storage is very good at some of the visited schools, but totally absent at others. Moreover, the opportunity to do individual adjustments in furniture differs a lot between the schools. Sometimes it is possible to adjust the furniture to the individual, but it is too difficult why it is not used anyway. Then the requirement is not satisfied regardless that the furniture actually includes that function. The major requirements that are not really satisfied are connected to the lack of flexibility in the classrooms today. The environment does not enable a good opportunity to change between various teaching styles, such as individual work and group work since the furniture are very stationary and there are no opportunities to rearrange furniture or walls and other interior in the classrooms. Moreover, there is no opportunity for the pupils to stand up while working during the lessons, which makes the working postures concentrated on sitting positions.

The requirement regarding that furniture in learning environment should be stable is in the most cases fulfilled in today's classroom, most of the furniture in the visited schools are also perceived as durable.

The defined needs and requirements may result in a wide range of products suitable for a school environment. In order to find a focus for further research and development, an area defined as "workstation" was made in consultation with supervisors at Kinnarps AB. A "workstation" is defined as: "work surface in connection to a sitting and/or standing opportunity".

4.3 Benchmarking - The five competitors

In order to investigate what products already exists at the market and how well these meet the identified needs, a benchmarking was done. In collaboration with the manager of Next Education at Kinnarps AB, who has good insight in the market of school furniture, a discussion was held and the five major competitors that can be seen in figure 4.14 were selected for further analysis. Furthermore, descriptions of the competitor solutions are presented.



Figure 4.14: The five products that are taken into the competitor analysis.

Four Design: (Four design, 2017b). Image used with permission

Skolbänk Mandal (Lekolar, n.d). Image used with permission

Pinta skolbänk, (Martela, 2017). Image used with permission.

ZAP from Højer, (Picture taken by the authors).

Node, (Steelcase, 2017). Image used with permission.

Four design - FOUR®CAST'2 WHEELER with Inno®Tab:

The analysed product includes the accessories: Inno®Tab, Compartment, and Dashboard, which makes it a complete "workstation". According to Four design (2017a), the Four®Cast2 Wheeler is "a unique, adjustable chair designed to offer the maximum comfort and ergonomic support to any student at all hours thanks to the V-shaped back, the flexible shell, integrated tilt mechanism and gas lift."

Lekolar - Mandal:

The combination of a school chair and desk with storage is a traditional solution, common in classroom environments. There are many different variations of this type of product, but this specific one chair and desk from Lekolar represent one often used. The desk drawer can contain 30 litres and the work surface can be tilted 6 degrees. There are a foot stand and two hangers for bags. The height is adjustable between 70 and 100 cm (Lekolar, n.d).

Martela - Pinta:

The Pinta school desk can be delivered in different variations, as the buyer can choose from table-legs with or without adjustable height, wheels and the tabletop may come with or without sharp corners. For this analysis, the model with adjustable height, round corners and wheels are investigated together with school desk chair Grip, presented in figure 4.14. The desk height is adjustable between 60-82 cm and can "easily form a single workstation or be arranged for group collaboration" according to Martela (2017).

Højer - Zap:

"ZAP is a functional, flexible and mobile workstation, making it easy to convert otherwise passive areas and outdoor spaces into workplaces for both students and teachers. ZAP can replace parts of the existing furniture or be incorporated into the school's existing interior and architecture – and create even greater freedom in teaching and spaces for differentiated learning" (Højer Møbler, 2016). Zap Totem with a Zap Board is representing an innovative workstation that allows the pupil to choose a preferable working height.

Steelcase - Node Tripod Base with work surface:

According to Steelcase (2017) "The Node chair is mobile and flexible. It's designed for quick, easy transitions from one teaching mode to the next. With Node, a classroom can transition from lecture mode to team mode without interruption".

Conclusion of benchmarking

The described solutions are representing a range of possible work stations, and the result from the analysis of how well they meet user requirements are presented in the QFD matrix in section 4.5.

4.4 Function analysis

As the aim of the product development is to meet the identified user requirements, the functions of the new concept must meet these needs. The functions needed are listed in figure 4.15 and 4.16. The "Main functions" (MF) describes what the product should primary do while the "Part functions" (PF) describes functions that will help to fulfill the main functions. The "Supportive functions" (SF) are functions which are good if the concept could have, but they are not necessary in order to have the main function to work properly.

In the next section, these functions are broken down into measurable product characteristics in the QFD analysis. For example "offer work surface" is broken down into the measurable "dimensions of work surface".

Functions	Classification
MAIN FUNCTION	
Provide work surface	MF
Provide sitting opportunity	MF
Provide opportunity to stand up while working	MF
MANUFACTURING	
Enable assembly	PF
Enable disassembly	SF
USE	
Be mobile	SF
Enable start / stop	SF
Be stable	PF
Be easy to adjust by the user	PF
Enable height adjustments of seating	PF
Enable position adjustments of seating	SF
Enable height adjustments of work surface	SF
Provide mobile work surface	SF
Enable various working postures	PF
Offer storage	SF
Easy to maintenance	SF

Figure 4.15: The function analysis part one, continues on the next page.

END OF LIFE	
Enable reuse	SF
Enable recycling of material	SF
AESTHETICS	
Express mobility	SF
Intuitive usage	SF
Express identity of Kinnarps AB	SF
Express quality	SF

Figure 4.16: The function analysis part two.

4.5 QFD

The outcome of the QFD is a rating of which functional requirements that should be focused on in order to satisfy the most important user requirements. To understand the correlation between the various parts and be able to read the result in the QFD chart, a description will follow below. To read the full version of the QFD-analysis, go to Appendix B, the figure 4.17 only gives an overview of which parts that have been used and considered in the QFD-house.

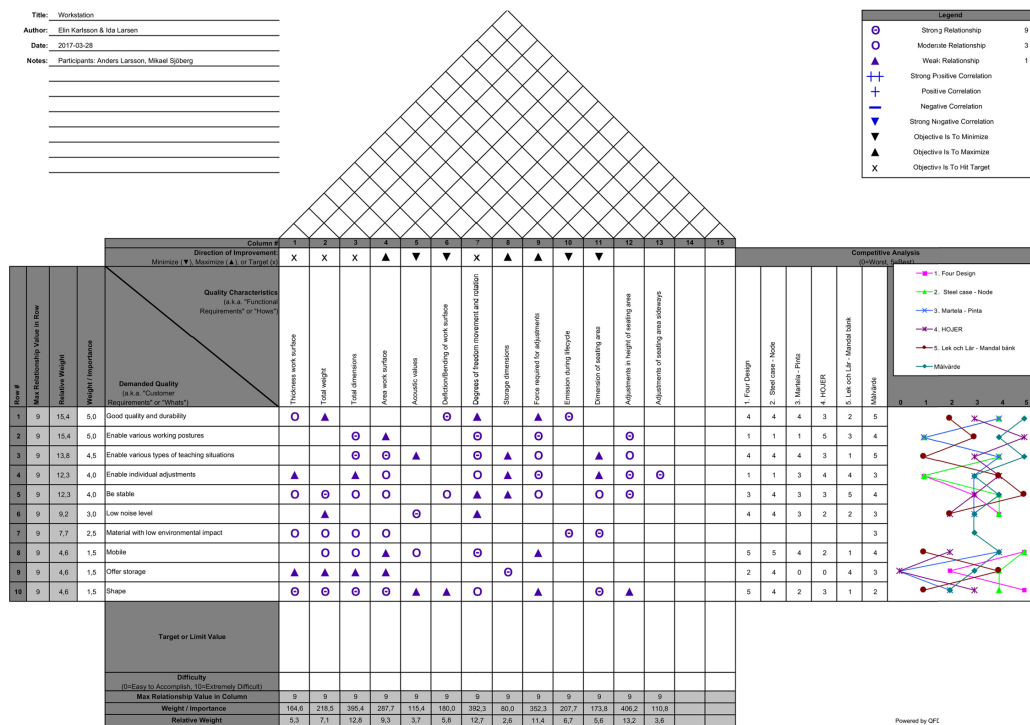


Figure 4.17: The QFD matrix.

The left part of the QFD chart shows the ten most important user requirements and the weight that were determined through the survey. The upper part shows the functional requirements that answer how (through which functions) the user requirements are going to be satisfied. These functional requirements are set by the project group with base in the function analysis.

The middle part of the QFD chart shows the relationship between the user requirements and the functional requirements. Some pairs have no relationship at all, why some squares are left blank. The relationship is described by symbols, which are explained in the figure's top right corner. Strong relationship means that a functional requirement has a strong impact on whether a user requirement is going to be fulfilled or not. Pairs of requirements, user/functional, can also have a moderate or weak relationship. For an example, which can be seen in the chart, the user requirement "Be stable" have a moderate relationship with the functional requirement "Area work surface" which means that they will affect each other in some aspects

but the area of the work surface might not be the only crucial part for the stability of the product.

At the right side of the chart, the benchmarking can be found where the five competitors that are presented in section 4.3 are rated regarding how well they fulfill the user requirements. This evaluation is done in collaboration with the manager for "Next Education" at Kinnarps AB who has a good insight in today's learning environments. The rating regarding the user requirement "Material with low environmental impact" are left blank when no information regarding this was to be found for these products. The target value for further product development are set together with the "Head of workstations" at Kinnarps AB and gives an indication of which user requirements that should be prioritised in order to develop a furniture that will satisfy the customer and the user. The target value is set to 5 (the highest value) for "Good quality and durability" and "Enable various types of teaching situations". The reason for that is that one of Kinnarps AB's most important values is to deliver high-quality furniture, which also is very important in a sustainability perspective. These two requirements were also rated the most important by the user survey.

The bottom section in the QFD chart expresses the compiled importance of which functional requirements that are the most important to focus on in order to satisfy the user requirements. There are four functions that are the most important which can be seen in Appendix B. These are: "Total dimensions", "Degrees of freedom, movement, and rotation", "Force required for adjustments" and "Adjustments in height of seating area". These requirements will be taken extra care of, while "Acoustic values" and "Dimensions of storage" will get lower priority in the further development process.

To summarise, some modifications of the QFD chart have been made in this project. The method was used in an early stage of the product development process, at a point where the type of product that should be developed to meet the user requirements was a "workstation" but not more specified, hence some functions were hard to set any values or limits for. The limit values for the functional requirements are therefore not considered at this stage, nor the "roof" of the chart which shows if the functional requirements have positive, strong positive or negative correlation between each other. It was too early in the process to determine this information why it was left at this stage. The next step regarding the target values will instead be presented in a list of requirements.

4.6 List of requirements

In the QFD-analysis, target values for all the requirements could not be set. Therefore, the resulting weight could have been affected if these values were set at this stage. Hence an alternative list was created, with requirements inspired by the QFD and the function analysis. The requirements should be fulfilled by a workstation in a classroom environment and the target values were defined by the project group in

collaboration with Kinnarps AB. The list of requirements can be found in 4.18 and will work as an underlay for further product development.

No.	Requirements	Target value	Demand/Wish
1	SAFETY AND MAINTENANCE		
1.1	Meet the requirements of Möbelfakta		D
1.2	Material should be tough	Fulfill Kinnarps AB's warranty 5 years	D
1.3	Material should tolerate cleaning		D
2	TECHNICAL FUNCTIONS		
2.1	Meet the existing norms regarding sitting height	Normal height sitting: 740 mm	D
2.2	Meet the existing norms regarding standing work height	Standing height: 1050 mm	D
2.3	Maximum force for adjustments	Through tests and norms	D
2.4	Be adjustable without tools		W
2.5	Maximum force at work surface		D
2.6	Be stable	Kinnarps AB's test	D
2.7	Be mobile on various floor materials in schools	Plastic, carpet, wood	
2.8	Lock movement of the furniture	Enable start - stop	W
2.9	Carry maximum weight	120 kg according to Kinnarps AB's norm	D
3	PRODUCTION AND ASSEMBLY		
3.1	Be manufacturable within Kinnarps AB's existing factories		D
3.2	The workstation should allow disassembly and separation of different materials		W
4	SUSTAINABILITY		
4.1	Meet the requirements of Möbelfakta		D

Figure 4.18: The list of requirements.

5

Concept Development

With the identified customer requirements and result from the weighting of demands in the QFD-analysis in mind, the concept development phase was performed. As mentioned in the research phase, a focus area was defined prior the idea generation called workstation. All ideas generated in the project and presented in this chapter answer to the definition of a workstation: a work surface in connection to a sitting and/or standing opportunity.

5.1 Idea generation

From the session of Brainstorming, a lot of ideas came out. "Katalogmetoden" was used as a complement to the Brainstorming, where a few more ideas occurred. In order to reach an even wider range of ideas, "Ideskiftesmetoden" was also used. The purpose of this method was to add new perspectives on current ideas and widen the range of concepts. This session resulted in that a number of concepts were further developed to a higher level and a few new designs appeared as well. These methods were used to generate the first ideas, and some of them are presented in figure 5.1 and 5.2.

In consultation with a supervisor, four concepts could be identified out of these sketches, and some of the concepts had more than one solution, further called variants. These concepts will be presented in next section where some further development and new sketches are made.



Figure 5.1: Sketches that describes various types of work surfaces solutions that could be attached to an existing student chair.

In figure 5.1 sketches of various types of work surfaces that could be attached to a student chair are presented. There are solutions that are attached to the centre pole and can be hidden behind the backrest of the chair when it is not in use. Other solutions describe a work surface that can be folded and stored underneath the seating area. Moreover, various shapes of work surfaces are described where some of them include the opportunity to store material and belongings.



Figure 5.2: Sketches which describe solutions of a workstation where a student chair is involved in some of them and others are separate solutions.

In figure 5.2 there are some solutions of a workstation that includes a student chair where a type of work surface are attached. Some other sketches describe solutions which do not have a connection to a chair at all. There are solutions that allow work while both sitting and standing up.

The student chair Xact

In the idea generation process, a student chair from Kinnarps AB was included as a source of inspiration. The chair that was chosen to be used as an underlay during the process was Xact, according to Kinnarps AB a good, ergonomic student chair. Some of the generated concepts are further developments of the Xact-chair while other ideas are not connected to a chair at all. In order to understand the further presented concepts that are built on Xact, a brief description is necessary.

Xact is according to Kinnarps AB (n.d., a) an ergonomic and robust student chair which is easy to move around and encourages activity and movement. The chair enables individual adjustments and can be ordered in different colours and materials, with or without padding. The various add-ons enable to choose between wheels or sliding feet. In the figure 5.3 the chair is presented in white plastic and wheels.



Figure 5.3: The student chair Xact, in plastic and no padding. (Kinnarps AB, n.d) Image used with permission.

5.2 The four concepts

In this section, four concepts are presented without any hierarchic order. Concept number 3 has three different variants but the total solution and the customer requirements that the variants meet are the same. All four concepts aim to meet the customer requirements with the highest rating which can be seen in figure 4.13.

5.2.1 Concept 1

This concept is based on using the base of Kinnarps AB's student chair Xact or similar. Some changes have been done in the back where the backrest console have been centered instead of running along both sides. The backrest can be flipped 90 degrees, which is illustrated in figure 5.13, and then serve as a work surface. This concept widens the range of usage areas for the original student chair and can now be seen as a workstation. Furthermore, the chair can still be used in combination with a traditional bigger table. This concept enables a more flexible and free learning situation where changes between work in groups and individual studies are eased, thanks to the integrated work surface that allows you to sit wherever you want, with the work surface always close within reach.

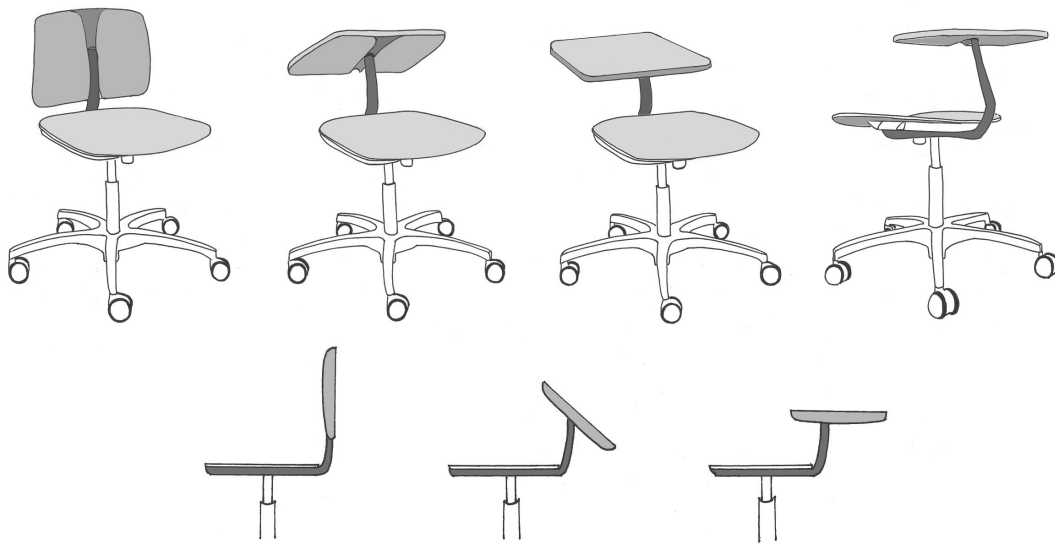


Figure 5.4: Concept number 1. (Picture created by the authors).

5.2.2 Concept 2

This is a furniture on wheels with an integrated work surface. The work surface is adjustable in height through a gas-spring, which allows height suitable for both sitting and standing up while working. Furthermore, the furniture has integrated storage underneath the sitting area, it can easily be moved around in the classroom and it can be used in combination with a traditional bigger table. This concept which can be seen in figure 5.5 is mobile thanks to the wheels, which also ease the change between various learning situations.

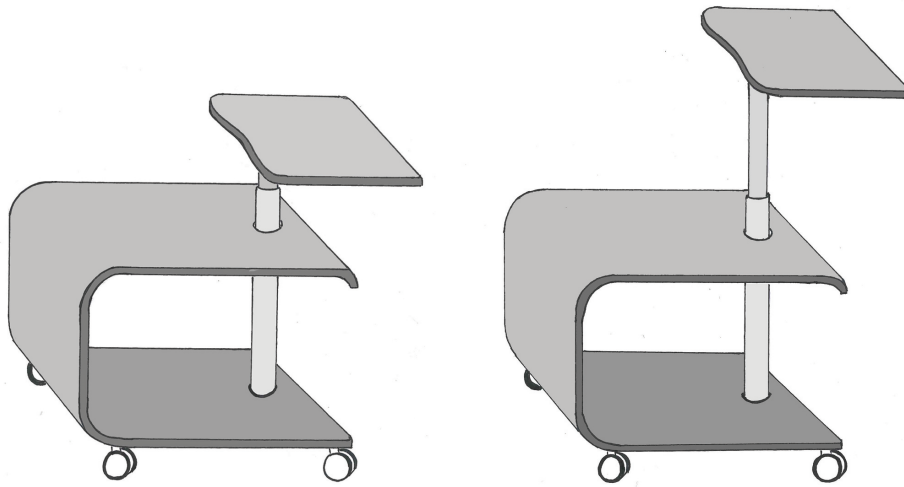


Figure 5.5: Concept number 2 in sitting and standing position. (Picture created by the authors).

5.2.3 Concept 3a, 3b, 3c

This concept is based on using Kinnarps AB's student chair Xact, or similar, in its original performance and attaches a work surface. This can be done in different ways, why three different variations are described below. The concept combines a chair and work surface, making it a flexible workstation which can be used alone or together with an ordinary table. In general, concept 3 enable the user to bring the work when alternating place to sit. The user can easily change between sitting in a group perhaps near a traditional table, to move the chair to work individual in a different part of the classroom.

3a

The 3a version which can be seen in figure 5.6 is based on adding an armrest that is attached at the back. At one side of the armrest, the work surface is fastened, which can be turned around and connected to the other armrest, in order to be used as a work surface whilst sitting down. While not being used the surface can be put down to the side again.



Figure 5.6: Concept number 3a. (Picture created by the authors).

3b

The version 3b keeps the chair Xact or similar student chair intact and is based on attaching a work surface with an arm on one side of the chair, as shown in figure 5.7. When the surface is not used, it can be hidden under the seat and easily be pulled out for use again.



Figure 5.7: Concept number 3b. (Picture created by the authors).

3c

In version 3c, the work surface is attached to the chair by an arm connected to the centre pole of the star-base. When the work surface is not used, it is put behind the chair's back, leaving an armrest at one side. By grasping the armrest and pulling it forward, the work surface rotates and locks in a forward position. The user can then pull the surface in a suitable working position, as it slides on two rails, as illustrated to the right in figure 5.8.



Figure 5.8: Concept number 3c. (Picture created by the authors).

5.2.4 Concept 4

This concept is in some ways similar to Concept number 3, with its integrated work surface in combination with the student chair Xact or similar. However, there is a major difference, why this concept will be presented on its own. The difference is that Concept 4 offer the possibility to stand up while working (see figure 5.9). The work surface is attached to the bottom area which is placed above the star-base and works as a storage area under the seat. The work surface can be adjusted in the height with a gas-spring and turned 180 degrees to be used as a stand-up table behind the chair.

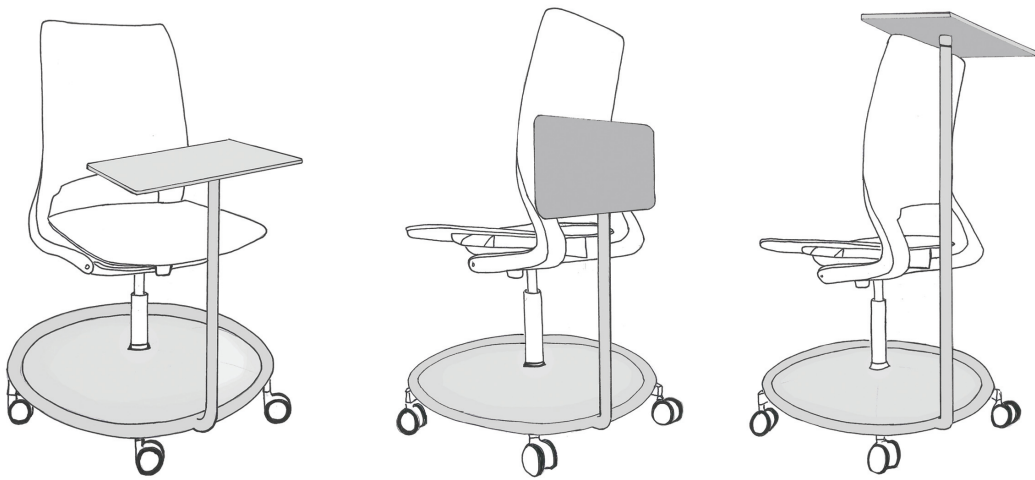


Figure 5.9: Concept 4 in sitting position, stowed away position and standing up position. (Picture created by the authors).

5.3 Concept elimination

The aim with the concept elimination is to consider and evaluate the four concepts regarding the user requirements, Kinnarps AB's opinion as well as the project group's thoughts, in order to take one of the concepts for further development. The collection of concepts can be seen in figure 5.10 below.

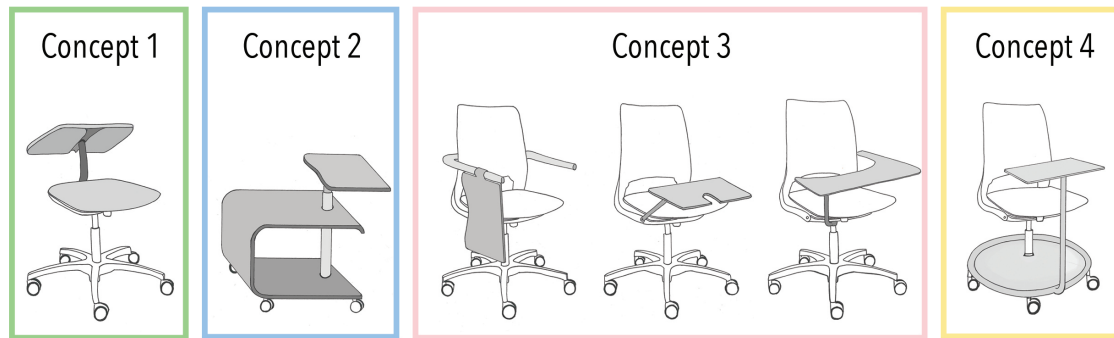


Figure 5.10: All concepts that is included in the elimination process. (Picture created by the authors).

5.3.1 Users' voice

The first step of elimination phase was to look at the user's voice and analyse how well the different concepts meet the user requirements. The weighting in the matrix which can be seen below in figure 5.11 is from the survey and shows what the users find the most important for furniture in learning environments. The decision regarding if/if not or possibly the concept meet the user requirement is taken by the project group. If the requirement is met, the concept is given the same points as the customer weighting. If the requirement is possibly met, the concept is given half of the weighting. Zero points are given if it is not met. The points are summarised in a total score.

User requirements	Weight (1-5)	Concept			
		Concept 1	Concept 2	Concept 3	Concept 4
Good quality and durability	5	Yes	Yes	Yes	Yes
Enable various working postures	5	No	Yes	No	Yes
Enable various types of teaching styles	4,5	Yes	Yes	Yes	Yes
Enable individual adjustments	4	Yes	Possible	Yes	Yes
Be stable	4	Yes	Yes	Possible	No
Low noise level (material)	3	Yes	Possible	Possible	Possible
Material with low environmental impact	2,5	/	/	/	/
Mobile	1,5	Yes	Yes	Yes	Yes
Offer storage	1,5	No	Yes	No	Yes
Total		22	25	18,5	23

Figure 5.11: The Voice of the Users.

The conclusion from this analysis is that concept 2 have the highest fulfilment of customer requirements. Taking this into consideration, the concepts may be developed further and by doing this analysis, it is identified where the concepts are lacking in fulfilment of requirements - and therefore, where more development may be needed to meet these needs.

5.3.2 Kinnarps AB's voice

One stage in the concept elimination phase included a presentation at Kinnarps AB where experts from different areas participated. The purpose was to include people with various expertise in the development phase, to get the knowledge about what can be constructed and not. Furthermore, the purpose was to include the audience in the elimination process through a voting, to see which concept(s) they thought would have the best potential to be a realised product within Kinnarps AB

During the presentation, the four different concepts in figure 5.10 were presented in sketches. In this phase, no detail construction was made but the feedback from the audience included important information about details and functions that are possible to solve, but also some parts that are more complex to develop and must be taken into consideration during further product development. New ideas regarding technical solutions also appeared during the discussion. In the end, a voting was

done in the audience regarding which concept that had the best potential regarding following areas:

- Best market potential
- Meets the customer requirements the best
- The voice of Kinnarps AB (personal favourite)

The result can be seen in figure 5.12 below and will be an important input factor in the elimination of these four concepts.

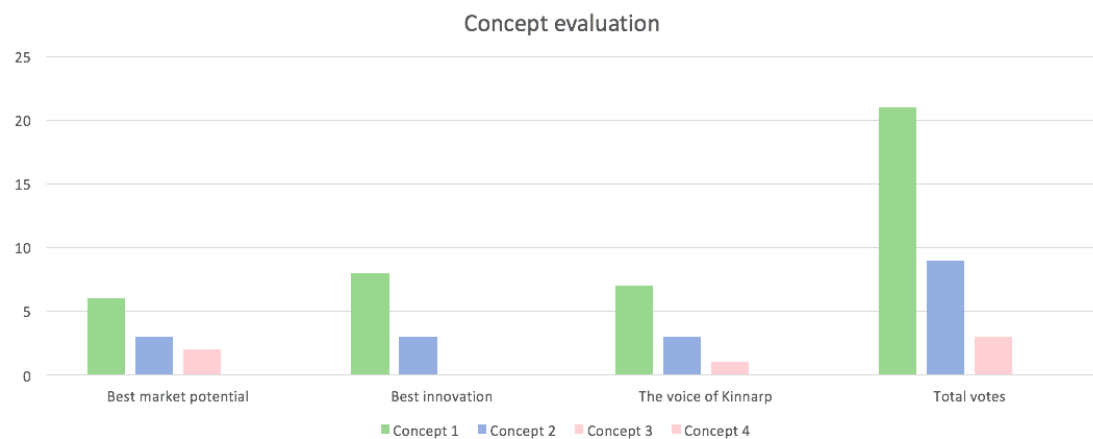


Figure 5.12: The result of the voting at Kinnarps AB during midpresentation.

After the four concepts were presented the audience had the chance to ask questions and comment on the voting result. The result shows that Concept 1 was the winner in all categories but the discussion afterwards also included many comments and thoughts about Concept 2, which got the second most votes. Concept 2 were pointed out as interesting since it enables both sitting, standing up, storage and a working surface, but there were also thoughts about that it might be a challenge to sell it to principals because of its nontraditional solutions. Concept 1 was viewed as a high market potential since it could be seen in Kinnarps AB's range of products and also could be sold to those buyers who are looking for a traditional chair, as well as those who wants a chair with a broader range of use situations.

5.3.3 Voice of the project team

In order to evaluate the concepts the project team used a PNI-analysis which shows the positive (+), negative (-) and interesting (?) aspects for all concepts.

Concept 1

Positive (+)

- + Can be used as a ordinary student chair.
- + Existing components can be used.
- + Flexible and easy to change way of use.

5. Concept Development

- + Few components.
- + Innovative solution.

Negative (-)

- Limited work surface area.
- Must be analysed regarding tip over risk.

Interesting (?)

- ? Possibility to make the work surface usable while standing up.
- ? Make the work surface larger.
- ? Might enable individual adjustments in height and horizontal position of work surface.

Concept 2

Positive (+)

- + Offer a wide range of possible using areas (stand up, sit down, use together with ordinary table).
- + Enables individual adjustments.
- + Offer storage.
- + Perceived stability.

Negative (-)

- New kind of furniture, might be hard to introduce at the existing market.
- Uncomfortable sitting area that needs further development.
- Many components.

Interesting (?)

- ? Great possibilities in development of the overall shape and expression.
- ? Good opportunities for further development of storage.

Concept 3

Below, the variants of Concept 3 is evaluated. Aspects that do not apply to all variants is marked, e.g. (3a) if the aspect is regarding only variant 3a.

Positive (+)

- + Can be used as a ordinary student chair.
- + Including armrest (3a, 3c).
- + Use of existing and good ergonomic student chair.
- + Efficient in use of space (3b).
- + Can be used as a side storage area while using an ordinary table(3c).
- + Flexible and easy to change way of use.

Negative (-)

- Might require too much space (3c).

- Risk of pinching (3a).
- Limited opportunities for individual adjustments.
- Some limitation of work surface area.
- Doubtful aspects regarding mechanics and durability.

Interesting (?)

? There are a few competitors at the market that already sell chairs with a writing surface, which shows that there are existing customers for this kind of product.

Concept 4***Positive (+)***

- + Can be used as a ordinary student chair.
- + Offer sitting, standing and storage of personal belongings.
- + Use of existing and good ergonomic student chair.
- + Enables individual adjustments.
- + Flexible and easy to change way of use.

Negative (-)

- Some difficulties in dimensions might occur.
- Might have a lack of stability.
- There is in a need of locking the wheels in use.
- Many components.
- Might be perceived as clunky.

Interesting (?)

? Good opportunities for further development of storage.

With the aspects from the PNI-analysis, the project team finds Concept 1 to be the most interesting concept to further develop. The argument for this is that the negative aspects are possible to further develop in order to meet the requirements better. There are few components and the concept might have a good market potential since it can be used as an ordinary chair, which may make it easier to introduce at the market. The concept also increases the areas of usage in an easy way without requiring notable much more space than an ordinary chair.

5.3.4 Conclusion of elimination process

The conclusion from the elimination process shows following results:

- Voice of the User: Concept 2
- Voice of Kinnarps AB: Concept 1
- Voice of the project team: Concept 1

Finally, Concept 1 was chosen to be taken into the further development process since that concept got support from both Kinnarps AB and the overall evaluation from the project team. In addition, with some further development, the concept have the

potential to get even higher score than Concept 2 regarding the user requirements. This makes Concept 1 the winner for further development.

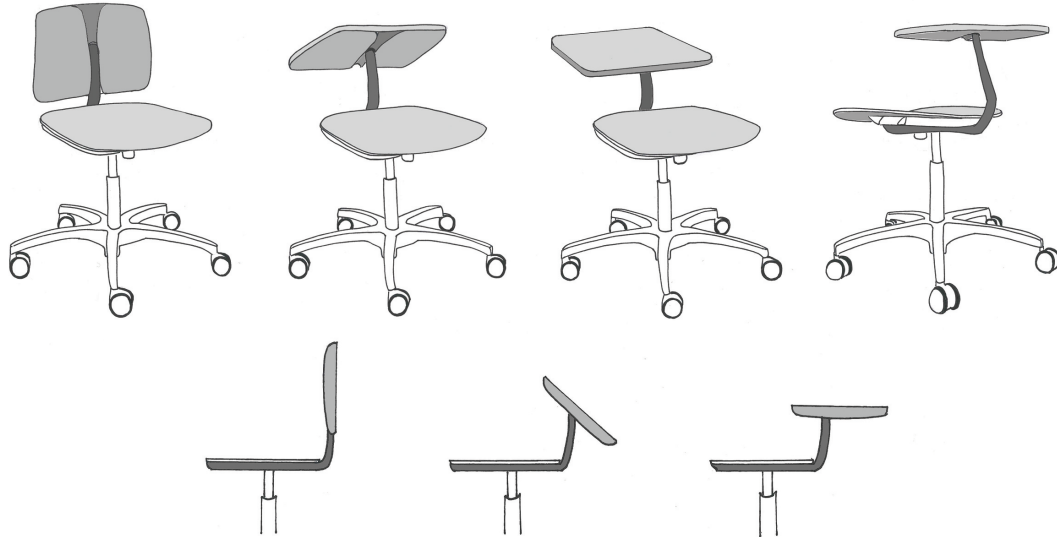


Figure 5.13: Concept number 1. (Picture created by the authors).

5.4 Further development of concept 1

Concept 1 is a new construction based on Kinnarps AB's education chair Xact. The base of Xact is used and kept in its original performance while the seating area and backrest are of a new design. This also makes the concept compatible to use with the base from other education chairs within Kinnarps AB's existing assortment.

5.4.1 Mock-up

In order to experiment with dimensions and the mechanism in the backrest, a mock-up was made. The base from Kinnarps AB's chair Xact was kept intact (star-base, wheels, gas-spring and the function to adjust height and position of the seating area). A new backrest was made as well as the seating area which got a symmetrical shape.

Foam board, paperboard, and wire were used in the construction, which were good materials when experimenting with the shape. The method supported the process of defining the dimensions for the various parts, before the CAD 3D-modelling session. The dimensions of the work surface were briefly tested to reassure that it offers support to elbows while working, that a laptop or a tablet fits, as well as notebooks.



Figure 5.14: Mockup of Concept number 1, in original sitting performance and turned 90 degrees for use of the work surface. (Pictures taken by the authors).

5.4.2 Detail sketching

In order to find out the details about the mechanism which enables the backrest to be flipped around, a small brainstorming session was made. The project team also studied existing solutions such as various hinges and locking mechanisms. Sketches in figure 5.15 below shows the mechanism that was chosen and should be further constructed in 3D modelling. The mechanism consists of a shaft with splines and a part connected to the work surface with the corresponding geometry, which together creates the locking geometry. When the shaft is moved, the work surface is allowed to rotate.

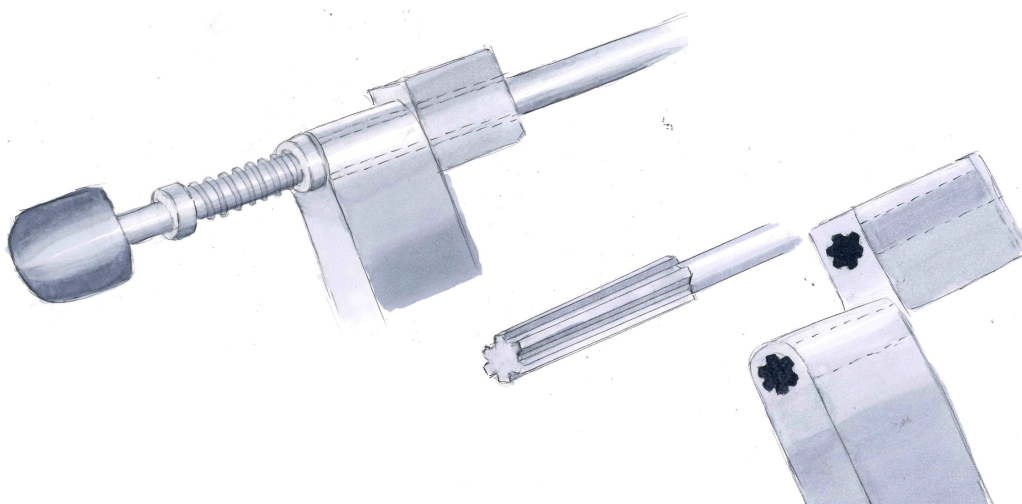


Figure 5.15: Sketch of the mechanism that will enable the backrest to be turned and locked in that position. (Picture created by the authors).

6

Final Concept

6.1 The concept

In its original performance, the concept works as a normal education chair with gas-spring and star-base with five wheels. When wanted, the backrest can be flipped 90 degrees in order to enable the use of the integrated work surface at the back of the backrest. The backrest console is adjustable in height and can reach a height suitable for standing up while working. The sitting area can be shoved back and forth in order to enable an ergonomic working posture, which is a function kept from the original performance of the Xact-chair. In figure 6.1 below the concept is presented with padding and in figure 6.2 it is presented without. The choice of colour for the fabric is just a suggestion to visualise the opportunity to have the concept with padding. More information regarding colours and materials are to be found in section 6.4.



Figure 6.1: The final concept shown in different perspectives. (Picture created by the authors).



Figure 6.2: The final concept shown in different perspectives without padding. (Picture created by the authors).

6.1.1 Dimensions

The chair has the dimensions for work in both sitting and standing position. In figure 6.3 the dimensions for sitting position in its lowest performance are shown. According to anthropometric data, that can be found in section 2.1.2 in theory, the elbow height in sitting position (measurement number 5 in the figure 2.1) should be 238 mm for the 50 percentile. The concept meet that requirement where the lowest height between the seating area and the work surface are 228 mm. To the right in figure 6.3 the concept is shown in stand-up position in its highest performance where a height of the work surface is set to 1050 mm, which according to Theory in section 2.1.2 is the standard that Kinnarps AB uses for standing work. In figure 6.4 the measurements of the backrest/work surface and seating area can be found, which were chosen through tests with the mock-up.

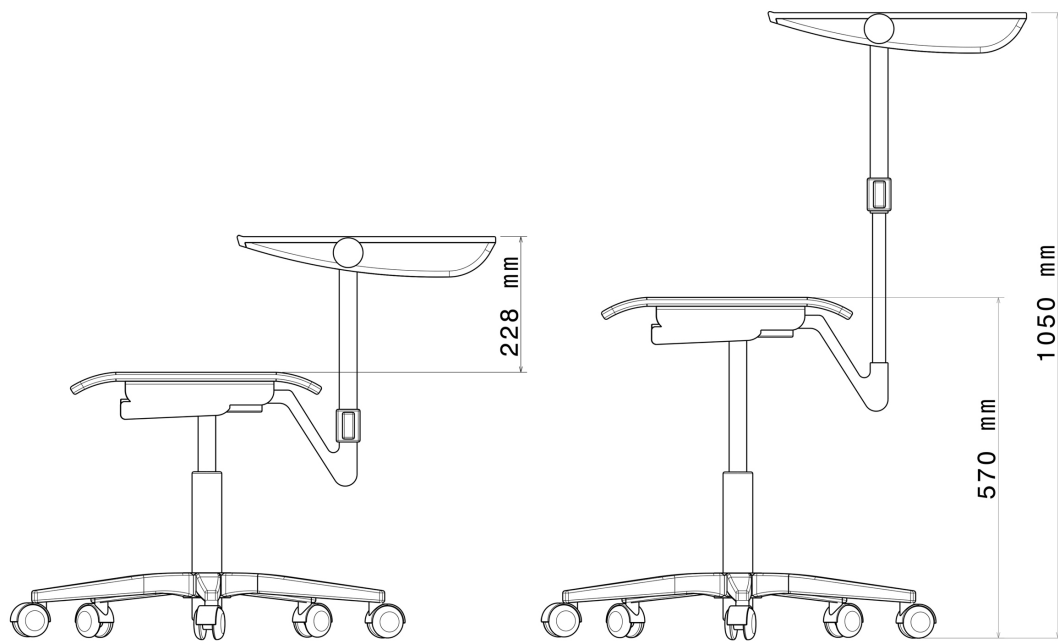


Figure 6.3: Shows the lowest distance between work area and sitting area, as well as the maximum height of the working area. (Picture created by the authors).

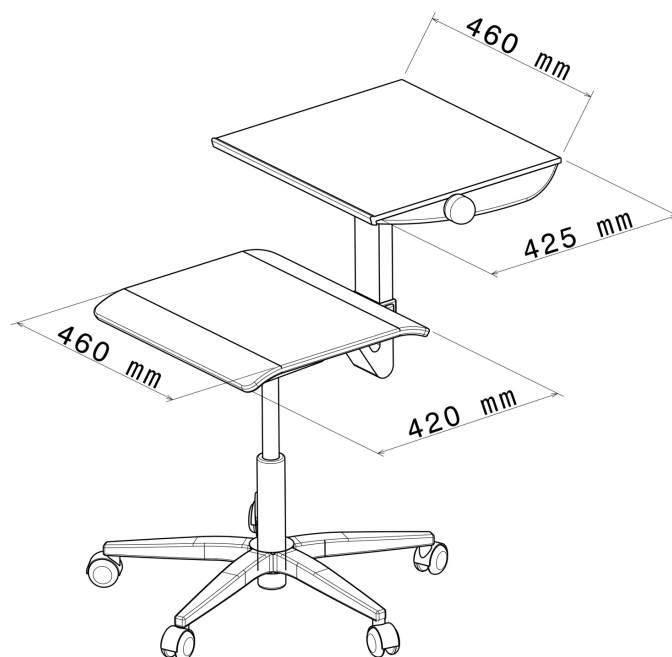


Figure 6.4: The dimensions in an isometric view. (Picture created by the authors).

Figure 6.5 visualises how the work station's dimensions relate to a user. The picture also shows two different working postures. In addition to these postures, the workstation also can be used as an ordinary chair together with an ordinary table.



Figure 6.5: How users may use the work station. (Picture created by the authors).

6.2 Description of components and functions

In order to visualise the concept further, the various components are to be found in this section, along with descriptions of every part.

Seating area

The new design of the seat is symmetric and enables the user to sit comfortably in two directions, which is required for the concept. The seat can be made of wood or plastic similar to Xact and can be mounted on a base with the same construction as Xact. The seating area can be used with or without a padding, which is illustrated in figure 6.6 below.

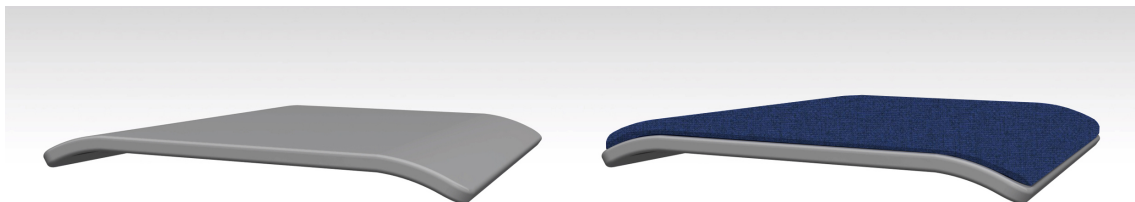


Figure 6.6: The seating area visualised with and without padding. (Picture created by the authors).

Backrest / Work surface

The backrest, illustrated in figure 6.7, has a shape that supports the lower back while using the chair together with an ordinary table. At the rear of the backrest, a work surface is attached, which can be used when the backrest is turned 90 degrees and locked into a horizontal position. Inside the backrest, the mechanism which enables the backrest to be fixed in that position is to be found. More information regarding the locking mechanism is described below. Due to the part's hollowness, it is possible to add sound absorbent material inside to minimise the noise level. The backrest can be used with or without a padding.



Figure 6.7: The backrest of the chair. (Picture created by the authors).

Locking mechanism in backrest

The locking mechanism that enables the backrest to be turned 90 degrees and fixed in a horizontal position, consists of an axis with varying geometry, a spring, and a knob. The component is shown in 6.8, which also illustrates the varying geometry that enables locking. The mechanism is attached inside the backrest and to flip the backrest the knob is grabbed and pulled out until the axis is in the right position that enables a rotation. The backrest has to be flipped manually and when it is in the horizontal position the knob can be let loose and the axis will slide into locking position which can be seen in figure 6.9.

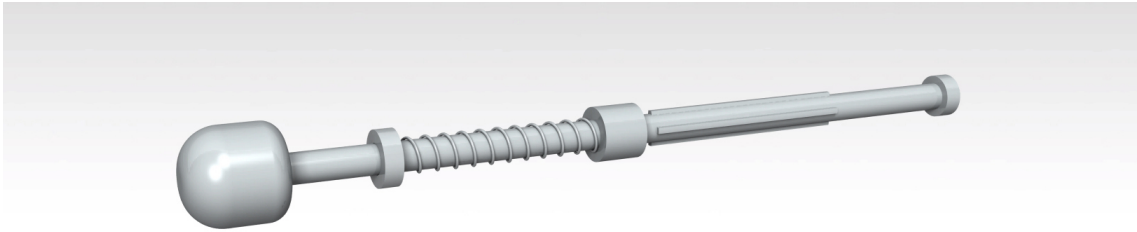


Figure 6.8: The axis and mechanism for turning the backrest 90 degrees and lock in that position. (Picture created by the authors).

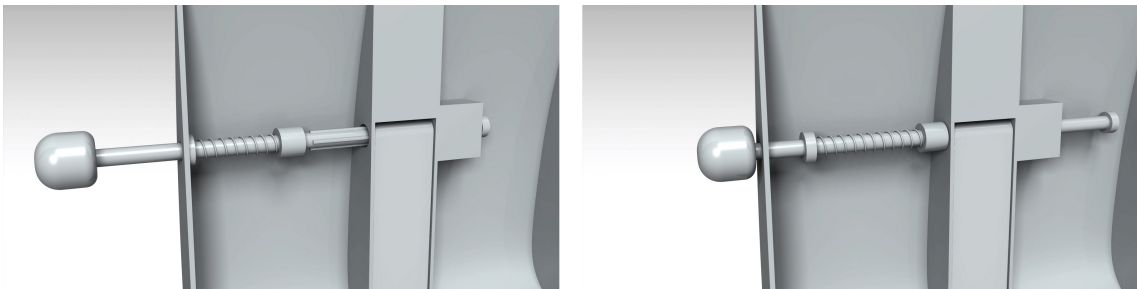


Figure 6.9: The backrest with the locking mechanism. (Picture created by the authors).

Backrest console

The backrest console connects the backrest with the base and seating area. It is adjustable in height and is dimensioned to reach a height which is suitable for both sitting and standing work. The construction of the adjustment handle is not defined, however, there are existing techniques providing this function which may be used in this design. The handle is positioned where the user can reach it according to figure 6.10, and is thought to enable rise/drop of the backrest console when the user pushes the button.

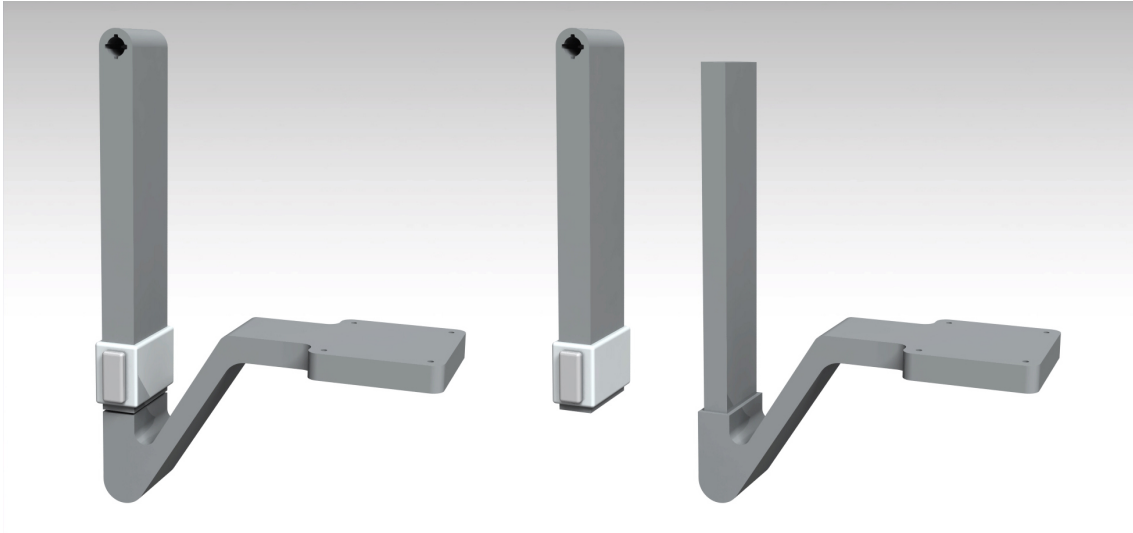


Figure 6.10: The backrest console in compiled position and separate which shows the two components. The illustration also shows the height adjusting handle. (Picture created by the authors).

The base

The base has not been developed in this project. Hence, only an example setup of wheels, star base and construction of the mount area are visualised in the final concept. However, since the chair can be used in a standing position it is recommended to use lockable wheels, to avoid the workstation to move when in use while standing.

6.3 Prototype

A prototype has been made by Kinnarps AB in Kinnarps Prototype Lab. The prototype presented in figure 6.11 has all defined functions, but does not include a proper base with wheels.



Figure 6.11: Prototype created by Kinnarps AB Prototype Lab.

6.4 Colours and Materials

In this section, a sample of colours and materials is presented. The colour and materials have not been developed in this project but is available in Kinnarps AB's collection. The colour schemes below are suggestions for what colours and materials that the concept could be presented in.

6.4.1 Textile colour scheme

In figure 6.12, textile colour suggestions for the concept with padding are presented. All concepts with padding are suggested to have a white shell made of plastic and the backrest console could be made of steel. The fabric chosen for the padding is "Step Melange" in the colours: "5069", "5059" and "5030" which all can be seen in figure 6.12. The fabric is labelled with "EU Ecolabel" and "Confidence in Textiles". According to Kinnarps AB (n.d., c), the fabric "Step Melange" is suitable for example public areas and school environment. For the work surface, the laminate "light grey" from Kinnarps Colour Studio is chosen (Kinnarps AB, n.d., d).



Figure 6.12: The concept visualised in textile. (Picture created by the authors).

6.4.2 Colour scheme for plastic and wood

In figure 6.13 the concept is presented in plastic, in the colours "Plastic Petrol" and "Plastic Black" (Kinnarps AB, n.d., e) but also in laminate in the material "Birch" (Kinnarps AB n.d., f). For the work surface, the laminate "light grey" from Kinnarps Colour Studio is chosen (Kinnarps AB, n.d., d).



Figure 6.13: The concept visualised in plastic and wood. (Picture created by the authors).

6.5 Interior proposal

In order to create visualisations of the environments that the concept is developed for, Catia V5 was used. Pictures of four different contexts are found below, which show the layout of a classrooms where various activities going on. The Concept are visualised together with the table "Foldex" from Kinnarps AB, which is a table on wheels that can be folded and is easy to move around (Kinnarps AB, n.d., g).

Lecture

This scenario describes how the concept can be used in a classroom during a lesson when the teacher is tutoring. Which can be seen in figure 6.14, all students sit on their own work station and the work surface is used.

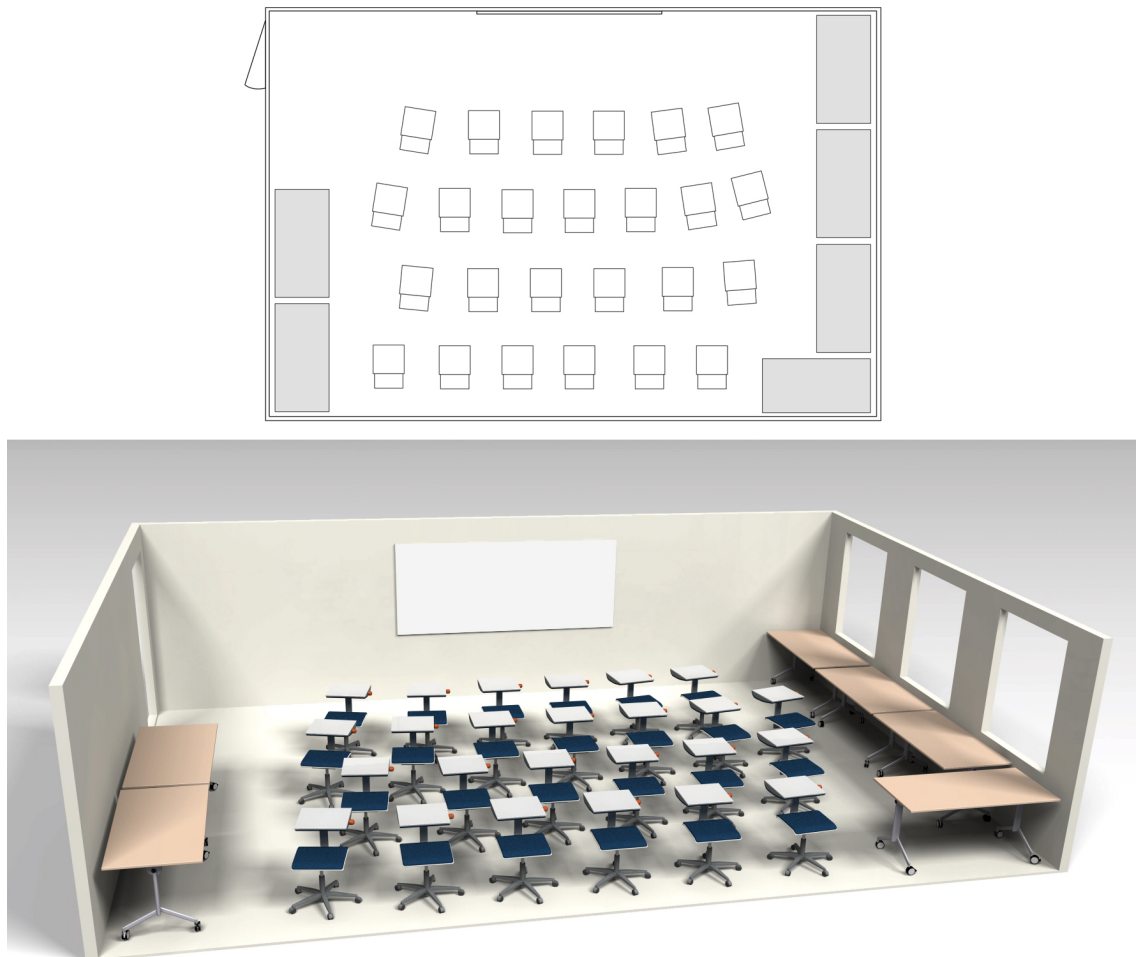


Figure 6.14: The concept visualised in a situation where a traditional lesson is held. (Picture created by the authors)

Work in groups / individual work

During work in groups and individual work, the situation below describes how the furniture can be used. Some students that want to work in groups can gather around a larger table and use the furniture as an ordinary chair. Students who want to work individually can use their workstation and sit undisturbed. Group discussions can be held through arranging workstations in a group that can be seen in 6.15.



Figure 6.15: The concept visualised in a situation where group work / individual work is on the schedule. (Picture created by the authors)

Test

The situation below in figure 6.16 describes how a classroom can be furnished during a test. It is easy to rearrange the furniture in order to make free space for every student.

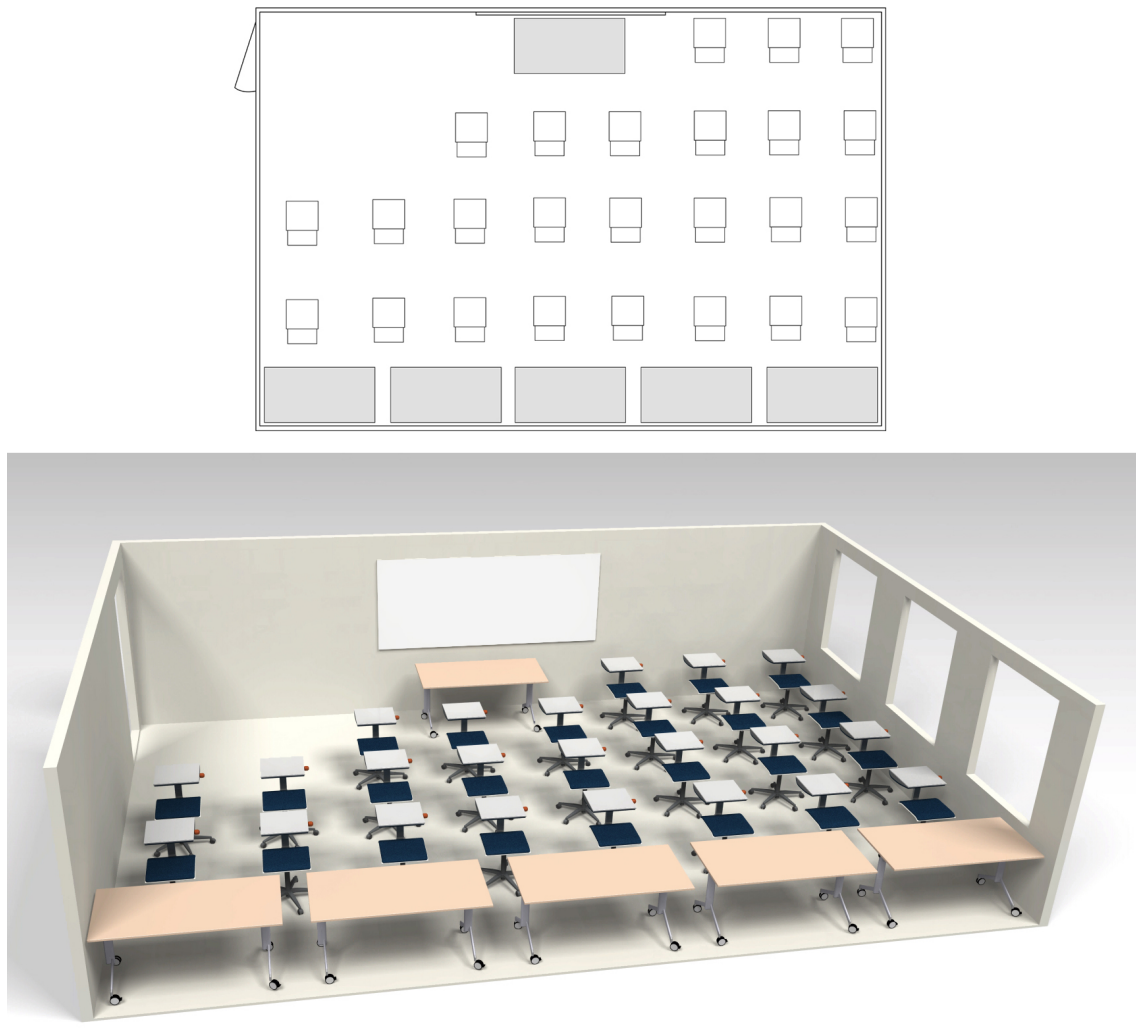


Figure 6.16: The concept visualised in a situation where a test is held. (Picture created by the authors)

Presentations

In situations where the students should do presentations, the workstations can be arranged in a half circle which can be seen in figure 6.17 in order to focus the attention towards the ones presenting. Some of the students use the work surface while others just sit on the chair in original performance.

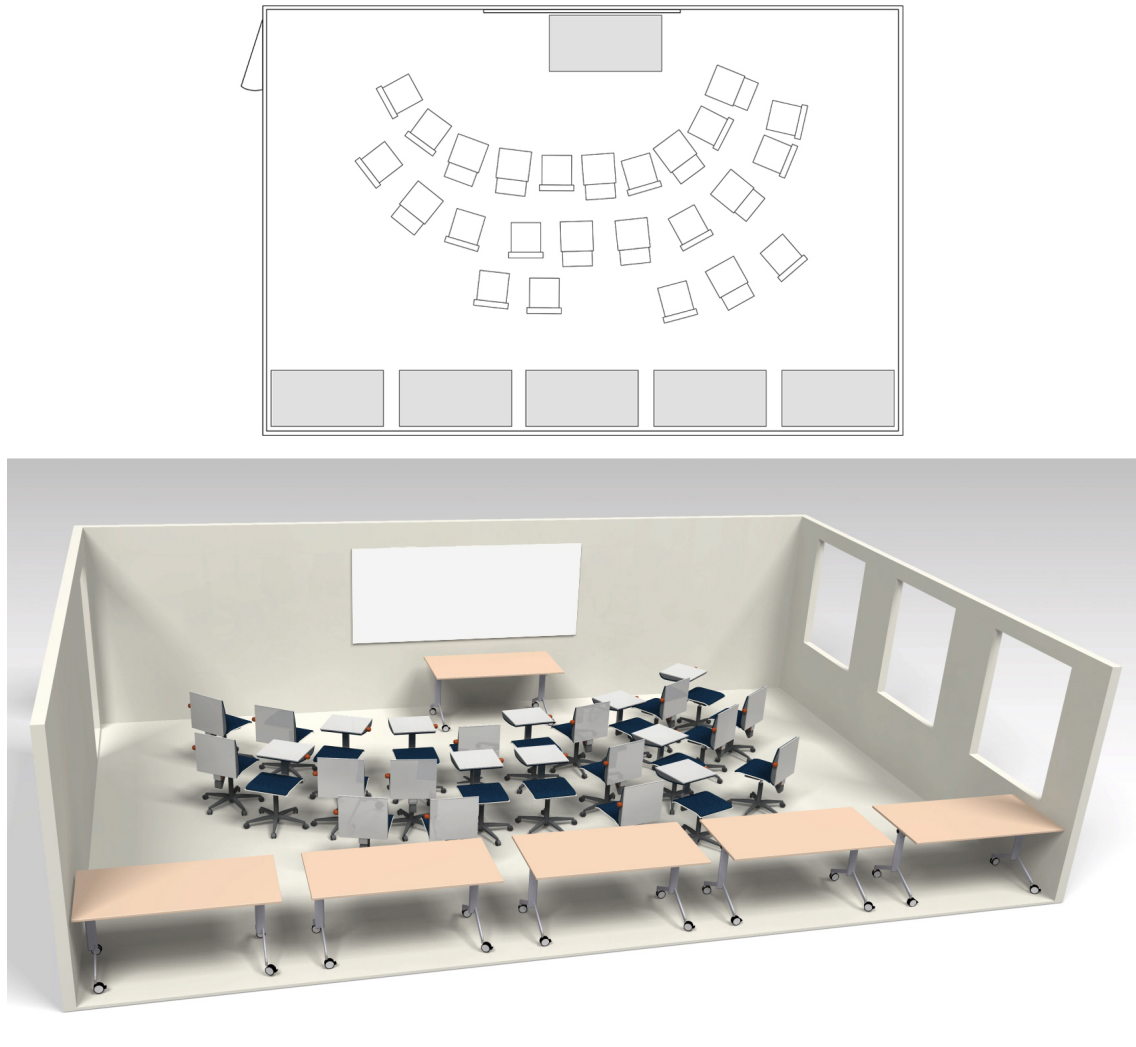


Figure 6.17: The concept visualised in a situation where presentations are held. (Picture created by the authors)

7

Sustainability Analysis

Sustainable development is important for Kinnarps AB, as one of the market leaders they have an ambition of striving towards a sustainable industry. As one part of the company's sustainability work, Kinnarps AB offer services such as furniture hire, spare parts sales, and recycling points. The company has also been involved in a project regarding re-use of furniture in the public sector, aiming for a more circular business in the future (Kinnarps AB, 2014).

The company joined Möbelfakta in 2012 and started to mark their new products according to the new labelling system later the same year (Möbelfakta, 2012). All new products at Kinnarps AB are developed to meet the requirements of Möbelfakta, which includes both social and environmental sustainability factors.

Kinnarps AB describes their work through the concept: The Better Effect, including all stages of the value chain: design, raw material, production, sales, distribution, use and end of life. Examples of responsible actions are the choice of material with low environmental impact, choice of subcontractors which production is socially sustainable, avoidance of unhealthy and harmful substances in all production processes, an own controlled distribution system with no disposable packaging as well as the creating of systems for recycling and re-use of furniture (Kinnarps AB, n.d.,b).

An education chair has the lowest environmental impact in its use phase since it is a passive product. When a product is said to be "passive" it means that it does not use any energy during the usage phase. The life cycle phases where the product has a larger environmental impact are, therefore, extraction of raw material, production, distribution, and end of life. The project group does not have the power to affect and improve these processes but have the power to develop a concept with these aspects in mind. The major opportunity to influence the final result is in the product development phase. The choice of material and to design for recycling and re-use are therefore the most important focus areas in this sustainability analysis. Since the product in this project is on a conceptual level, only an estimation of its environmental impact will be done.

In the sustainability declaration regarding Xact (Kinnarps AB, 2017a, p. 3), Kinnarps AB declares the following about their used materials:

- "Fabrics: All of Kinnarps' standard fabrics are free from flame retardants and azo dyes. Kinnarps can also offer multiple fabrics labelled with or fulfilling the requirements of EU Ecolabel and/or Oeko-Tex."
- "Wood: We use FSC® and PEFC certified wood material in the production of our products. The origin and legality of all wood material is controlled and assessed in accordance with Kinnarps Timber Trading Policy. All of our boards fulfil E1 requirements and many have half the E1 values or lower."
- "Plastic: Plastic components that are used in products produced by Kinnarps are free from PVC and flame retardants, with the exception of some plastic parts of electrical components. The plastic is also free from PFOS, Bisfenol A and phthalates. Plastic components over 50 g are labelled according to ISO 11469."
- "Padding: The padding in our task chairs is manufactured in Kinnarps' factory in Skillingaryd, Sweden, which enables us to have control over the whole process and ensure a safe production. The padding used in other products is certified with Oeko-Tex. All padding used in Kinnarps' products are free from flame-retardants and azo dyes."
- "Metal finishing: Kinnarps use powder coating for surface treatment of metal which gives very low emissions of volatile organic compounds (VOC). For chrome executions, only trivalent chrome is used."
- "Wood finishing: Kinnarps treats the surface of veneered tables and storage with water based UV-lacquer which ensures very low application quantities of volatile organic compounds (VOC)."

No new material has been developed in this project, why the final concept is intended to use materials in Kinnarps ABs existing range.

According to the sustainability declaration regarding model Xact 295 Plastic (Kinnarps AB, 2017a), the total amount of plastic is 5,7 kg and the amount of steel 3,7 kg. The material is stated to have 100 % recyclability and the product does not contain: Substances on Reach candidate list, Substances on Living Building Challenge Red List, Asbestos, Heavy metals, Phthalates, Brominated or halogenated flame retardants, PVC, Hexavalent chromium.

The final concept can use the base of the student chair Xact, hence it is estimated that the same amount of steel will be used. If the backrest console is produced in steel, the total amount will be slightly increased. Because of the integrated work surface, the concept will use the same amount of material (wood or plastic) as before plus material to the work surface, resulting in a total amount of more material in comparison with Xact in its original performance.

To design for recycling, materials must be pure and separable. The developed concept has the same modular structure as many of Kinnarps ABs other chairs, no glue is used and the different parts can be separated when needed. This also enables maintenance and repair of the product, if needed. To design for re-use, it is according to Kinnarps important to have an inclusive design, a modular product, a flexible product and a durable product high in quality (Kinnarps AB, 2014). Further development of the final concept will define the products quality, yet the design is modular and inclusive in its flexibility which requisites good opportunities to become a product suitable for re-use and circular business model if the concept is further developed.

Conclusion of sustainability analysis

In conclusion, the new concept will most likely use more material than the original chair Xact. Although, when comparing *workstations*, the final concept in comparison with the original chair Xact together with a work desk in Kinnarps ABs range of products, the new concept will use *less* material in total. This is an important aspect.

When choosing material to the developed concept, it is important to choose a material with a low environmental impact as possible. Many of Kinnarps ABs products, including the new final concept, can be produced in both wood and plastic. This choice is often made by the buyer. Thus, it is important to inform the buyer about the different effects and raise awareness.

8

Discussion

In this chapter, the process of the project and used methods are discussed along with the resulting concept. Moreover, recommendations regarding further concept development are stated.

8.1 Process

The first phase of the process consisted of initiating the project and setting the framework for the assignment. From the beginning, the project suggestion was focused on developing an add-on writing surface for a chair in a learning environment. However, through further discussions it was decided that the project should take on a wider perspective in the research phase. Together with Kinnarps AB, a purpose of the project was stated that included research of classroom environments in its total, in order to find what user requirements that occurred in various learning situations and surroundings.

The initial planning of the project that was stated in a Gantt-schedule has been followed relative well, although some dates were not decided when the project plan was stated. Moreover, the phase for user studies required more time than the initial plan, which was needed in order to reach the aim of the research and user studies. The result of this did not affect the overall project more than the work with further research was performed parallel with the last user studies. The project is also extended with one week since the date for the final presentation were not set in the project planning phase.

8.2 Methods used in the project

The methods used in this project have all been significant for the compiled result of the project. The methods were chosen carefully to help the project process within the given time limitations. If the project had been greater in terms of time, other methods might have been chosen or used to a greater extent. For example, the project group gladly would spend even more time on user studies to cover other geographic areas.

Some of the methods discussed below had a diverge result from what was expected or planned but were still used in the project. Furthermore, modifications of the used

methods were done in order to fit into the framework of the project and to achieve more relevant results.

Survey

The weighting of user requirements that were conducted through a survey generated 55 answers in total. The target group for the research and development in this project were pupils in upper schools, high schools and universities and the survey was sent to all these groups together with teachers and experts in various areas in the furniture business. The amount of answers in the survey were not split equally in between these groups, hence students in university were over-represented. This may affect the result of the weighting of the requirements in some aspects. The optimal result may have been an equal spread and additional respondents in all user groups. Yet, the result from the survey is still found valid enough because of that the user studies, which generated the requirements that were input in the survey, were primarily made in learning environments in upper school and high school, why the voice of these users still have been considered. In addition, the result of the survey served only as a guide in the development phase.

QFD

The method QFD was used relative early in the project development process. Using the method in this way resulted in some useful results regarding the competitive analysis, and identification of the relation between the user requirements and the functions answering how the user requirements could be met. The result that not could be achieved at this stage was the technical parameters that should set the requirements for further concept generation. The QFD method was used in a stage where the range of possible concept solutions that answers to the definition of a workstation still was very wide, leaving technical parameters hard to define. If the method had been used in order to further develop an existing product, it had been more suitable to use it in this stage, and would probably have given some good results regarding the technical parameters as well. In this project, it might have been more useful to conduct a QFD analysis in a later phase of the development process when the range of possible solutions was narrowed.

The solution for the lack of defined technical parameters was to create a list of requirements after the QFD analysis, where technical parameters were considered but not totally determined. In its total, the QFD analysis was useful in some aspects, but the alternative list of requirements was needed in order to support the concept generation phase.

8.3 Result from user studies

The semi-structured interviews with pupils in the visited schools were open, in groups, which may have affected some of the pupil's answers, as peer pressure might have occurred. The answers from these interviews are hence used to understand

the users and their situation, more than the use of specific facts. Something that also became very obvious during these interviews, was that youths and adults have different perspectives of how a learning environment should be designed, why these interviews added an important perspective for the project in order to understand the primary users.

The observations that were done during the user study phase were necessary in order to get to know the user and to get a holistic picture of various learning environments. Regarding the sample of schools and grades that were observed, schools in Gothenburg with its surroundings and pupils in grades 6-9 plus high school students were chosen. When the last observations were conducted, it did not generate much of new information, although the already observed moments and facts were confirmed by these observations. Hence, the observations can be considered as valid enough to describe brief and general situations in today's learning environment. In order to get more detailed information and identify differences between for example private schools and public schools, more observation must be done. The result of these observations could also have been different if another geographic area was chosen to observe or if even more observations had been done.

One specific need that has not been taken into consideration in this project is the opportunity to charge digital devices such as laptops and mobile phones. This was a user need that could be seen in all schools since the digitisation influence the education today. This specific need was evaluated to be connected to the existing physical environment and its limitations, why it was not considered in the product development.

The four examples of new types of teaching phenomena presented in Theory section 2.3 were not seen in the user studies. The final concept is designed to meet the identified user needs, hence no consideration to these phenomena was taken during the product development. However, it might be interesting to keep these theories in mind in future user studies.

8.4 Does the concept meet the requirements?

In this section, the concept is evaluated regarding how well the identified user needs are met. Furthermore, the concept will be compared to the function analysis to analyse which functions that are fulfilled with this concept and if there are any functions that would rather be further developed. Finally, a check is done regarding if or if not the concept meets the demands that are stated in the list of requirements.

User needs

The concept is a mobile workstation that enables different teaching situations thanks to its flexibility. It also enables various working postures and individual adjustments - needs that were high in priority - thanks to the opportunity of changing working height, adjustment of the seating position and seating height, as well as the oppor-

tunity of both sitting and standing while working.

Since the concept is equipped with wheels, it reduces the noise caused by moving furniture in the classroom. The user need of a low noise level can, therefore, be considered as met, however tests regarding this aspect must be conducted. As described in the final concept, it can be further developed by incorporating sound absorbing material and therefore the concept has the potential of meeting this need to an even greater extent. The concept does not offer storage, but as this was defined as a need of lower rating by the user studies, it was not prioritised.

Regarding if the concept meet the need of good quality and durability, this is something that must be evaluated later in the product development process, as it depends on the detail construction and choice of material. However, the concept is designed with the intention to meet this need. The need for a safe and stable product is also a concern of further development, though the product is designed with the safety aspect regarding the risk of pinching in mind, with the aim to eliminate this risk.

The shape of the product is defined through several aspects: ergonomic, the size of the work area and overall expression. The backrests shape is intended to be ergonomic, supporting the lower back when sitting. The shape is also defined by the work area - which was designed to be large enough for individual work. The size was chosen through tests with the mock-up. The user requirement "Shape" was low prioritised relative to the other user requirements, but to evaluate whether it is met or not - some further user tests is recommended.

Functions

When compared to the function analysis, see section 4.4 the final concept can be described with the same setup of functions, except the supportive function "offer storage". Furthermore, the functions in the end of life category are depending on the choice of material which is not explicitly defined at this point.

The concept is developed with the aesthetic functions in mind, but in order to ensure that the concept has these functions, it may be necessary with further user tests and iteration. The mobility is expressed through visible wheels. The relatively large adjustment levers and the opportunity to enhance these details with a colour is a part of the function of intuitive usage.

Requirements

As the aim of this project was to deliver a concept and no detail construction data, many requirements are impossible to evaluate. Yet, the technical requirements 2.1 and 2.2 regarding norms in sitting and standing height are met.

Though it may need further development, the requirement 2.4 "Be adjustable without tools", is likely to be met due to the lever features which are adjustable by the user.

The requirements regarding Möbelfakta (1.1, 4.1) cannot be evaluated at this point of the development process since the final result is a concept which not yet can be tested. Although, with these aspects in mind during the concept generation, the concept's chances of meeting the requirements are believed to be high. The later choice of fabrics and colours are affecting whether the requirements of Möbelfakta are met as well.

8.5 Recommendations for further development

The concept is delivered on a conceptual level why further research and development is necessary before it could be a realised product within Kinnarps AB. The concept needs to be tested to evaluate risks of tipping over as well as tests for abrasion resistance. In order to find the optimal dimensions for the work surface, tests with users are recommended. Furthermore, techniques for manufacturing need to be further researched and some modifications of the performance of the concept might be necessary in order to make manufacturing possible at Kinnarps AB's existing factories.

The choice of colours and materials that are presented in the project are only suggestions and can be changed during further development in order to meet the requirements from customers and sustainability aspects.

The function that enables the backrest to be turned 90 degrees and locked in a horizontal position are not tested and might need some further development and abrasion tests in order to work properly. Construction data is outside of the delimitation of this project why only suggestions for how this mechanism could be designed are made. Regarding the mechanism that enables the backrest to be elevated to standing height and locked in that position, the same limitations are made. At the delivery time of this project, the concept will only include shape and proposals of mechanisms on a conceptual level to solve the various functions.

9

Conclusion

The final concept was developed in order to meet the user requirements stated in the pre-study phase of this project. The purpose of the project was to search for and analyse what user needs that are not met in today's classroom environment with the existing furniture. Furthermore, the purpose was to investigate how these needs can be met through the development of school furniture. As a result of this research, the aim was to develop a furniture in order to enable a more flexible learning environment that will meet the needs in today's and future schools.

Following research questions were stated in the beginning of this project:

- What needs in today's learning environment cannot be satisfied with today's existing furniture?
- How can a furniture be developed within Kinnarps AB, in order meet the identified user needs in the school environment?

The research shows a variety of existing needs in a school environment. There are needs which are met in some environments, but not met for users in other environments. Overall, common needs that are not met in the studied environments are somehow connected to flexibility and individual adjustments of furniture. The classrooms have a stationary performance with chairs and tables that are not easy to move around in order to adapt the furnishing after the current teaching situation. In some schools, furniture that enables individual adjustments can be found, but it seems to be too difficult for the user to adjust why the functions are not used. Moreover, the opportunity to change working posture, for example standing up while working are not satisfied for any users in the studied context.

The resulting solution to meet the identified user requirements is a "workstation" which is a chair with wheels and a backrest that can be turned 90 degrees in order to be used as a work surface. The concept answers to the aim of making the learning environment more flexible and enables various teaching situations where the personal workstation can be placed in groups in order to participate in a discussion or easily moved to a personal space in order to work individually and be able to concentrate. Furthermore, the workstation is dimensioned in order to enable work in a standing position, something that together with the flexibility, answers the question of how a furniture for a school environment can be developed in order to broaden the range of possible use situations. In conclusion, the research questions have been answered and therefore, the project is evaluated as successful.

References

AllaStudier.se. (2015). *70 000 studenter på Sveriges första MOOCs*. Received from: <http://allastudier.se/tips-o-fakta/3226-70-000-studenter-p%C3%A5-sveriges-f%C3%B6rsta-moocs/>.

Björklid, P. (2005). *Lärande och fysisk miljö: En kunskapsöversikt om samspelet mellan lärande och fysisk miljö i förskola och skola*. Kalmar: Lenanders Grafiska AB.

Bohgard, M., Karlsson, S., Lovén, E., Mikaelsson, L-Å., Mårtensson, L. Osvalder, A-L., Rose, L., Ulfvengren, P. (2015). Att utforma arbete och teknik på människans villkor. In M. Bohgard., S. Karlsson., E. Lovén., L-Å. Mikaelsson., L. Mårtensson., A-L. Osvalder., L. Rose., P. Ulfvengren. (Red.), *Arbete och teknik på människans villkor*. Stockholm: Prevent.

Boussard, J. (2015). *MOOC kommer till Sverige*. Received from: <http://allastudier.se/tips-o-fakta/3109-mooc-kommer-till-sverige/>

Bryman, A. and Bell, E. (2013). *Företagsekonomiska forskningsmetoder*. Stockholm: Liber AB.

Chalmers University of Technology. (2016). *Mooc - Massive Open Online Courses: Välkommen till Chalmers digitala campus - ChalmersX*. Received from: <https://student.portal.chalmers.se/sv/chalmersstudier/Sidor/Mooc---Massive-Open-Online-Cour.aspx>

Cornell University Center for Teaching Excellence. (n.d.). *Collaborative Learning: Group Work: What is collaborative learning?*. Received from: <https://www.cte.cornell.edu/teaching-ideas/engaging-students/collaborative-learning.html>

de Laval, S. (2010). *Hur kan skolans arkitektur stödja lärandet?: Dokumentation av ett seminarium på Arkitekturmuseet*. Received from: www.arkus.se/files/104/Skolans_arkitektur_larandet.pdf

- Demoskop. (2016) *Slutrapport: Undersökning om skolmiljö*. Unpublished manuscript.
- EDUCASE Learning Initiative. (2013). *Connected Learning*. Received from: <https://library.educause.edu/~media/files/library/2013/5/eli7096-pdf.pdf>
- edX. (2017). *Our Story*. Received from: <https://www.edx.org/about-us>
- Four design. (2017a). *FOUR@CAST'2 WHEELER*. Received from: <http://fourdesign.dk/products/fourcast2-wheeler#toggle-id-1>
- Freeman Herreid, C., Schiller, A. (2013). Case Studies and the Flipped Classroom. *Journal of College Science Teaching, Volume(42)*, No.5. Received from: http://capone.mtsu.edu/vjm/Univ_Service/CRWG_Home/References/CRWG-SPEE-REF-01.pdf
- Gustafsson, J.E, Håkansson, J., Myrberg, E., Román, H., Rosén, M., Sundberg, D.&Yang-Hansen, K. (2009). *Vad påverkar resultaten i svensk grundskola?: Kunskapsöversikt om betydelsen av olika faktorer*. Skolverket. Received from: https://www.skolverket.se/om-skolverket/publikationer/visa-enskild-publikation?_xurl_=http%3A%2F%2Fwww5.skolverket.se%2Fwtpub%2Fws%2Fskolbok%2Fwpubext%2Ftrycksak%2FBlob%2Fpdf2260.pdf%3Fk%3D2260
- Hägg, G., Ericson, M., Odenrick, P. (2015). Fysisk belastning. In M. Bohgard., S. Karlsson., E. Lovén., L-Å. Mikaelsson., L. Mårtensson., A-L. Osvalder., L. Rose., P. Ulfvengren. (Red.), *Arbete och teknik på människans villkor*. Stockholm: Prevent.
- Högskolan i Skövde. (2011). *Vad är antropometri?*. Received from: <http://antropometri.se/theory.php>
- Højer Møbler. (2016). *A new kind of table*. Received from: <http://zapconcept.dk/en/>
- Johansson, C. (2010). *Framgång i undervisningen: En sammanställning av forskningsresultat som stöd för granskning på vetenskaplig grund i skolan* (2010:1284). Skolinspektionen. Received from: <https://www.skolinspektionen.se/globalassets/0-si/08-om-oss/sammanfattning-forskningsoversikten.pdf>
- Johannesson, J., Persson, J.G., Pettersson, D. (2013). *Produktutveckling*. Stockholm: Liber AB.

Karlsson, M. (n.d). *Observation för att identifiera användarkrav*. Received from: <http://www.cse.chalmers.se/research/group/idc/ituniv/kurser/06/analys/Observation.pdf>

Karlsson, M. (2007a) *Kurskompendium - Lyssna till kundens röst* Received from: <http://www.cse.chalmers.se/research/group/idc/ituniv/kurser/07/analys/Lyssna%20till%20kundens%20röst.pdf>

Karlsson, M. (2007b) *Metod Appendix: Kurskompendium - Lyssna till kundens röst* Received from: <http://www.cse.chalmers.se/research/group/idc/ituniv/kurser/07/analys/Metodappendix.pdf>

Kinnarps AB. (2017a) *Sustainability Declaration: Xact*. Unpublished manuscript.

Kinnarps AB. (2014). *The better report*. Received from: <https://global.kinnarps.com/globalassets/sustainability-downloads/sustainability-report-2014-kinnarps.pdf>

Kinnarps AB. (n.d.,a). *XACT*. Received from: <http://www.kinnarps.se/contentassets/b916f42f8d8144f4b06d9670a7f0273e/xact-brochure-sv.pdf>

Kinnarps AB. (n.d.,b). *Hållbarhet: THE BETTER EFFECT*. Received from: <http://www.kinnarps.se/kinnarps/hallbarhet/>

Kinnarps AB. (n.d., c). *Kinnarps Colour Studio: Step Melange*. Received from: <http://www.kinnarps.se/design-tools/farger-och-material/?family=Step%20Melange>

Kinnarps AB. (n.d., d). *Kinnarps Colour Studio: Laminate*. Received from: <http://www.kinnarps.se/design-tools/farger-och-material/?family=Laminate>

Kinnarps AB. (n.d., e). *Kinnarps Colour Studio: Coloured Plastic*. Received from: <http://www.kinnarps.se/design-tools/farger-och-material/?family=Coloured%20plastic>

Kinnarps AB. (n.d, f). *Kinnarps Colour Studio: Laminate*. Received from: <http://www.kinnarps.se/design-tools/farger-och-material/?family=Fanér,Laminate>

Kinnarps AB. (n.d, g). *Foldex*. Received from: <http://www.kinnarps.se/contentassets/4c1ea837eab34cbfb85fe1c37356eea6/foldex-brochure-sv.pdf>

- Koroma, E. (2012). *Framtidens klassrum flyttar in!*. Received from: <http://www.edu.su.se/om-oss/nyheter/m%C3%A5nadens-profil/framtidens-klassrum-flyttar-in1.87637>
- Larsson, Å. (2015, 24 September). Lärare: Yrkesroll i förändring. *Skolvärlden*. Received from: <http://skolvarlden.se>
- Lekolar (n.d). *Skolbänk Mandal akustik ljusgrå*. Received from: <https://www.lekolar.se/sortiment/mobler-inredning/bord/skolbank/skolbank-mandal-akustik-ljusgra>
- Lozic, V. (2016). *Kvalitativt god undervisning viktigast för elevers lärande*. Received from: <https://www.skolverket.se/skolutveckling/forskning/didaktik/undervisning/kvalitativt-god-undervisning-viktigast-for-elevers-larande-1.194694>
- Martela. (2017). *Pinta*. Received from: <http://martela.se/skolmobler/skolbankar-skolbord/97pinta-skolbank>
- Möbelfakta. (2011). *The purpose*. Received from: http://www.mobelfakta.se/about_mobelfakta/the_purpose_of_mobelfakta
- Möbelfakta. (2012). *Nyheter 2012: Kinnarps går med i Möbelfakta*. Received from: http://www.mobelfakta.se/nyheter_mf/nyheter_2012_2/kinnarps-gar-med-i-mobelfakta
- Möbelfakta. (2015). *Criteria: Quality*. Received from: http://www.mobelfakta.se/about_mobelfakta/criteria_of_mobelfakta/quality
- Möbelfakta. (2017). *Criteria*. Received from: http://www.mobelfakta.se/about_mobelfakta/criteria_of_mobelfakta
- Nationalencyklopedin [NE]. (2017). *Pedagogik*. Available: <http://www.ne.se/uppslagsverk/encyklopedi/l%C3%A5ng/pedagogik>
- Osvalder, A-L., Ulfvengren, P. (2015). Metoder. In M. Bohgard., S. Karlsson., E. Lovén., L-Å. Mikalsson., L. Mårtensson., A-L. Osvalder., L. Rose., P. Ulfvengren. (Red.), *Arbete och teknik på människans villkor*. Stockholm: Prevent.

- Skolverket. (2016a). Läroplan för grundskolan, förskoleklassen och fritidshemmet 2011 (Rev. ver.). Received from: https://www.skolverket.se/om-skolverket/publikationer/visa-enskild-publikation?_xurl_=http%3A%2F%2Fwww5.skolverket.se%2Fwtpub%2Fws%2Fskolbok%2Fwpubext%2Ftrycksak%2FRecord%3Fk%3D2575
- Skolverket. (2016b). *Didaktik - vad hur och varför*. Received from: <https://www.skolverket.se/skolutveckling/forskning/didaktik>
- Steelcase (2017). *Education: Featured products*. Received from: <https://www.steelcase.com/discover/information/education/>
- Stridsman, S. (2015, 24 September). Så är skolan 2045. *Skolvärlden*. Received from: <http://skolvarlden.se>
- The Connected Learning Alliance. (n.d.). *What is Connected Learning?*. Received from: <https://clalliance.org/why-connected-learning/>
- Thylefors, I. (2015). Psykosocial arbetsmiljö. In M. Bohgard., S. Karlsson., E. Lovén., L-Å. Mikalsson., L. Mårtensson., A-L. Osvalder., L. Rose., P. Ulfvengren. (Red.), *Arbete och teknik på människans villkor*. Stockholm: Prevent.
- UC Berkeley Library. (2016, 31 October). *Center for Connected Learning: A Vision for the Future* [Video file]. Received from: <https://www.youtube.com/watch?v=zis3ningbYU&feature=youtu.be>
- Wallin, E., (2000). *Skola 2000. Nu!: En helhetssyn på pedagogik, arbetsorganisation och fysisk miljö*. Halmstad: Bulls Tryckeriaktiebolag. Wahlgren, A. (2012). Låt dataspelen forma skolan. *Skolvärlden*. Received from: <http://skolvarlden.se/artiklar/lat-dataspelen-forma-skolan>
- Österlin, K. (2011). *Design i fokus för produktutveckling*. Malmö: Liber AB

Picture references

Figure 2.1, Dimensions. Picture created by the authors.

Figure 2.2, Anthropometry. Picture created by the authors.

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Figure 4.4, Pupils in 3rd grade of high school. Picture created by the authors.

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Figure 4.14 The competitors:

Four design (2017b). *FOUR®CAST'2 WHEELER* [Electronic image]. Received from: <http://fourdesign.dk/products/fourcast2-wheeler#toggle-id-7>

Lekolar (n.d). *Skolbänk Mandal akustik ljusgrå* [Electronic image]. Received from: <https://www.lekolar.se/sortiment/mobler-inredning/bord/skolbank/skolbank-mandal-aku>

Martela (2017). *Pinta skolbänk* [Electronic image]. Received from: <http://picture.martela.com/folder/135/11%20School/08%20Pinta>

Höjer. Picture created by the authors.

Steelcase (2017). *Node* [Electronic image]. Received from: <https://www.steelcase.com/resources/furniture-images?search=Node&page=2>

Figure 5.1, Sketches 1. Picture created by the authors.

Figure 5.2, Sketches 2. Picture created by the authors.

Figure 5.3, The student chair Xact Kinnarps AB (n.d). *Xact*. [Electronic image].
Received from: <http://www.kinnarps.se/produkter/sittmobler/elevstolar/xact/>

Figure 5.4, Concept number 1. Picture created by the authors.

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Figure 5.15, Sketch of locking mechanism. Picture created by the authors.

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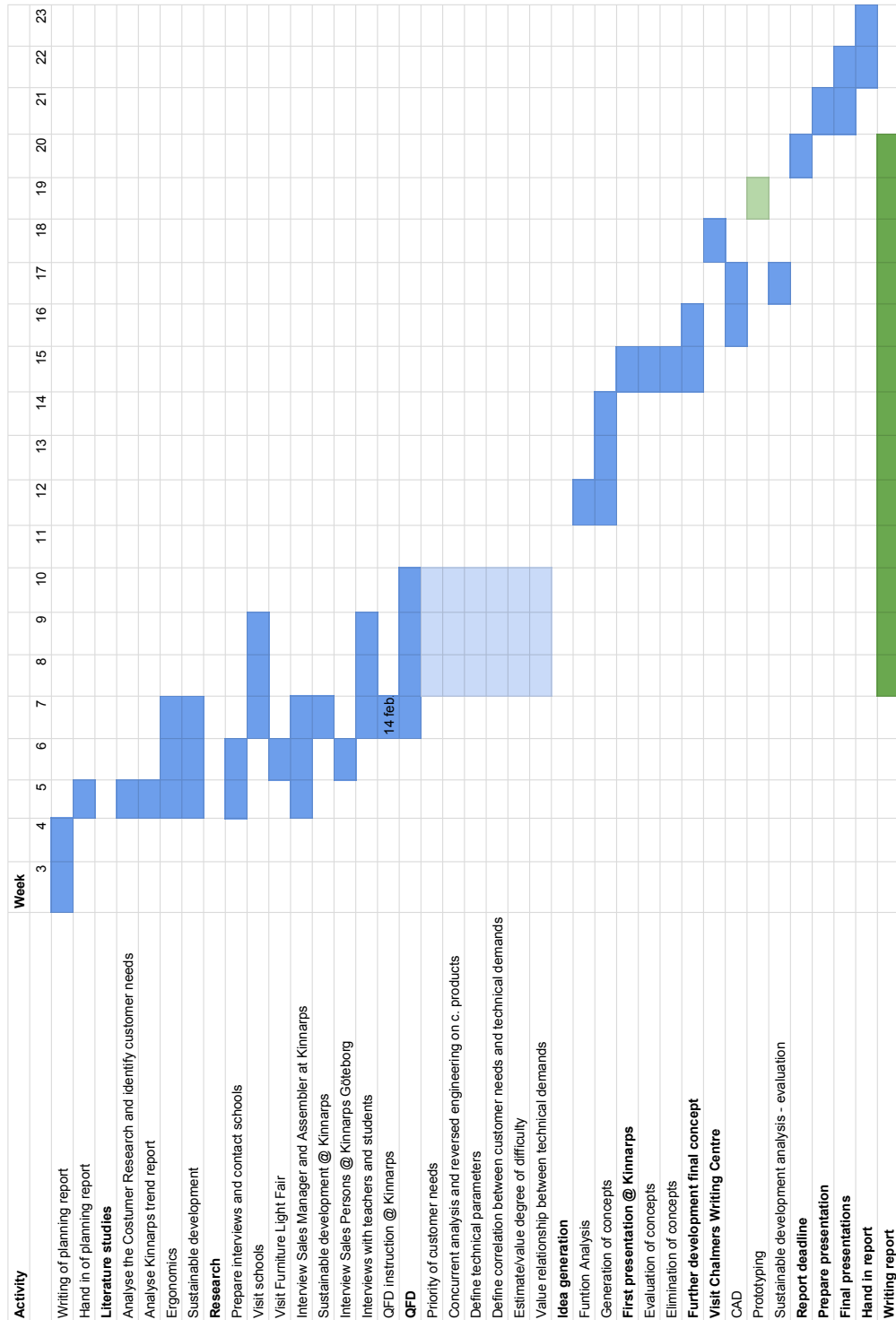
Figure 6.13, Test. Picture created by the authors.

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Figure 6.15, Presentations. Picture created by the authors.

Appendix

A Gantt schedule



C Interview guides

C.1 Teachers

- Vilka ämnen undervisar du i?
- Hur länge har du arbetat som lärare?
- Vilka hjälpmedel/redskap använder du i din undervisning?
- Upplever du begränsningar i den fysiska klassrumsmiljön? Vilka?
- Vilka behov i klassrumsmiljön upplever du som störst?
- Hur tror du att framtidens sätt att lära ut kommer att se ut?
- Vilka förändringar ser du i dagens sätt att lära ut/undervisa gentemot när du själv gick i skolan?
- Vilka behov i den fysiska miljön tror du kan komma att uppstå i framtiden?
- På vilka sätt anser du att digitala hjälpmedel och teknik kan tillföra något till skolans undervisning? Kan det försvåra undervisningen?

C.2 Furniture business

- Kan du beskriva din roll på Kinnarps AB?
- På vilka sätt arbetar du med Next Education?
- Har du direktkontakt med skolor i ditt arbete?
- Vilka behov ser du inte tillgodoses i dagens skolor?
- Vad finns för begränsningar i dagens lärandemiljö som hindrar nya typer av undervisning?
- Vilka behov ser du kunna uppstå i framtidens skolmiljöer?

C.3 Special Pedagogue

- Kan du berätta lite om din yrkesroll, om vad du gör?
- Vad har du haft för olika typer av roller i skolan?
- På vilket sätt behöver skolorna stöttning?
- Vad ser du för behov i skolmiljön?
- Hur hade du möblerat om du fick drömma?
- Tror du att det finns en helt optimal fysisk skolmiljö?