BYENS SKOLE

"A SCHOOL FOR THE FUTURE"

PROGRAM & PROCES

Master Thesis 2020
Sustainable Architecture
Aalborg University

CECILIE BRUUN JENSEN CHRISTINE DAMLUND EVEN ÅRSLAND ANDERSSEN

Master thesis /

Byens Skole - A School for the Future

Main supervisor /

Michael Lauring
Associate professor, Department of Architecture, Design and Media Technology

Group 15 /

MSc04 Arch, Department of Architecture and Design
Aalborg University

Technical supervisor /

Claus Topp
External lector, Department Manager at Niras, Aalborg

Project period /

Spring 2020
01.02.2020 - 28.05.2020

Report information /

Pages / 160
Appendix / 4 (7 pages)

Abstract /

This report presents the Master Thesis of Msc04 Arch/Sus group 15. The thesis presents a design proposal for a new school in Sundby, Lolland, focusing on social and environmental sustainability. As there is an ongoing competition about a new school in Sundby, the specific tender documents has been used as a basis for the project.

As a result of the national state school reform of 2013 implying more individuality and the educational strategy of "problem based learning", the architecture of schools calls for a change. The question remains how to design a place fitting all individual needs regarding personal development and education. Through research, studies and field trips, a program has been made where the most important keypoints of modern knowledge are concluded in a room program and specific design strategies taking all the different users of the building into account.

Sundby is situated in one of the municipalities in Denmark which has the highest amount of socially deprived children, making the implementation of well-being architecture essential. Through the spatial design, the school investigates spaces which acts as safe, restorative spaces.

The architecture is a result of the integrated design process, with a focus on implementing a great indoor climate, natural resources and a low energy consumption. Through implementing strategies to fulfill these technical aspects, the goal is to increase the awareness of sustainability for both pupils, teachers and the town of Sundby, making the building a teacher in itself.

The final outcome is a zero energy building which creates a new gathering point for the town of Sundby, while also considering the functionality of a modern school.

Cecilie Bruun Jensen

Christine Damlund

Even Årsland Anderssen

READING GUIDE

This project is divided into two parts with to different formats; a program- and process report, and a presentation report. The two parts are highly connected, and to understand all aspects of the project it is recommended to read both in the aforementioned order. Both parts are using the Harvard-method for referencing, where "(ibid.)" references to the last mentioned source. Each illustration is marked "fig.x", referring to the list of illustrations at the end of each part. If a figure is not in the list of illustrations, it corresponds to an illustration created by the group.

The assignment has been inspired by the tendering documents of a building program (Guldborgsund Kommune 2, 2019), where the group has extracted key information and inspiration for the spaces needed in the building. Though, it is not necessary to read these documents to understand this proposal.

As a result of the Covid-19 crisis, this assignment is exclusively handed in digitally, unfortunately making scales, sizes, colours and line weights highly dependent on the readers screen. Both PDFs are designed as spreads, but exported as pages. Though, it is recommended to read both PDFs, and especially the Program and Process, as spreads. **For the best graphical presentation of the project, the PDF should be read in Adobe Acrobat, and the following settings should be applied:** Open the file in Adobe Acrobat. Click **"View"** (vis) > **"Page display"** (sidevisning) and apply **"Two-Up"** (to-sidevisning). Go to **"Edit"** (rediger) > **"Settings"** (indstillinger) > **"Page Display preferences"** (sidevisning). Here, under **"Resolution"** (Opløsning), check the box for **"Custom Resolution"** (brugerdefineret opløsning) and set the resolution to **300 pixels per inch** (pixels/tomme). Under **"Rendering"** (gengivelse), **UNCHECK** the box for **"Enhance Thin Lines"** (forfin tynde streger). Make sure the box for **"Smooth Line Art"** (udjævn streggrafik) is checked.

This will make the PDF a bit more heavy to scroll, and the pages may need a few seconds to load, but in return the quality of the graphics are more representable. It is still recommended to zoom in the PDF if diagrams, drawings or pictures if they appear unfocused or dissolved. This is especially in regards to the plans, elevations, sections, diagrams and illustration with a high amount of lines. If the reader wants to print out the assignment, both document sizes fits within an A4. Though, there is no guarantee for the quality of drawings, pictures, nor scales if printed.

Every measurable drawing is presented with a suitable measuring bar, as well as a vignette displaying where the illustration has been made from.

PROJECT DEMARCATION

As the project is inspired by tendering documents from an ongoing competition, there are a few parts of a school the group has left out. The CKR-department, which requires thorough investigation of demands for handicapped and disabled persons, as well as the sports hall, has only been disposed in regards to the volume and necessary availability.

The project is designed as a sketch project, and as a result of the large amount of square meters, there are some parts of the building which is not fully detailed. Furthermore, the availability in the building and outside areas are solved at a conceptual level, and designed with enough surrounding area to follow the specific rules and dimensions in the eventual projecting phase.

The main technical focus has been the indoor climate in terms of atmospheric, thermal and visual comfort. All though these three aspects has been calculated, analysed and designed for, there are still parts of them that are mainly solved at a conceptual level. This is for example the ventilation strategy, where estimations has been made to secure enough space for the ducts. Fire and acoustics has also influenced the design, but not detailed in the same way as other focus areas.

In regards to the construction, the focus has been to incorporate principles and spatiality based on presumed carrying points. Because no calculations has been made, the dimensions, placement and amount is only solved at a conceptual level.

PROG

NEXT UP...

P

GRAM

ROLOGUE

INTRODUCTION

Only 70 years ago, we thought that left-handedness was a curable disease and therefore designed classrooms with daylight from the left, so the light unobstructedly hit the paper (Kirkeby, I. M., 2006). Some sources argue the first schools were established to create precise and obeying workers for factories (Prince Ea, 2016). In Denmark, we thank the christianity for initiating the school as a place to form everyone into good christians (Sørensen, J., 2013). Regardless of origin, the school was highly generic, systematic, and treated every individual the same in spite of the social, economic, physical and physiological differences existing among us.

These very roots of the traditional the school is still somewhere visible today, but as society has progressed, so has the perception of the individuals. This leaves our educational system with a huge responsibility of being able to see, accept and adjust according to each individual. The school has become the setting for the individuals development in our society, where we should learn how to survive in the outside world. However, there are many who can not complete state school, resulting in an evil circle of reduced welfare (Regeringen, 2013).

In the light of the need for accommodating our individual needs, research shows that children from socially marginalized families has more trouble concentrating, psychological problems and conflicts, compared to children from socioeconomically advantaged families (Ploug, N., 2005). It is time to accommodate the diversity and needs, and create spaces for discovering the individual potential which lives within us. How can we create a system that treats everyone fair, while still satisfying the individual?

At the same time, the world screams for a global change of attitude in terms of our climate which are now starting to threaten our society with rising sea levels, temperatures, emissions and more extreme weather. What better place to secure this respect, than in the generations to come? What if the architecture itself could be a medium to increase the awareness of our climate and the effect we have on it for both the children, teachers and public?

To provide an answer and a new approach to a school facing all the challenges mentioned, this master thesis will make a proposal on the ongoing competition regarding a new school in Sundby. Sundby is one of the places in Denmark with the highest degree of socially deprived children and the building program asks for a public building that connects the local society and provides educational spaces for both children and adults, while still focusing on sustainability (Guldborgsund Kommune 2, 2019)(Viden til velfærd, 2018).

PROBLEM

The school is a powerful tool for the community and an early intervention in social distances, but how is a future school optimally designed to include all pupils regardless of background and act as an unifying organism in its community? How do we create the framework to support different kinds of teaching, with spaces for calmness and concentration, while environments for movement and social inclusion emerges? How can the school through its architecture act as a pedagogue and tool for education and sustainability?

FIELD OF STUDY

This project focuses on sustainability, healing architecture and health in school buildings as a trinity, where modern learning environments, well-being architecture and environmentally sustainable solutions will be the driving force for the final design. It will be a school for the future, focusing on social aspects that embrace all children regardless of socioeconomic background and educational needs. The project is to be located in Sundby, which is a local community in Guldborgsund municipality in Denmark. Guldborgsund municipality has a high amount of socially deprived children, belonging to the 20 % of the most disadvantaged neighbourhoods in the country (Viden til Velfærd, 2018). Additionally, there is a concrete plan to build a new school in Sundby and the specific tendering documents will be a part of the basis for the presented program and final design (Guldborgsund Kommune 2, 2019). The site is an empty field project in a contextual mix of nature, residential- and industrial areas, close to the city of Nykøbing Falster.

The project must not only focus on the pupils, but also implement the needs of the employees, the parents and the local community as a whole. A holistic approach to teaching methods, the spatial tendencies and sustainable awareness will be incorporated in the final design of the future school.

The school will be between 5.000 - 8.000 square meters and facilitate 500-600 pupils. Furthermore, the target is to reach zero energy-standard and exude a focus on awareness around sustainability through the building design, use of materials, indoor environment and use of passive and active strategies. More exclusively, the project will focus on energy performance, natural daylight and thermal- and atmospheric comfort. These specific parameters will be a part of evaluating the different concepts through the design process.

fig. 1.

METHODOLOGY

The integrated design process. The integrated design process will form the basis of the project and act as the foundation to integrate engineering and architectural knowledge. The IDP is defined as an iterative method, consisting of five phases. The problem phase describes the initial part of the project by defining the basis of the project idea. The analysis phase encompass different analysis' that should incorporate all parameters; site informations, architecture of the context, microclimate, demands/limits for the area, location and relation etc. The sketching phase embrace the outcome from the previous phases and here the professional knowledge of engineers and architects are combined. This should result in the most appropriate solution, which is further detailed in the synthesis phase, combining all phases. Lastly, the presentation phase is the creation of the final presentation material for the project, which must show all qualities and how the aims have been fulfilled (Knudstrup, M. A., 2004).

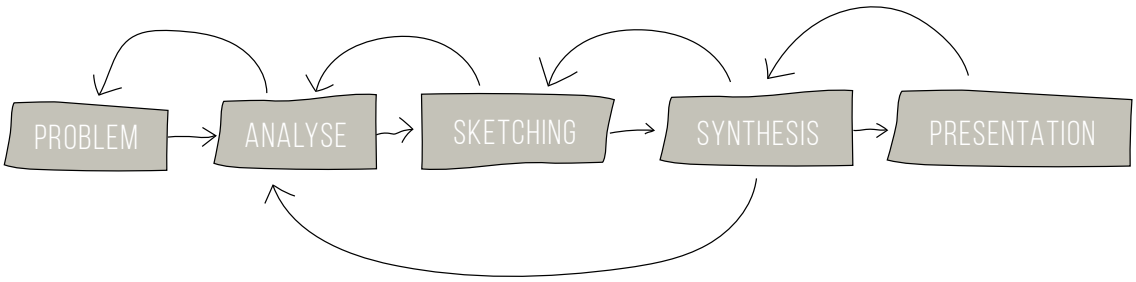


fig. 2. IDP: Knudstrup, M. A., 2004.

From problem to a future school building. As the IDP may seem like a structured recipe, the reality when designing a new school building in Sundby, is that it is on the contrary more or less free and without boundaries. The more jumps between the stages, number of loops and tools exploited throughout the project, the more arguments it is for the final result. Hereby, one can look at the integrated design as the narrative about the foundational arguments for an architecture, which has solved the problem about designing a future school, reaching the zero energy building standard and incorporating sustainable solutions to lower the CO_2-emission, in the best possible way.

This project will be a result of a sketching phase, where a lot of analog sketching through hand-models and -sketches has been made. Though, at some point in the process a switch will happen, when the integrated design process encourages for digital simulations, calculations and fast parametric modulations.

The digital program Sketchup is often the first software in the sketching process and therefore acts as a portal into the digital world, also supplying information for Be18 and BSim. The final design will end up in Revit for final modulations, where the Revit-model will form the basis for final energy- and indoor climate calculations and presentation material.

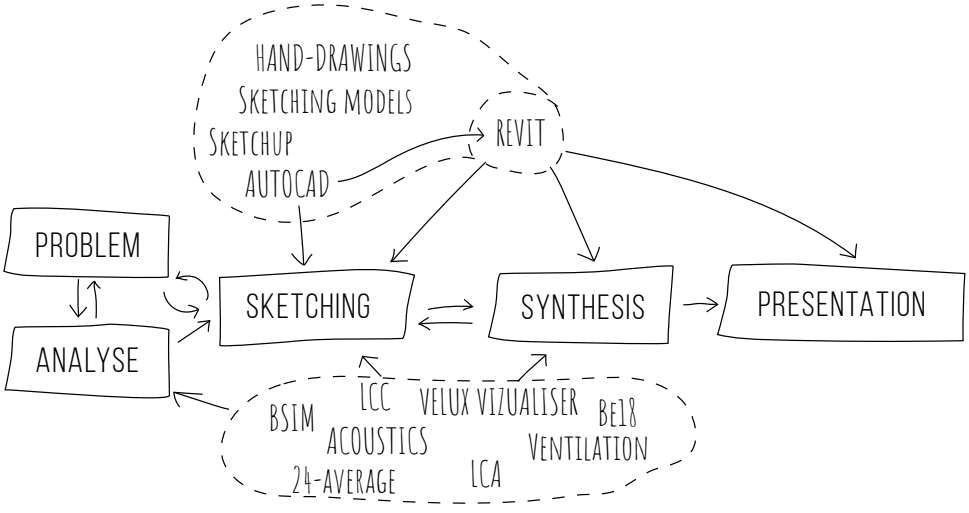


fig. 3. the group's IDP

ANALYSIS PHASE

Literature studies. (academic papers, evidence-based design, books) When starting this master thesis about a future school, the first step was to do literature studies at the library through books and online through academic papers. This method will be used to get a strong scientific grounding and insight in existing knowledge and theory related to school projects. It is important to be critical in the selection of sources, due to quality and time perspective. Furthermore, it is a way to gain insight in the tendencies of modern school architecture and be capable of discussing arguments and solutions through theory (Eriksen, T., 2016).

Interview. (transcription, interview guide, recorder, notes) To get a better insight in the users of the new school, a qualitative semi-structured interview of both pupils and teachers is an efficient method. The informant answer freely questions asked by the interviewer, formulated in an interview guide to structure the interview. While the interview goes on, follow-up questions secure that relevant topics in accordance to the use of the school building is covered. This method is subjective because the informant state own points of view, hence it is important to have a critical approach in regards to the selection of informants and formulation of questions. The answers are being compared to each other to see potential patterns, clarify the daily use, find problems that needs to be taken into consideration and potential solutions in the way of designing a new school (Larsen, A. K., 2010).

Case study. (field trips, hands-on analysis, spatial investigations) When studying existing school buildings, an understanding regarding the users, concept, typology and architectural qualities occur. Furthermore, the case studies will take part in a reflective and critical state of mind when starting the sketching phase (Ågård, 2014).

Collecting empirical data. (maps of the city, weather data files, databases) It is important to be aware of the context's environmental challenges and advantages in Sundby. By collecting and analyzing data about the weather and present it graphically, it will act as an indicator of what to be aware of and focus on when designing the building.

James Corner, mappings. (field trip and observations, hand drawings, hand notes, CAD-tools) This method is used to be able to analyse and interpret the urban environment in Sundby and around the site, hereby constructing the unconfirmed. It is an efficient way of investigating selected elements as for example the infrastructure, typologies, nature elements and other education buildings in the context. By using and interpreting this mapping method, an overview of the content and the potential of the site will appear, hereby leading to an analysis of the connection between the site and its surroundings (Corner, J., 1999).

Gernot Böhme, atmosphere. (field trip and observations, photo-registration, hand notes, digital programs) This method should work as a sensual supplement to the mapping method and be a between-phenomena analysis focusing on the relation between subject and object. This method should contribute with a clarification of the atmosphere on site, how different viewpoints can be useful for the design and give a more phenomenological perspective to the project (Böhme, G., 1998).

Sven-Ingvar Andersson, building and landscape. (field trip, observations, photo-registration, hand notes, digital programs) This method should contribute with a description of the landscape composition and create a stronger connection between the future school and the surroundings in Sundby. Furthermore, to understand the building in a precise relation to the landscape; in the middle, on the top, on the middle, at the edge and inside. The school should not only focus on fulfilling practical purposes, but also let the architecture act as art and hereby emerge as a symbol and signal a positive identity. By using this method, potentials of the site will occur, which will ensure that the building are able to give something back to Sundby (Andersson, S., 2002).

SKETCHING PHASE

Inspiration board. (analogous collages, digital collages, photo-registration) In the very beginning of the sketching phase inspiration boards in line with the school theme, sustainability and architectural ideas will concretise and frame ideas. These boards will show relevant associations and potential architectural qualities.

Volumetric studies. (sketching, physical modelling, Revit, Sketchup) In the beginning of the sketching phase volumetric studies is a great way of understanding the square meters that the users demand. Furthermore, it will create an understanding of the square meters in relation to the scale of the context and the landscape at the site. Volumetric studies is also useful in investigations of details, hereby contributing with potentials to the design. A translation of both analog and digital 2D drawings into 3D digital volumines and physical models, will make more problems occur, which needs to be investigated in-depth and hereby bring more knowledge into the design.

Sketching. (analogous sketching, CAD-tools, Sketchup, Revit, physical modellering) When the sketching phase really sets in, 'Reflection Drawing' will be used. This is basically the way of drawing the non-existing world. It could be fast hand drawings of different form concepts but also internal room concepts of the school. Furthermore, 'designing-by-drawing' will be an essential part of solving problems of specific designs and here more drawings must follow to investigate the potential of the concept. This method uses hand drawings but also digital drawings, digital 3D-models and physical models, where the method of hand drawing often is a faster tool to adjust a concept. Though, it is important to use all ways of sketching to be able to investigate more extremes and find potentials of the spatiality and the atmospheres, which sometimes is more convincing in physical models (Steinø, N., 2018).

Midterm seminar. When there has been generated a lot of concepts in the sketching phase, it is time to select some of the best ideas for the midterm seminar. Here the method 'Communication Drawing' will be used for communicating the idea to others with the intention of getting constructive feedback from professionals. The seminar will hopefully lead the process into the final part of the sketching phase, where the concept will get more detailed. Sometimes a need for going back in the analysis phase to shed light on a specific topic occurs and then the sketching phase will continue just with another aspect taken into consideration (Steinø, N., 2018).

Pre-studies. (Velux Visualizer, Grasshopper, Be18, Revit) To investigate more aspects of a specific concept, pre-studies due to shadow-studies, sunlight radiation analysis, daylight analysis, energy performance, acoustic rule of thumbs and LCA analysis will be necessary. These pre-studies could also be a way of deselecting or selecting some design solutions based on a more technical foundation with justifications and quantitative measures. Hereby, the investigations encourages a more professional discussion with each other.

SYNTHESIS PHASE

Simulations. (Bsim, Velux Visualizer, Revit) In the synthesis phase more technical simulations related to the building performance in its microclimate will be helpful to investigate more extremes and get closer to the target of reaching the zero energy building standard. Furthermore, it is important to investigate the indoor climate when designing a school building to find the best possible solution. Therefore, the indoor climate should be studied with more and more details as the design process progress.

Calculations. (Be18, 24-hour, mount average, acoustic hand calculations, LCA analysis, LCC analysis) When designing a school building nowadays, sustainability is more and more a focuspoint. Therefore, it is important to integrate the use of LCA analysis to reduce the CO_2-emissions from the materials, but also to state the focus on using more natural building materials. The impact of daylight is essential in a school building due to the pupils well-being but also to secure that the building will perform in the best sustainable way. Therefore the use of the program Be18, 24-hour- and month average analysis spreadsheets, will be useful for the outcome of the final design. Also in this phase it can be necessary to return to one of the previous phases to investigate something more and then go back and adjust the final design. Another important aspect is the acoustics that also need to be integrated throughout the whole design process and adjusted due to the finding results.

PRESENTATION PHASE

Illustrations. (Illustrator, Photoshop, CAD-tools, Indesign, Sketchup, Enscape) Making illustrations is a technique to visualize the final school design. It can also be a useful tool to supplement and visualize text, hereby maintaining the reader's interest. When making illustrations, the project will be presented through a certain style, that will express and reflect the intention of the future school.

Renderings. (Enscape, Revit, Photoshop) To present the reader for a deeper understanding of the spatial impact the school has in relation to the wanted atmosphere, the needs and the concept at all, 3D-perspectives will be exploited. There are different types of rendering styles; either they are of a more realistic style, or more conceptually presented. Last-mentioned will be used to express the atmospheres, spatialities and the final concept. Furthermore, how we as architects think the school building should appear for the users. Different perspectives (eye-height, bird-height, frog-height) is a crucial part of how to perceive the concept, especially when the users of a school differ a lot in height.

Presentation folder. To present the future school building, a presentation report will be made. Additionally, this is a way to structure the unstructured design process. To present it for the reader as clear as possible, the reports are constructed as chronological sequences, but in reality the process behind has been of iterative character.

Model making. To present the final design as a simplification of the reality and get a spatial understanding, a physical model will be made. Furthermore, this model will contribute with a reflection of the constructional aspects, explain how the school building is situated in the landscape and underline the overall conceptual thoughts.

fig. 4.

NEXT UP...

THEORY

THE STATE SCHOOL REFORM

In 2013 the danish government presented "Folkeskolereformen", which brought up statistics, target goals, and the economic and strategic methods to achieve these goals for a brand new school system. While the intentions for the reorganization of the Danish school system were good and highly ambitious, the reform was criticised by politicians, teachers, pupils and parents for its strict appearance in 2013 - and now, six years later, also for its lack of results. Besides being a plan to secure a higher quality of the average education, the reform is brought to life because of Denmark's wish to stay internationally competitive in the infosociety we live in (Regeringen, 2013).
The government adopted three main goals. These overall goals cumulates in an ambition of having at least 95% of the pupils completing at least one upper secondary education after leaving elementary school (ibid.).

1

THE ELEMENTARY SCHOOL SHOULD CHALLENGE ALL PUPILS, SO THEY BECOME AS SKILLED AS POSSIBLE.

2

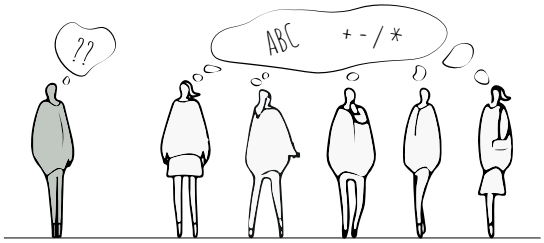
THE ELEMENTARY SCHOOL SHOULD REDUCE THE IMPACT OF SOCIAL BACKGROUND IN TERMS OF LEARNING RESULTS.

3

THE ELEMENTARY SCHOOL SHOULD STRENGTHEN THE LEVEL OF TRUST AND WELL-BEING THROUGH A RESPECT FOR PROFESSIONAL KNOWLEDGE AND PRACTICE.

Besides, there is an overall goal to increase the pupils well-being in school (ibid.). Presenting several points of change, the most important moderations is the implementation of 1 daily hour of physical activity, increased cooperation between the school and parents, longer day of school and the establishment of more silence in the classrooms (Regeringen, 2013). Stressing that the reform would take 10-15 years to
take roots, the Minister of Education is now adjusting the reform after knowledge from the statistical reports. Certain points has seen a smaller change, both positively and negatively, and other has remained the same. The conforms are though seen as minor changes in the total picture, still leaving the 2014-reform with a great amount of trust (Bjerril, S. and Møller, E. B., 2019).

There is no doubt the school reform´s intention was to ensure more quality and well-being for pupils attending the elementary schools. How this has carried out in practise is another question, and as Kommunernes Landsforening points out: to introduce these new terms is difficult, almost impossible, in spaces that are designed for something else. This calls for a change in the way we structure, arrange and design schools (Kommunernes Landsforening, 2013). We have to tailor the rooms to meet the requirements of the new teaching methods and honor the name of school architecture as the third pedagogue.



"BETWEEN 15 AND 17 PCT. OF THE PUPILS LEAVES ELEMENTARY SCHOOL WITHOUT SUFFICIENT READING- AND MATHEMATICS SKILLS, AND A LOT OF THE STUDENTS ARE BEING REFERRED TO SPECIAL SCHOOLING." (REGERINGEN, 2013)

fig. 5. statistic

HISTORY OF THE DANISH SCHOOL

The idea of education has been known since the Middle Ages, where the school was highly related to the Christian church. From the beginning of The Reformation in Denmark in 1537, it was the national state who got the responsibility for the schools. Before the first national School Act was stated in 1814, several types of schools appeared, finding inspiration in the philosophy of the Age of Enlightenment (Sørensen, J., 2013.). The public school has been developing in interaction with the progress of society the last 200 years, where there has been a transition from schools forming good, Christian citizens, to a school characterized by freedom, equality and personal development (Børne- og undervisningsministeriet, 2019.).

Throughout the years in Denmark, the different schools can be categorised into two overall typologies; the vertical school with a centre aisle and homogeneous classrooms, and the horisontal school where the building spreads out into the landscape, with views to the outside from all rooms (Viltoft, K., 2017.). Furthermore, we can place the school buildings into 6 different typologies, which is typical for a given period of time. Because of schools being extended throughout the years, it has often resulted in a mix of these typologies (Center for Indeklima og Energi ved DTU, 2016).

Village School. This school type is a one storey, detached building situated in the middle of the village (ibid.).

Multiple-storey School. A centrally located school to gather pupils from different districts. This type of school building is often in 3-4 stories with a central entrance and classrooms placed along a corridor (ibid.).

Main hall School. The main characteristic for this building is the implementation of a main hall or a centrally placed atrium and that it typically consists of 2-3 stories. The classrooms include large windows and the facades are often constructed of concrete or bricks (ibid.).

Finger School. This building is divided into branches with different functions. The typical Finger School consists of one storey, hence a largely covered ground area, and is often seen with a brick facade (ibid.).

Open-plan School. This typology is based on the principals of the Finger School, but makes it possible to support the project-based teaching by securing spaces for group work in different constellations. The building typically consists of 1-2 stories (ibid.).

Project-based School. The modern school buildings equate pupils and teachers, and the needs from the different users has all been taken into consideration. Some of the characteristics for this type is the high-ceilinged rooms with large window areas for natural light and great outdoor facilities (ibid.).

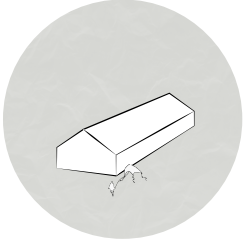


fig. 6. village school

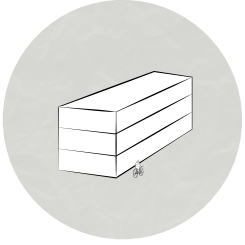


fig. 7. multiple-storey school

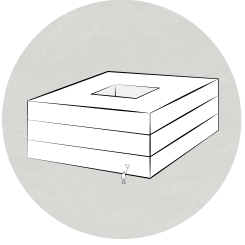


fig. 8. mail hall school

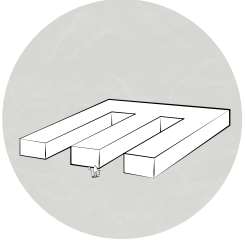


fig. 9. finger school

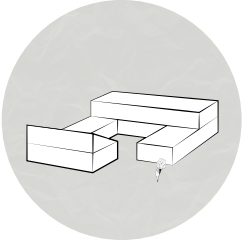


fig. 10. open-plan school

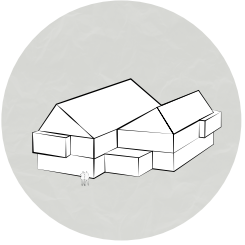


fig. 11. project-based school

SUSTAINABLE ARCHITECTURE

The underlying basis of the way we see and talk about sustainability today comes from the Brundtland-report presented in 1987. Since then, the term "sustainability" has developed, but the idea of considering our own well-being without compromising the same opportunities for the generations to come is still the same (Dansk Arkitektur Center, 2017). A huge amount of responsibility can be put on the building business, as the industry is responsible for 36% of the CO2-emissions in the EU (Europa, 2019). Likewise, we spend 90% of our time inside a building, and most likely during the last 10% we are surrounded by the built environment (Doktor, T. 2019).

To secure a holistic approach, there are three core areas of sustainability; social, environmental and economical. The social aspect is considering people's well-being, and is now getting increased focus through the 17 global goals. Economic sustainability is about considering the societies economic growth, while the environmental part is about looking after the planet we are living on through either adaptation or mitigation (Dansk Arkitektur Center, 2017). All of these aspects must be considered in the building industry, and the increased attention for sustainable considerations has left us with classification systems like DGNB, LEED, and BREEAM. DGNB is applied in Denmark, considering all three sustainable aspects in a building.

Be18 is used to calculate the buildings energy performance. The final energy score has to meet the 2015 energy class, where the demand is varying with the function of the building. This final energy score will further reveal whether or not the building may be classified as a type of Zero Energy Building. Through these ongoing demands for the building's energy consumption, the demand for energy consumption has decreased from 350 kWh/sqm to 20 kWh/sqm in 60 years (Sonne, F. G. H., 2019).

Scientists are now claiming there is a certain "control" on the energy consumption, emphasizing the next step is to reduce the embodied energy of the buildings through considerations regarding sustainable materials, construction methods and the whole lifespan of the building and its materials. This makes tools like LCA highly relevant during the design process (ibid).

As the architecture of schools in Denmark are experiencing an intervention, a lot of new schools are being built every year. If we can design these buildings with a low emission and energy consumption, it will have a positive effect on the total green accountings. By also planning the school as a multifunctional and accessible building, the need to build other buildings will decrease in the local societies. Besides, designing schools with an eye to sustainability, numbers show a significant relationship between a healthy environment and good student results. In an economic perspective, the money saved on energy consumption, may used wisely for other educational purposes (Gelfand, L. & Freed, E. C., 2010). Strategies on how to achieve this will be handled in section of "The Sustainable School".

The "New School in Sundby" will focus on reaching the Zero Energy Building-standard through both passive and active solutions. Designing a building to convey knowledge, these strategies will be used as design drivers to further educate and increase the awareness of the users and visitors about sustainability. Besides the focus on energy consumption, the schools final design will be argued for through LCA- and LCC-analysis for some of the crucial building parts.

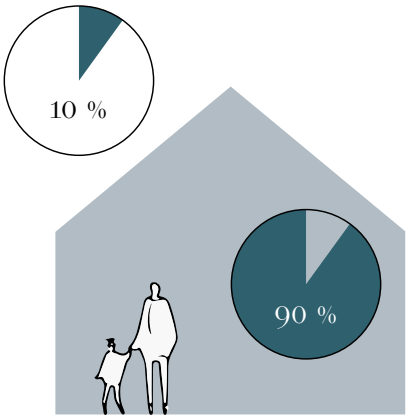


fig. 12. used time indoor

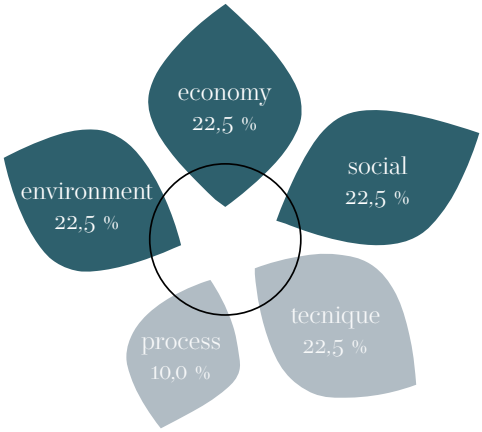


fig. 13. DGNB

WELL-BEING ARCHITECTURE

The definition of good health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity,", while well-being is "in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community." (World Health Organization, 2014.).

In our modern society, there is a huge demand for our brain to continually pay attention and quickly process new information. This huge amount of continuous information originates from our surroundings and affect us as positive or negative stimuli, and for an increasing number of Danes it results in stress and/or related disorders (Sundhedsstyrelsen, T., 2019). As 90% of our time is spent inside the built environment, this would be an obvious place to start increasing our well-being, and research has proven specific spatial parameters having a direct influence on feelings of stress, annoyance and anxiety (Sullivan, W., 2011.).

How do we create an architecture that promotes physical and psychological wellness for as many as possible? It all comes down to the creation of restorative spaces; our environmental medicine. These are spaces, and transitions between them, that offers a break for the mind and brain, stimulates the senses, makes us focused on the present and acts as a foundation for well-being: feeling good and functioning well (Nanda, et al. 2013). There are multiple strategies for designing restorative spaces, but a common denominator is the clear reference to a natural environment in regards to light, sounds, tactility, views, smells and materials.

Besides focusing on the design of restorative spaces, another strategy to promote well-being is designing to avoid stressors such as noise, lack of light, too much light, lack of legibility and too many choices. These stressors stimulates the brain negatively by triggering the natural instinct of fight-or-flight, which in the end leads to stress (ibid.).

A school is a large part of children's life, and may therefore be considered as the cornerstone for the individuals further development, health and well-being. There is a strong relationship between the well-being of students, their results and the amount of absence. Numbers actually shows, that the educational progression is up to 20% better in classrooms with sufficient daylight and pleasant acoustics (Gelfand, L. & Freed, E. C., 2010).

SUB CONCLUSION

The State School Reform has ruled since 2013, with the aim of a high-quality education for everyone through longer school days, physical activity and more project-based learning. Many of today's school buildings are not designed for this. Therefore, a future school need spaces that form the basis for project-based work and nudge all the users to be more physically active.

The longer days induce that the pupils lives revolves more around the school, which makes the indoor climate a crucial parameter for their well-being. To avoid that the physical environment will result in more stressed pupils, it is important to secure a good indoor climate, views to green surroundings and a clear wayfinding system. In addition to this, the new school should be a pioneer within sustainability to help reduce the environmental impact from the building industry.

To reach Zero Energy Building standards, different parameters such as materials, energy supply and the overall performance should be taken into consideration. Furthermore, the usage of the school building should be optimized and be more multifunctional. This will allow the local community to use it and hereby also contributing to the society through a more social sustainable perspective.

NEXT UP...


SITE

PLAN AND PROGRAM

Local plan. The local plan 193 "Ny skole i Sundby" (Guldborgsund Kommune 1, 2019), describes an area in Guldborgsund municipality which should be used for public aims. With this local plan, the city council is planning for a new public school as replacement for the old school called 'SUNDskolen'. The overall vision is to build a public learning center where the school, a future daycare institution and the local community will stick together and create an environment for learning and social development. The new school should, through the way of designing, create more awareness around the Sustainable Development Goals, with a special focus on learning environments, choice of materials, encouragements for movement and the buildings energy consumption. The building must be built in maximum two stories and have a maximum height of 10 meter. Furthermore, the local plan describes the future of the nearby infrastructure and how the school should be accessed (ibid.).

Gulborgsund municipality building program. The building program (Guldborgsund Kommune 2, 2019) supports the local plan and clarifies the ambition for a project with a main focus on sustainability and well-being, combined with the opportunity for project- and practice-based learning environments. The future school is to be established as an 'empty field project' in an exciting environment with nature areas against north and west, residential areas towards east and an industrial district towards south.

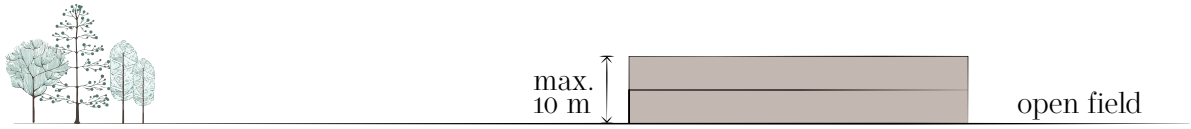


fig. 14. building height

FOCUS POINTS

This section describes significant parameters from the building program written out by Guldborgsund municipality, important tendencies in modern school architecture and evidence-based design.

The future school must contain of 0.-9. class for 500-600 pupils, and the total square meters are expected to be around 5.000 - 8.000 containing all essential functions. The school must act as a liaison between Sundby and Nykøbing to make it possible to merge different social stratums. The pupils everyday life must be characterised by predictability and fixed boundaries, where the teacher is able to push the pupils concurrently with their own development. The school must support todays pedagogical way of teaching in the full-day school (Guldborgsund Kommune 2, 2019).

Since the school must focus on incorporating more movement and physical activities, zones for physical activity and a sports hall will be needed. Furthermore, specialised classrooms and administration acts as essential parts of the future school. There is a need to focus on creating a balance between large gathering spaces for the community and more decentral, comfortable rooms for the individuals. Another important parameter will be the flexibility for the future needs, all though it is impossible to tell the future and what will be needed. Lastly, it will be a focus on increasing the awareness around sustainability by exploiting ordinary factors like daylight, air and rainwater as design drivers. This will transform the school into a learning-element itself (ibid.).

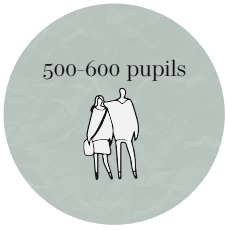


fig. 15. number of pupils

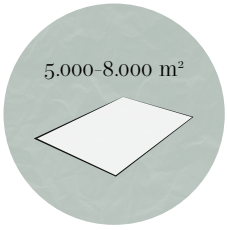


fig. 16. squaremeter

fig. 17. type of school

GULDBORGSUND

The history. Guldborgsund Kommune, was established in 2007 after a consolidation of multiple minor municipalities within Falster and Eastern Lolland. The municipality is connected by Guldborg Sund and has its administrative center in Nykøbing Falster. Nykøbing Falster has been a nodal center since the railway opened in 1872. The railway extended to Gedser in 1886, where a harbor was built and welcomed railway ferries from 1903. In 1963 Nykøbing became a part of the run called 'Fugleflugtslinjen', which is one of the main connections to the rest of Europe (Den Store Danske 1, 2017).

During the 19th century Nykøbing built a harbor and the first bridge connecting Falster and Lolland over Guldborg Sund, which gave birth to the satellite town of Sundby. The city mainly contains single and two-family houses from the interwar period and newer single-family houses (Den Store Danske 2, 2017).

The eastern coast of Lolland, where Sundby is placed contains cultivated fields and forests. There are 1130 preserved burial mounds from the ancient time all over Guldborgsund Kommune (Den Store Danske 1, 2017).

Facts. The area of Guldborgsund Kommune is 907 square kilometers with a total of 60.735 citizens, where 16.904 lives in Nykøbing Falster and 2.843 lives in Sundby (ibid,.)(Guldborgsund Kommune, 2020).

Statistics. In 2018 the full-time unemployment rate in Guldborgsund Kommune was 4,57%, while the average in Denmark was 3,83%. Also the nearby municipalities had a high unemployment rate (Skift-A-kasse, 2019).

In 2016 a study of schools in Denmark was made. Here the pupils grades corrected by their socioeconomic background weighted 40%, the pupils absence 20%, the pupils well-being 20%, and the amount of subjects where the teacher has competencies as the main subject 20%.

770 out of Denmark's approximately 1000 public schools including 9th. grade participated. Twelve schools was located in Guldborgsund Kommune. Out of the 770 schools, three of the schools from Guldborgsund ranked in the bottom 10. The best school from the whole municipality ranked 462. In average, the twelve schools scored best on the pupils grades and the teachers competencies, while they scored worst in pupils absence and well-being (Bünger, T., 2016).

In 2019 the percentage of danish citizens in the age 25-69 having an upper secondary education or higher was 74%. Guldborgsund Kommune was among the quarter of the municipalities with lowest percentage, 69,1%. Though, if you isolate the vocational education, the numbers shows that Guldborgsund´s inhabitants has a larger amount of vocational education than higher education, compared to the national numbers (Danmarks Statistik, 2019).

A measurement of how many socially deprived children per citizen there are in the different municipalities, Guldborgsund Kommune was among the 20% with most socially deprived children. Additionally, the score was the highest possible, which means they are actually some of the municipalities with the highest amount of socially deprived children in Denmark (Viden til velfærd, 2018).

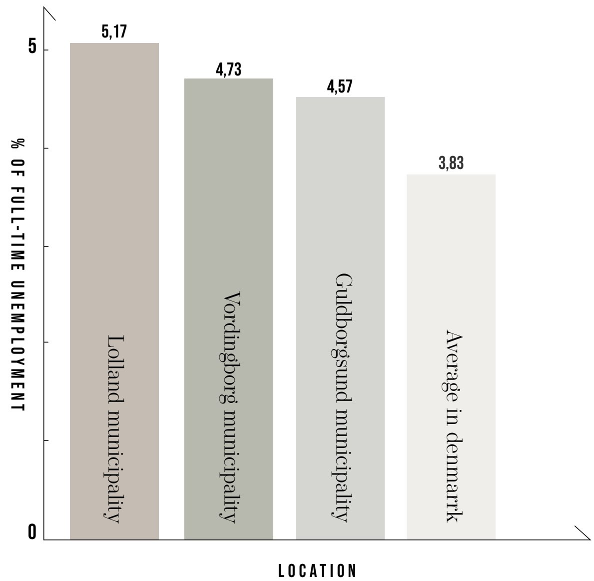


fig. 18. statistic

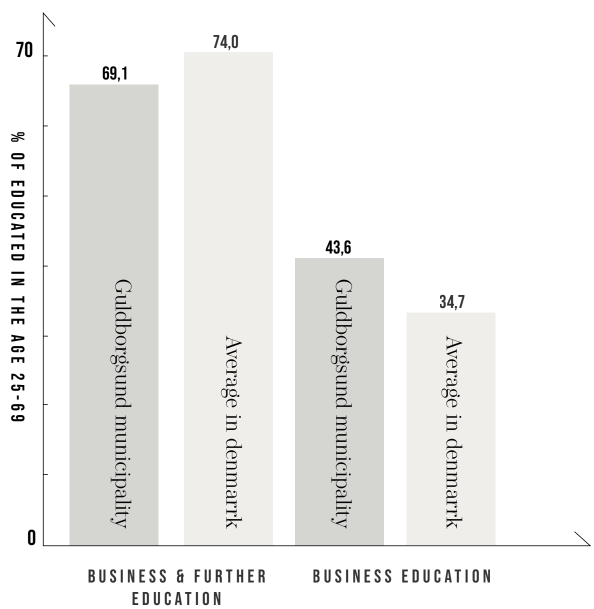


fig. 19. statistic

THE SITE AREA

The site is placed at the edge of Sundby. Towards west and northwest, there is an open flat field were trees are seen in the horisont. Northward, a smallholding called Nagelsti Skovgaard is placed. The land in which the site is placed on, is owned by Det Classenske Fideicommis, who has agreed to sell the land to Guldborgsund municipality to build a new school (Guldborgsund Kommune 3, 2019).

It is also "Det Classenske Fideicommis" who has developed the settlement towards north. Here, 88 building sites were developed back in 2007, but only 11 sites are sold today (Det Classenske Fideicommis, nd.). It is in the northern part of the site, towards the edge of the settlement, that the playground, sport facilities and playing field should be placed (Guldborgsund Kommune 1, 2019).

Towards east there is a preserved burial mound, with a landscape which has a protected circumference of 50 meters. A part of the protected area is placed on the site, but should stay untouched (ibid.).

The eastern part of the site twists itself into a neighborhood and stretches towards the center of Sundby. Here, there should be laid an access by bike and foot, and additionally bike parking should be placed (ibid.).

Southward is where the heavy industry lies, while the railway and main road runs by. Both from here and from the north, access roads are planned. Therefore, a mix of car access and greenery should be landscaped. The school building itself should be placed somewhere between the center and the southern part of the site (ibid.).

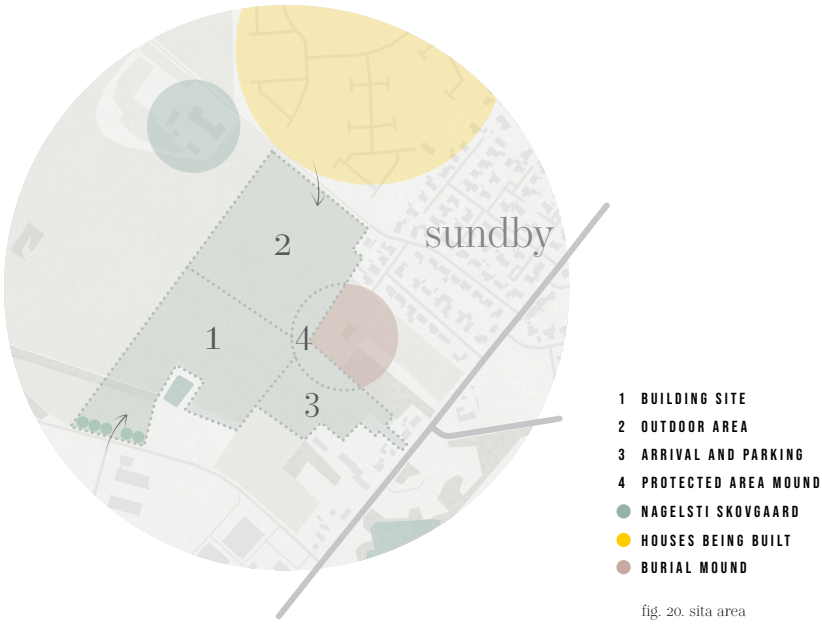


fig. 20. sita area

fig. 21. Nagelsti Skovgaard

fig. 22. Nagelsti Skovgaard

fig. 23. East access road

MAPPINGS

Institutions. In the near context to the site, SUNDskolen is the only public school in Sundby. The other schools are all placed in Nykøbing at the other side of Guldborg Sund. Further educations consist of two upper secondary educations and three vocational educations in the center of Nykøbing. In Sundby an institution called FGU is placed, and here you can get basic education as preparation for further education or access in to the job market.

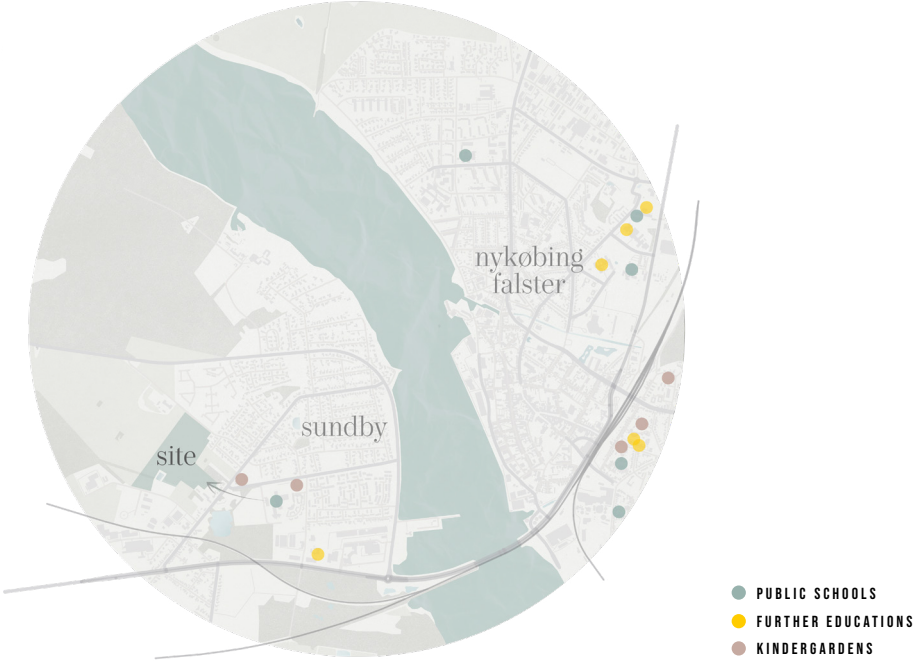


fig. 24. institutions

Learning environments. A school should exploit different learning environments in the city. Sport facilities in Sundby and Nykøbing are mainly water sports. Around the actual site, nature can be used for teaching - both the woods, a small lake and the strait are nearby. In the context, many different cultural buildings are placed. This includes museums, theatres, a church, and evening schools.

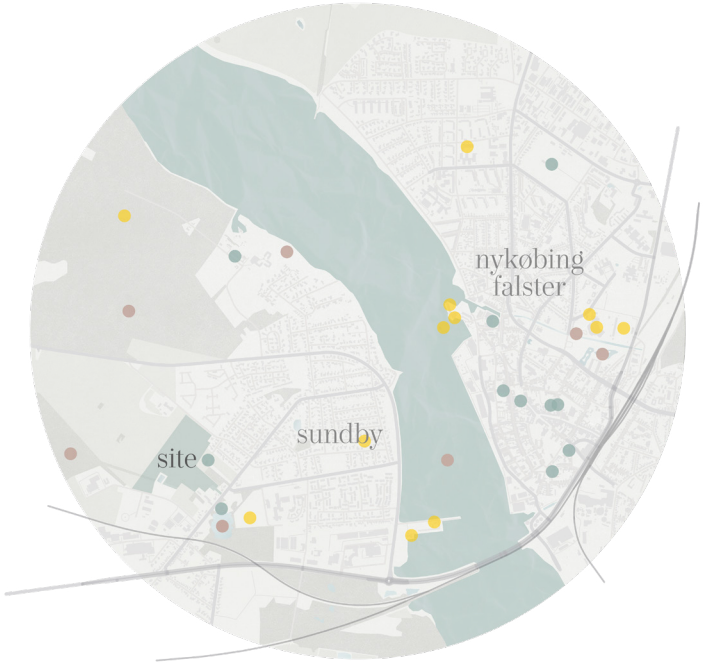


fig. 25. learnings environments

Infrastructure. The main traffic in the area runs southward of the site. Here, the main road and the railway run from the bridge towards Nykøbing. A very small station is placed here too.
North of the site the orbital surrounding Sundby can be seen. In between these main roads around town, two distributional roads with bus stops run through Sundby, and from these the smaller roads appears.

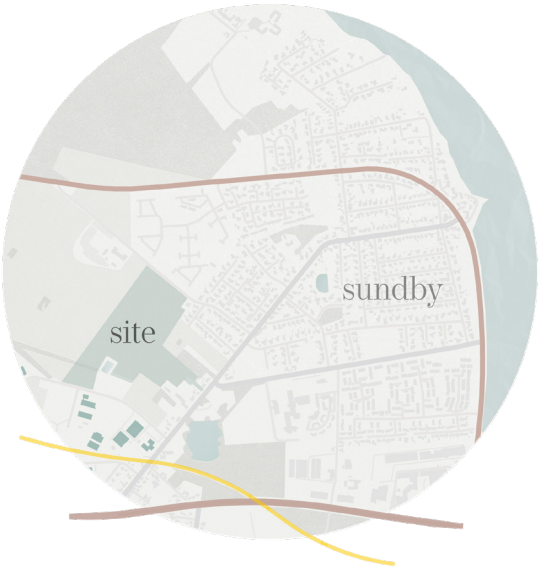
Typologies. In the center and northern part of the town, the main typology is the single-family house. The southern part of Sundby closest to the center includes row houses, while the part towards the main road and railway, accommodates industry and shopping centers appearing with a raw look.

Noise. The site is places at the edge of a small town, which means that it is generally a quiet place. Yet, the main roads towards south and north emit a consistent noise from the cars driving by, because of the exposed character of the site. The railway south of the site also contributes with shorter periods of noise when trains passes by. Though the heavy traffic influences the total sound picture, the industry in the south, rarely contributes directly with loud noises.

fig. 26. infrastructure

SMALL ROADS
MAIN ROADS AND BUS STOPS
RAILWAY AND STATION

fig. 27. typologies



LOUD NOISE VERY RARE
NOISE IN SHORT PERIODS
CONSTANT LOW NOISE

fig. 28. noise

MICROCLIMATE

Wind. The annual average wind speed is around 7,0 to 7,8 m/s. Between 30% and 40% of the wind comes from the west (DMI 1, 2020). While the wind during summer primary comes from the west, it is more even between the eastern and western wind during the spring. However, the winds are in general more mild in this period. During the autumn, the wind blows from the south and in winter from west/southwest (DMI, 1999). Storms and hurricanes with wind speed from 24,5 m/s are mainly seen during the winter, and appear in average every second to third year. All in all, there has generally not been seen radical changes in the wind climate since the 1800s (DMI 1, 2020).

Temperature. The average annual temperature was 8,3 degrees from 1981 to 2010, but increased to 8,9 degrees from 2006 to 2015. Since the 1870s the average temperature has increased with around 1,5 degree (DMI 2, 2020). It is assumed that the average temperature will increase between 1 and 4 degrees until 2100, depending on the future emission of greenhouse gases. The amount of days with heat waves has also increased, and until 2050 it is assumed that it will increase with 2 days, and until 2100 with 4 days (Klimatilpasning 1, 2015). As the temperature has increased, the average annual hours of sun has too (DMI 3, 2020).

Precipitation. The average annual precipitation has increased the last years. The average from 2006 to 2015 was 792mm, which is higher than the climate normal from 1981 to 2010 of 746mm. Since the 1870s until now, the average annual precipitation has increased around 100mm (ibid.). Also, heavy precipitation has changed to both stronger intensity and more frequently, especially during summer. The intensity of heavy rain 24 hours-events is expected to increase with around 7% in 2050 and around 23% in 2100. These numbers are clear signs of the climate changes (Klimatilpasning 2, 2015).

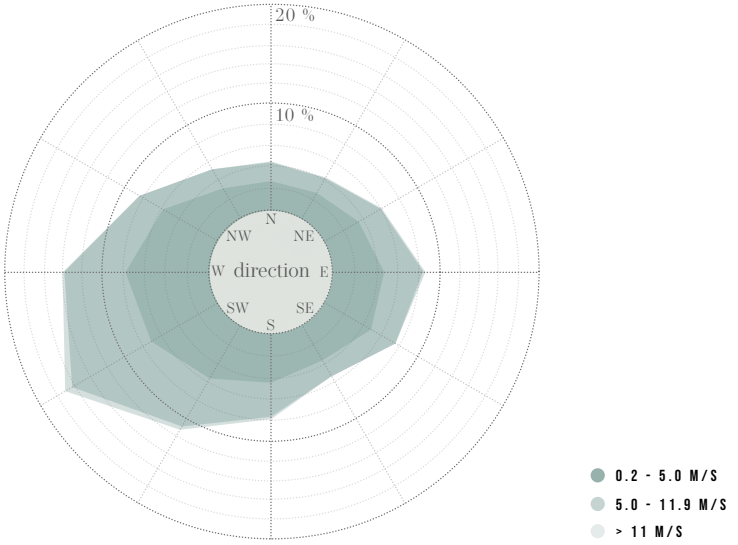
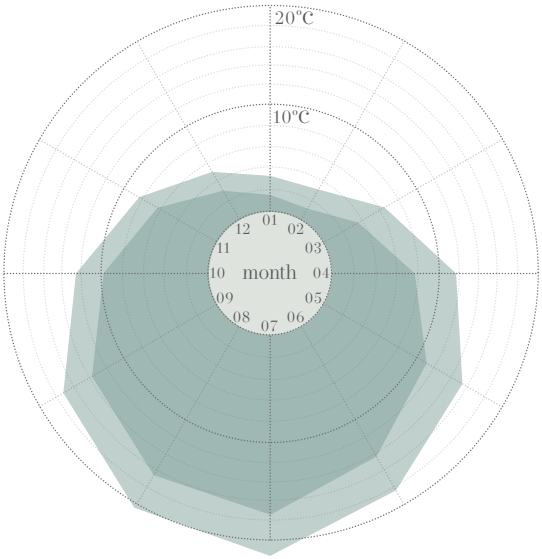
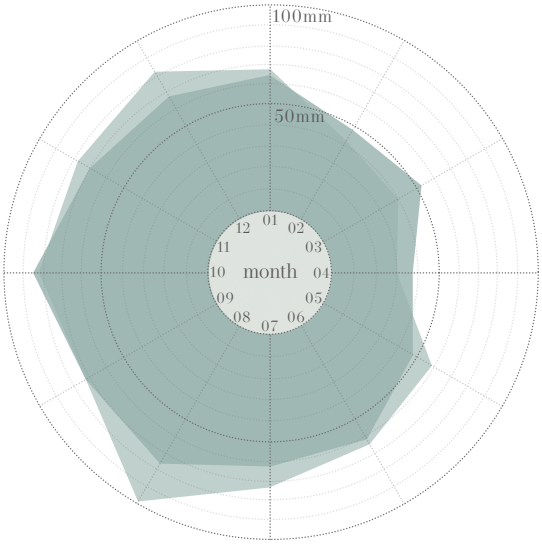


fig. 29. wind diragram



AVERAGE TEMPERATURE
AVERAGE MAX. TEMPERATURE

fig. 30. temperature diagram

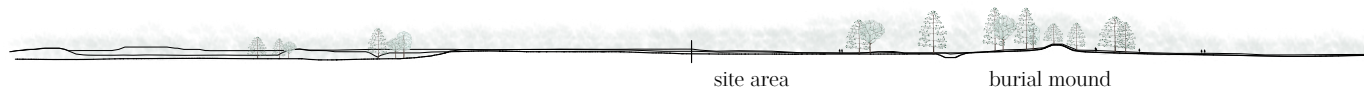


AVERAGE 1981 - 2010
AVERAGE 2006 - 2015

fig. 31. precipitation diagram

TOPOGRAPHIC ANALYSIS

Based on vector data from Kortforsyningen, a longitudinal- and cross section has been made to analyze the landscape. Besides the burial mound, the site is fairly flat, which promotes the opportunity to form the landscape in a suitable way regarding wind, rainwater collection and playgrounds. The dimensions of the site, is shown in the isometric view.



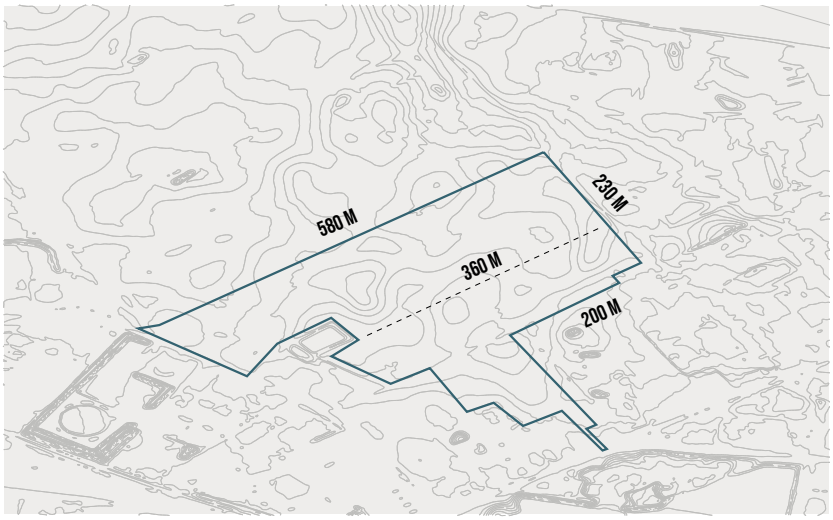


fig. 34. isometric of site area

fig. 32. cross section towards southwest

fig. 33. longitidinal section towards southeast

PROJECT AREA

fig. 35. site area

fig. 36. site area

ATMOSPHERE

The long drive to Lolland was drawing near an end. **Industrial pipes** pumped out large clouds of white smoke, while the rain hit hard on the windscreen. Gigantic plants for production were passed. They seemed out of proportions compared to the small city of Nykøbing Falster on the other side of the road. **Factories larger than the city itself**... Crossing the water over to Sundby, the scale was suddenly of another character. Trees and two-storey single-family houses in red and yellow bricks guided us to the open-fielded site.

The sign said no parking, **but who would catch us?** There were no one here. I stepped out out into the rain. On my right there were a labyrinth of streets, but only three houses. It looked... **incomplete**. The large field opened up, trying to push me away with a strong wind and a squeeze of iced rain.

Reaching the small development, the trees and building volumes provided shelter. The black wooden facade seemed robust together with the volumes in bricks and timber-framing. A facility grown over decades, it seemed. I said hello to the horses and gazed out on the open field. **Withered grass, mud, trees, light and air**.

Stepping out into the field, a **feeling of being watched** grew inside me. But there were nobody here, except the cold winter. Enormous, and open in all directions except towards east. The sound of my footsteps drowned in the cold gusts... Splash! **There went my dry feet and white shoes**. Deep tractor tracks collected water, forming small muddy puddles.

The middle of the undulating landscape revealed small hills, just large enough to cover the horizon of trees. **I felt naked. Unprotected. Exposed**. The only sign of life, was the small, purple flowers barely surviving the harsh weather. It smelled fresh. Clean. The closer I got to the industry in the south, the stronger the wind.

I move towards the burial mound, hoping it can give protection from the february weather. At the top, the naked trees catched some of the rain and stopped the wind, while the site revealed itself as an **endless field without any borders**. It felt safe having this overview while standing under the dripping trees.

But nothing could stop the cold. I ran down, through the residential area and found our car. **No yellow fine**. The air condition turned to maximum on my dry, cold feet, we drove back towards the capital.

fig. 37. atmosphere collage

SUB CONCLUSION

The building program issued by the municipality is highly ambitious within a small budget. This assignment will exploit the program and use it for guidances in regards to the wanted spaces, site considerations, user needs and most importantly the desire to create a school which acts as a new city centre, but will not be seen as a limitation for creative freedom. When investigating the statistics of the existing schools in the area, the place screams for a school which fronts well-being and education. How can the school act as a refuge and be a window into the rest of the world?

Guldborgsund municipality, Sundby and Nykøbing Falster are places which has been an important part of the danish history, which now may seem to be forgotten. The amount of burial mounds, commercial activities and heavy infrastructure underlines this. Besides, vocational education, which may be seen as a lesser education in the rest of the country, is in the high seat in these small communities. Therefore, the school should enhance a sense of proudness for these educations, as well as referring to the history and traditions of the place. In this way, the school can form proudness and identity for both pupils and their parents.

The building itself should front the city towards east, which will be seen as the main entrance into the site. Pedestrians and bikers should be considered from all directions, while cars should enter the site from the north and south.

As the site opens up towards west and the main wind direction is from the west, careful considerations must be made in regards to the relation between shelter and openness to create usable outside spaces and the possibility for natural ventilation. The same considerations must be made, to make sure the exposed feeling is avoided. This can be done through plants, fences and building mass.

fig. 38.

NEXT UP...

THE AR


CHITECTURE
OF SCHOOLS

TENDENCIES OF MODERN SCHOOLS

The architecture of a school is highly dependent on the way teachers want to structure, organize and convey their knowledge. This is done quite differently in schools all over Denmark, based on the individual teacher, pupils and available resources. Though, what has been seen as a tendency over the last 100 years is the progressing need for spaces with either a high degree of flexibility or rooms with a specific function (Kirkeby, I. M., 2006).

As the years progressed during the 20th century, teachers in Denmark saw that by physically including the pupils in the classes, it had a great learning effect. This challenged the traditional pedagogical methods, and gave birth to "learning by doing". Until the 1970´s, education was synonymous with sitting in uniform classrooms at desks, with windows on the left, in straight lines, listening to the teacher, but the focus on pupils participation in class, the individuals well-being and functionalistic way of thinking forced new learning environments to arise (ibid.).

As a result of this, the traditional classroom has slowly dissolved, and turned into more flexible environments allowing both teaching for groups and individuals. The architecture itself should now act as a pedagogic tool (ibid). This might be connected to the way society is focusing more and more on the individual's well-being, social- and educational development, self-realization and the simple fact that we all are different. What now becomes the problem, is that the traditional spaces of a school do not suit the new, more open ways of learning.

Regarding the physical environment of the learning facilities, Kommunernes Landsforening established inspirational material directly connected to the new "State School Reform". In this document, Kommunernes Landsforening underlines that the learning facilities also includes the outdoor area and functions nearby. Furthermore, they present evidence for how much the rooms are being used throughout a day (above illustrations), which calls for more flexible and multifunctional spaces to activate all the square meters. This leads to arguments for establishing multifunctional rooms suitable for adults and children, while the reforms demand for more physical activity calls for spaces that nudges for activity (Kommunernes Landsforening, 2013).

CLASSROOMS PERCENTAGE OF USAGE THROUGHOUT A SCHOOL DAY

70%

'SPECIAL ROOMS' PERCENTAGE OF USAGE THROUGHOUT A SCHOOL DAY

30%

SFO, CANTEEN AND GROUP ROOMS PERCENTAGE OF USAGE THROUGHOUT A SCHOOL DAY

20%


"IT IS A GENERAL CHALLENGE, THAT MOST SCHOOLS ARE DESIGNED FOR THE PURPOSE OF TRADITIONAL CLASS TEACHING, WHICH UNTIL NOW HAS BEEN THE PREDOMINANT PART OF THE PUPILS DAY OF SCHOOL."
(KOMMUNERNES LANDSFORENING, 2013, P. 5)

fig. 39. quote

THE SPACES OF SCHOOLS

Gitz-Johansen, Kampmann and Kirkeby describes the interaction between the pupils and the schools physical surroundings through the "five rooms". All are located on the same place at the same time, but does not necessarily need to be seen as specific rooms (Gitz-Johansen, T. et al., 2001).

The social room. This space is the frame around social interaction and here exists the opportunity of change between the large and the small communities and being able to cooperate crosswise in classes. To ensure circumstances for the existence of the large community where several classes can meet, it is important to have specific gathering rooms. Secondly, classrooms or "home-areas" are designed for the life that takes place in a class. For this zone, the location and the design are not the only parameters that have an impact, but also the furnishing and the organization of them. Furthermore, it is important to secure areas for group work and more demanding activities, where the need for screen enclosure can arise. Zones for smaller groups, particularly for the youngest pupils, are necessary because of its significant part in the learning goals (ibid.).

The new tendency is to gather the tables for work in pairs, where the height of the tables are similar to a kitchen table with high chairs. This facilitates different working postures, methods and pupils can choose more privacy in smaller zones (ibid.).

The room of action. This space is about how the architectonic details are a part of the actions that happens throughout the school day. There is an interplay between the user and the physical frame, where elements in the zone is a part of the action. The location of the needed functions are a part of structuring the day. It is seen, that long distances complicates interdisciplinary activities. Furthermore, it is important to see the usability of empty spaces without predetermining functions and potential. Lastly, the readability in interaction with the physical surroundings is important, likewise environments and resources that are inspiring and supports the learning process (ibid.).

The behavioral regulatory room. This space is how the design is a part of sustaining the school as a smaller community in the overall community, with its own norms and rules. The architecture can be used as an enforcement of rules, also called externalised, where the maintenance of rules are delegated to the spatial design. An example of this could be a wall or fence to avoid the children running out on the street. It can also be the other way around, called internalised, where the architecture is more passive and nudging the children to be aware of their surroundings (ibid.).

The room of impact. About how the rooms and the design of them are experienced in relation to their impact on the children. This way of interpreting the room is also about the transmission of tendencies in the society and the culture of the place the school is about to be build in. When observing the building, the underlying approach in relation to the children and the teachers will be visible (ibid.).

The balanced room. About creating harmony and what immediately is felt with the five senses. Furthermore, it is how light, colours, sound, scent, materials, surfaces, proportions and views are "invisible" parameters, but can change the room significantly. The goal is to be present in a room, being in harmony with the surroundings and have a high degree of well-being. The human brain responds to changes, hence flexibility could be a way to manipulate the surroundings and make it appear more friendly (ibid.).

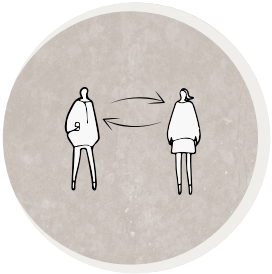


fig. 40.The social room

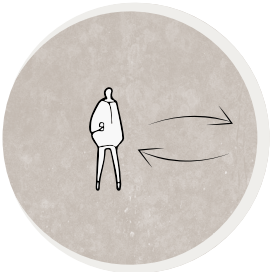


fig. 41.The room of action

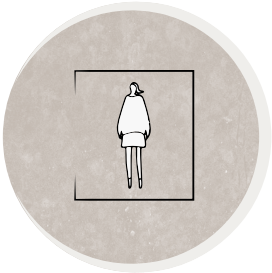


fig. 42.The behavioral regulatory room

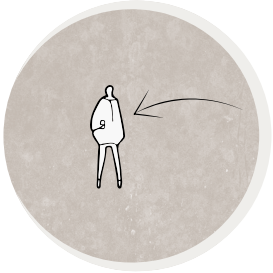


fig. 43.The room of impact

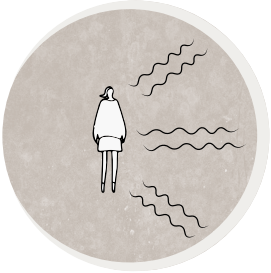


fig. 44.The well-disposed room

THE ORGANIZATION OF SCHOOLS

The visual mean depth. In terms of organizing the different internal spaces in the school building in relation to the hierarchy of accessibility and visibility, research shows that predicting the users behaviour may benefit the modern way of teaching. Through a space syntax analysis of two newly built schools, the visual mean depth (VMD) of each space was found, proving the rooms actual degree of privacy. A zone with a high VMD translates into a more private space, while a low VMD-value is transparent and easily accessed. With this knowledge, the level of affordances and how the space is suited for self-directed learning may be designed. (Fouad, A. T. Z. and Sailer, K. 2019)

By predicting the flow and accessibility of the building, it might be used to tactically program the zones. A hallway being used by everyone has a low VMD, hence a potential of being translated into a social core. On the other hand, it is not suited for quiet contemplation. Opposite, a less used hallway is more suited for self-directed learning and can be programmed to act as a place for concentration. A way to do so, is to give the less used hallways more space/width, increasing its probability to be used as a multifunctional space.

To attract pupils, the social zones must furthermore be designed as easy accessed, while the spaces for teaching and concentration should be designed with a high value of VMD (ibid.).

Soft or hard functionalism. Furthermore, there should be a balanced relationship between the level of programming in the different spaces. By carefully designing zones characterized by either soft or hard functionalism, the pupils will form different relationships to the atmospheres. Soft functionalism describes rooms and elements, that are architectonically well-defined, but functionally weak, while hard functionalism describes spaces with a defined architecture and function (Kirkeby, I. M., 2006). The softly designed rooms are important, because it encourages interpretation and realization of ideas. But, in these times of multifunctionality and flexibility, the hard functionalism is important to remember, because of its effect to connect action and space. An example of this is the wood workshop, which has a certain smell, lay-out, lightning and tools connected to a very specific activity (ibid.).

Because the new school in Sundby should act as a building for the whole community, a clear strategy needs to be established in terms of functions, circulation, security and energy. The school is among the largest municipal buildings in a local community and should therefore be used as much as possible, by as many as possible. By gathering the public functions, it will be easier to “shut down” the rest of the school, while at the same time being more heat efficient (Gelfand, L. & Freed, E. C., 2010).

fig. 45.

ELEMENTS OF SCHOOLS

Gathering spaces. There should be different scales of these zones; some for gathering smaller groups, some for a whole class and some for gathering multiple classes together. This area should implement great daylight, to secure the pupils well-being and accomplish a more attractive area. These zones should secure educational activities such as learning to listen, whole group teaching and literature skills (Taylor, A., 2009.).

Group-projects area. These areas should be designed as a centrally shared workspaces, surrounded with display walls and different types of smaller learning-niches, learning centers and storage. In this zone it is important to provide natural daylight to secure a great learning atmosphere and sustain concentration (ibid.).

Learning niches. These are smaller well-defined niches in relation to the group-project area, but also integrated as a part of the walking area or common spaces to utilise the areas as well. These niches should secure learning activities such as independent reading, independent computer activity and learning to write (ibid.).

Circulation and hallways. Circulation areas such as corridors can be made into places by giving them additional functions. The circulation and hallways needs to expand its definition to include all levels of satisfaction and to surpass basic needs, which paves for a more creative design. All areas should be designed as learning zones and instructional spaces and hereby will the school building reduce the amount of unused areas and utilize the square meters most efficient (ibid.).

Learning porch. A covered outdoor zone, preferably in continuation of the common spaces, for sitting circles, furniture, displays, presentations and individual work (ibid.).

Learning gardens. Gardens that encourages active learning in smaller groups, such as planting experiments, plant identification, demonstrative learning; show and tell in a special environment and scientific learning: exploring, discovering, investigating, wondering (ibid.).

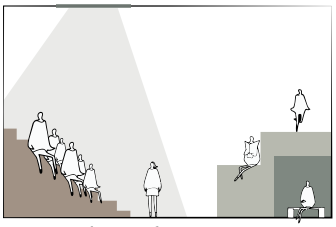


fig. 46. gathering spaces

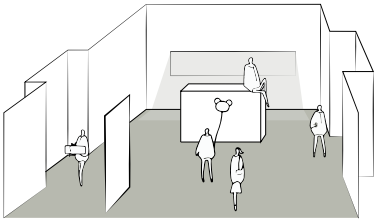


fig. 47. group-projects area and learning zones

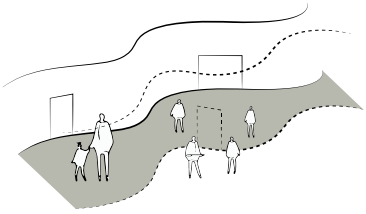


fig. 48. circulation and hallways

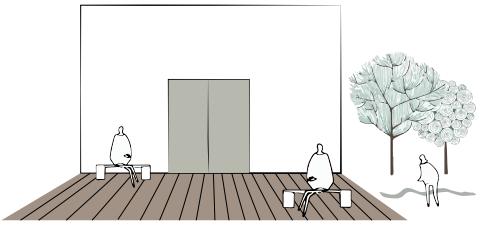


fig. 49. learning porch and learning gardens

SUB CONCLUSION

As the society has made giant technological leaps within the last 100 years, so has the way we are being educated. Todays school, also through the school reform, needs tailored rooms to meet the requirements of the new teaching methods and honor the name of school architecture as the third pedagogue. To introduce these new terms is difficult, almost impossible, in spaces that are designed for other ways of learning.

Five different spatialities is described, which all are necessary to educate children in the right way. There are multiple ways in which these spaces can be designed and arranged, but by carefully considering the degree of soft or hard functionalism in the space, the readability and pedagogical effect may improve.

Because the school should act as a new center for the town, a well-defined strategy needs to be implemented to meet both the pupils and public needs. This strategy must include circulation systems, energy, placement of different functions and security. A way to get a deeper understanding of this organization could be through considering the desired VMD-value of the different spaces.

fig. 50.

NEXT UP...

SUSTAINA
AR


ABLE SCHOOL
CHITECTURE

ZERO ENERGY BUILDING

Zero Energy Building. The Energy Performance of Buildings Directive in EU requires all new public buildings from 2019 to be nearly zero-energy buildings (nZEB), which means that the building has a very high energy performance, and that the remaining energy requirement should be covered by renewable sources, including on-site or nearby production (European Commission, 2020).

In Denmark, Bygningsreglementet (BR18) contains the danish requirements based on the Energy Performance of Buildings Directive in EU. This states that the low energy class is the danish requirement, and that non-residential buildings are classified low energy, when the total energy demand is less than 33,0 kWh/m2 pr. year (Bygningsreglementet, 2020).

To succeed in creating a ZEB, where the energy demand is 0 kWh/m2 per year, some kind of energy production needs to be established. Though, as stated by "Videncenter for Energibesparelser i Bygninger", this production can maximum reduce the final energy demand with 25 kWh/m2 per year. In practice, this means a ZEB should aim for a energy demand of under 25 kWh/m2 per year before adding PV-panels and/or other active solutions (Videncenter for Energibesparelser i Bygninger, 2018). Furthermore, the energy demand may see an addition as a result of increased ventilation rates, lightning demands and time of usage.

Indoor climate. BR18 describes all legislations and requirements for new buildings. Both in terms of high energy performance and indoor climate. While not exceeding the 33,0 kWh/m2 pr. year, the indoor climate requirements must be fulfilled as well. In this case the requirement in educational buildings are to be followed (Bygningsreglementet, 2020).

LOWER THAN

0

KWH/SQM PER YEAR

THERMAL COMFORT

max. hours above 26° C	100
max. hours above 27° C	25

VISUAL COMFORT

window / floor area ratio	10%
lux demand 50% of day	300 lux on 50% of floor area

RECOMMENDED REVERBERATION TIMES

classrooms	0.6 s
common areas with group work	0.4 s
common areas without group work	0.9 s
stairways	1.3 s

ATMOSPHERIC COMFORT

ventilation rate pr. child	3.0 l/s
ventilation rate pr. adult	5.0 l/s
ventilation rate pr. squaremeter	0.35 l/s
max. CO_2 consentration	1000 ppm

fig. 51. Bygningsreglementet 2020

AWARENESS OF SUSTAINABILITY

When using both invisible and visible sustainable solutions in school architecture, the pupils get a higher awareness of their environment. The academic paper "Live green, think green: Sustainable school architecture and children's environmental attitudes and behaviors" studies the influence of the school design on its pupils, by measuring the environmental attitude and behavior of pupils in both newer sustainable primary schools and the more conventional primary schools (Tucker, R. & Izadpanahi, P., 2017).

The outcome shows, that schools designed as sustainable buildings with promotions of environmental sustainability such as water, energy, materials consumption, educates the pupils more about the perception of the environment. Based on the pupils answers to questions about their thoughts and behavior about the environment, the largest difference between the two types of schools was in the score for children's environmental attitudes towards environmentally sustainable design at school. Also the behaviors towards resource and energy conservation, the pro-active eco-behaviors and the attitudes towards human intervention was highest for the pupils from the sustainable schools (ibid.).

The sustainable schools educate children with the benefit of using buildings in ways that minimize resource consumption. The schools incorporate sustainable design features such as improving children's bonds with nature, use of non-polluting and renewable energy sources and materials, avoiding unnecessary energy consumption and growing their food locally in a school garden (ibid.). As the pupils evolve in this sustainable environment, they will carry these habits regarding their impact on their world into their adulthood (Gelfand, L. & Freed, E. C., 2010).

When looking at the community as a whole, the impact on sustainable awareness integrated in a school extends beyond only pupils and teachers. As the school appears as a local point of attraction and education, it may adjust and inspire the local community to join in on the ideas of sustainable initiatives (ibid.).

"THE MOST TYPICAL OUTCOME OF ENVIRONMENTAL EDUCATION IS THE ENHANCEMENT OF THREE SPHERES OF AWARENESS: ENVIRONMENTAL KNOWLEDGE, ATTITUDES, AND BEHAVIORS. (...) THIS FINDING SUGGESTS THAT EDUCATORS MIGHT COLLABORATE WITH ARCHITECTS TO BETTER REALIZE THE PEDAGOGICAL POTENTIAL OF SCHOOL DESIGN FOR ENVIRONMENTAL EDUCATION."

(TUCKER & IZADPANAHI, 2017)

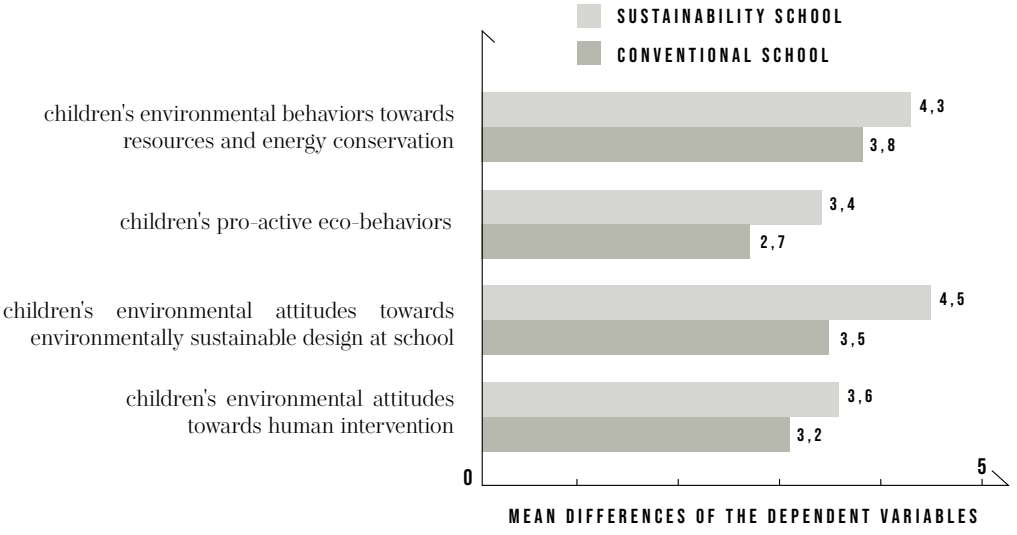


fig. 52. statistic

ENVIRONMENTAL SUSTAINABILITY

Ventilation strategies.
• Ventilation with heat recovery, making the exhausts and inlets highly visible to increase the awareness.
• Cross ventilation through multiple facade openings and thermal buoyancy through skylights.
• Solar chimneys for natural ventilation. The chimneys will be visible in the exterior expression, which can evoke curiousness and educate about physical processes.

Thermal comfort.
• Thermal masses to stabilize the temperature from large heat loads caused by a large amount of children at the same time.
• Passive solar heat through careful design of windows, with alternatively integrated shading devices. The windows in the thick building envelope can furthermore be exploited for niches for contemplation and storage.

Water handling and site.
• Collect rainwater and exploit it for non potable purposes. The process of collecting and filtering may be made visible through ponds and technical shelters in glass to educate the pupils.
• Green roofs and facades to absorb and delay the waterflow, as well as creating additional natural playing grounds.
• Safe and attractive infrastructure for pedestrians, bikes and eventually public transport. Make it unattractive to arrive by car.

• Sheltered areas and natural ventilation by designing with wind in mind as a playful experience. This can be done through for example wind tunnels, turbulence and visual objects.

LCA and LCC.
• Sustainable materials with a low embodied energy, while also considering the lifespan and need for maintenance of the surfaces.

Energy.
• Integrated, visible and natural energy strategies, such as solar collectors, chilled beams, PV-panels.
• Heat pumps through geoexchange for hot water and ventilation.

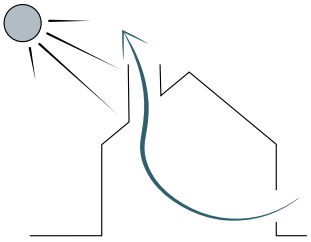


fig. 53. ventilation

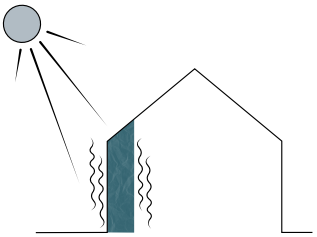


fig. 54. thermal comfort

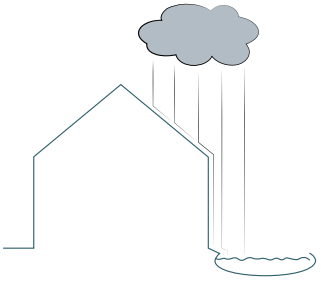


fig. 56. water handling, site and outdoor areas

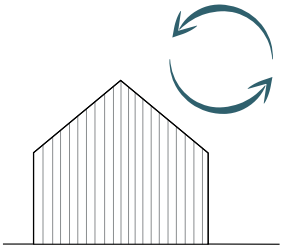


fig. 57. lca and lcc

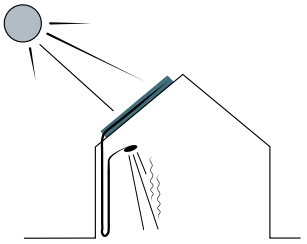


fig. 55. energy

SOCIAL SUSTAINABILITY

Acoustics.
• Reverberation time in rooms should be regulated by use of sound absorbing and reflecting surfaces. Acoustic adjusters can be made flexible and be a part of the education.
• Include sound insulation by considering the adjacent rooms and functions.
• Avoid sound from outside environment, ventilation and other mechanics.

Daylight.
• Diffuse light for a focused environment. By designing openings from multiple directions, the light turns more uniform.
• Focus points created by natural daylight.
• Different daylight settings for different functions
• Avoid glare and control direct sunlight.

Materials.
• Colors for different light and atmospheres.
• Forms that can be made in different materials, and hard or soft expression of these.
• Honest and natural materials to teach and make the children aware of the resources used.
• Surfaces with different tactilities to stimulate all senses

Restorative spaces.
• Views towards nature or creations for restoring and inspiration.
• Window niches as private spaces with a strong connection to the outside nature.
• Room in room to consolidate the children scale and avoid too many impressions at once.

Physical activities.
• Outside areas for all seasons and weather types
• Sport facilities and playgrounds of good quality to encourage physical activity
• "Lift-less" building, making the children use the stairs.
• Indoor activity paths implemented in the architectural layout
• Shoe-less school invites to more climbing and jumping about.

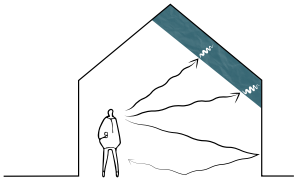


fig. 58. acoustics

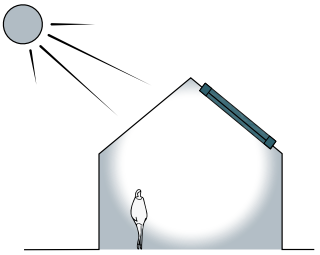


fig. 59. daylight

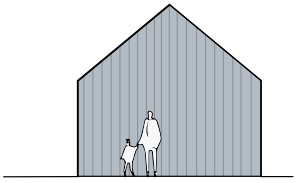


fig. 60. materiality

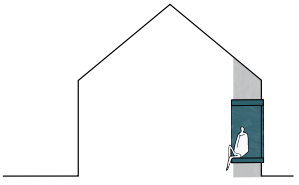


fig. 61. restorative spaces

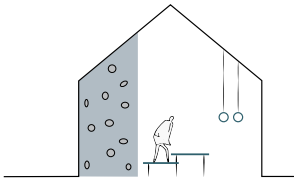


fig. 62. physical activity

SUB CONCLUSION

The target for the new school in Sundby is to reach the Zero Energy Building standard of 0kwh/m2 per year. Though, the building should reach the 25 kwh/m2 per year before calculating with energy production. This encourages for a compact building with multiple strategies considered to lower the total energy demand for the building.

At the same time it is important to implement well-being strategies, through a healthy indoor climate, spatial design, materials and integration of elements nudging for physical activity both inside and outside. By incorporating these strategies from the very beginning, the chances of creating restorative spaces is much better.

Research shows that by using sustainable strategies as visible design drivers, it actually has a positive effect on the pupils relationship to the environment. This is done through making the sustainable initiatives very clear, and let the building itself become a medium of awareness. As the school should act as a future city center for Sundby, the initiatives will also have an impact on the local community as a whole.

fig. 63.

NEXT UP...


USERS

PUPILS

The school must be centralised around the pupils needs to be a more inclusive school for everybody. Therefore, it is essential to secure that the design of the building can facilitate different needs due to age groups and personalities (Viltoft, K., 2017.).

The pre-preparatory classes will have a larger need for safety and intimacy during the school day, which imply smaller rooms and niches. In addition to this, the younger pupils have a minor movement radius, compared to the older ones, which must be reflected in the spatiality. A way to secure this, is to create smaller defined areas with a high degree of clarity (ibid.). They need a space that they have a sense of belonging to and a place that they perceive as a comfortable zone (Appendix 1). Furthermore, it is important to create areas with different atmospheres to secure a more close relation, but also allocate space for movement, where the acoustic parameter is essential (Matthews, E., et al. 2019.).

There is an in-between stage when going from the youngest age to the oldest, where the pupils show more courage and do not need the same safety anymore. Still, they desire a home-base where they have the clarity and spaces for both play and immersion (Viltoft, K., 2017.).

The oldest pupils have a major focus on their own identity development, transforming from a kid to a young person. Therefore, it is important the environments in the school indicates that they are about to grow up. The oldest pupils understands the school as a place to investigate social relations and test their own boundaries (ibid.). In proportion to spatial needs, the oldest pupils do not need a home-base, but rather rooms for gathering and socialising. More of the teaching takes place in specialised classrooms and common areas with different inspirational themes. Still, they need spaces for concentration, working in groups or individually (Appendix 2).

It is stated in a study regarding physical activity and its relationship to the pupils mental health, that pupils needs more physical activity during the day, to increase their mental well-being and self-perception of social acceptance. Therefore, physical activity and movement as a part of the building design are essential aspects, when designing a new school in Sundby, that takes the pupils well-being and health into consideration (Barth, I., et al, 2020.).

Furthermore, it is important to secure the same opportunities for all children, no matter social class and that the school owns the ability to embrace acceptance and secure learning in different ways (Bellomo, A., 2020.).

Spatial needs.

- Design a home-base for the youngest pupils to feel safe (Anonymous 1, 2020.)
- Spaces for working in groups and individually (Anonymous 1, 2020.)
- Easily accessible physical activity opportunities (Anonymous 2, 2020. and (Barth, I., et al, 2020.)
- The oldest pupils needs more specialised classrooms (Viltoft, K., 2017.)
- The oldest pupils needs spaces for socialisation and gathering (Anonymous 2, 2020.)
- Good acoustics for spaces for consentration (Astolfi, A., et al., 2019. and DCUM, 2019.)
- Healthy indoor climate to maintain the focus on learning (Matthews, E., et al. 2019 and DCUM, 2019.)
- Sufficient lighting / daylight in working areas to support well-being and the pupils attention (DCUM, 2019. and Matthews, E., et al. 2019)
- Spatial legibility that guides pupil's activities to support focused behaviour (Matthews, E., et al. 2019)

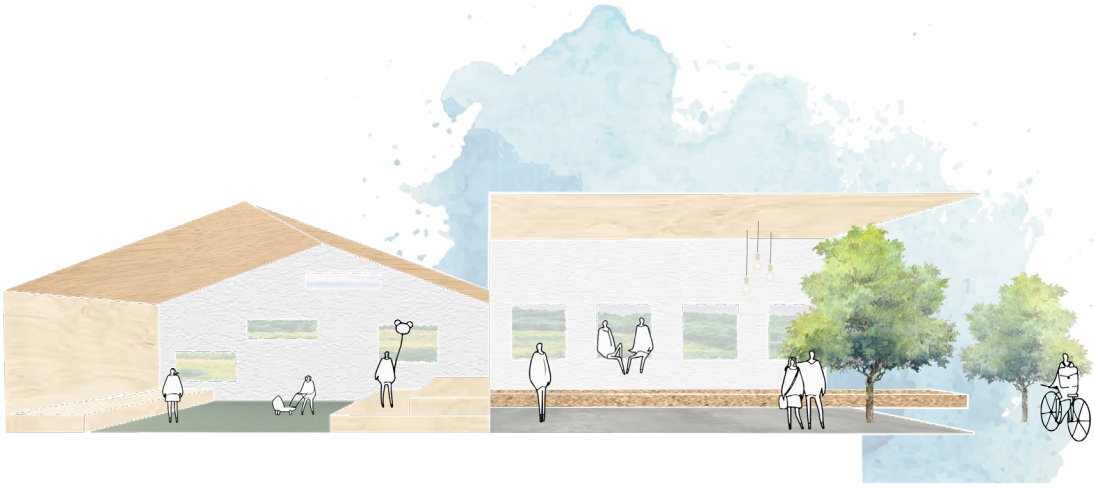


fig. 64.pupils spatial needs

TEACHERS

The state school reform contributes to longer working days, more teamwork, project based teaching and a major diversity due to the pupils (Regeringen, 2013). Therefore, the future school demand new spatial opportunities and teaching methods to secure the right learning environment for the pupils but also for the teachers (Viltoft, K., 2017.).

The teachers needs spaces for teaching, preparation, breaks and to meet with their colleagues. The teaching rooms demand different spatial needs in relation to the specific function/subject of the room or zone. Flexible solutions due to the furnishing can secure the need for different ways of grouping in the classes (Appendix 3).

In the classroom, the teacher needs a place to put the computer and confidential materials aside. A great overview of the pupils in class and common areas is a necessity to ensure high quality education, avoid conflicts and a safe feeling (ibid.). In addition to this, the opportunity for storage is essential, both closed off to secure a tidy and not stressing environment, but also some with higher transparency to nudge the pupils to investigate their curiosity about something new (Matthews, E., et al. 2019).

It is also important to have spaces for gathering several classes crosswise in order to hand out information, instructions or community singing (Appendix 4).

External spaces is a great resource to be used in order to enhance curricula, work with a learning inductive method and include more pupils in the learning environment. Moreover, keeping of animals, outdoor laboratories, environmental educational spaces, planting beds and so on, would enable pupils to be in contact with natural elements, explore and learn about the nature (Bellomo, A., 2020.)

Spatial needs.

- Flexible furnishing for easily reorganization (Anonymous 3, 2020.)
- Spaces for personal preparation, confidential material and collegial spirit (Anonymous 4, 2020.)
- Outdoor environmental educational spaces that nudge hands-on exercises and get more knowledge about natural elements (Anonymous 4, 2020. and Bellomo, A., 2020.)
- Overview in the classrooms (Anonymous 3, 2020.)
- Courses reflected in the classrooms (Anonymous 3, 2020.)
- Integrated movement elements in the spatiality (Anonymous 4, 2020. and Barth, I., et al, 2020.)
- Aesthetic exhibition and storage solutions, to secure calmness but also practical applicable (Anonymous 4, 2020.)

fig. 65. teachers spatial needs

PARENTS

The parents role in the school is mainly concerning bringing and picking up the children in the pre-preparatory classes. In the older classes their role is more passive. Most of the time, the parents are a part of the school through online communication and less human contact and attendance (Aisinger, P., 2019.).

All parents are different and they all have different opinions due to the school. These differences are held together by the social class barriers in the society and the parents own experiences from school. Parents with a medium long- or long further education, with a successful career tend to have more surplus energy and search for social and academic activities with their children and other families. At the other hand, there are parents with a short or none education and a 8-16 job, who will not have the same surplus energy. They will attempt to live up to the requirements from the school, while some parents will put up resistance because of the lack of academic competencies to support their child (ibid.). Therefore, it is essential that the school seems inclusive for all parents and children.

Spatial needs.

- The school must appeal of safety in order to make the parents perceive the children's well-being and learning (Viltoft, K., 2017.)
- Create and present different ways of learning emit an inclusive school (Aisinger, P., 2019.)
- Apparent planning and designing for physical activity during the school day to support learning, well-being and health (Barth, I., et al, 2020. and Børne- og undervisningsministeriet, 2019.)

fig. 66. parents spatial needs

LOCAL COMMUNITY

When designing a new school in Sundby and a "new public hub", the local community is an essential operator to include due to the use of the building. When the school is opening up towards the surrounding community, it will become a more varied school day for the pupils. Furthermore, the cooperation with sports clubs, cultural institutions and firms will contribute to more learning for the pupils, and vica versa (Børne- og undervisningsministeriet, 2020.). In addition to this, the local community, will be able to utilise some facilities when school has finished, which will enrich their association to the school in a positive way.

Spatial needs.

- Functions that can be used by the local community after a finished school day (Børne- og undervisningsministeriet, 2020.)
- The opportunity for a physical demarcation of functions for safety reasons
- Visibility of usable functions to the public on ground level
- A welcoming atmosphere, both inside and outside

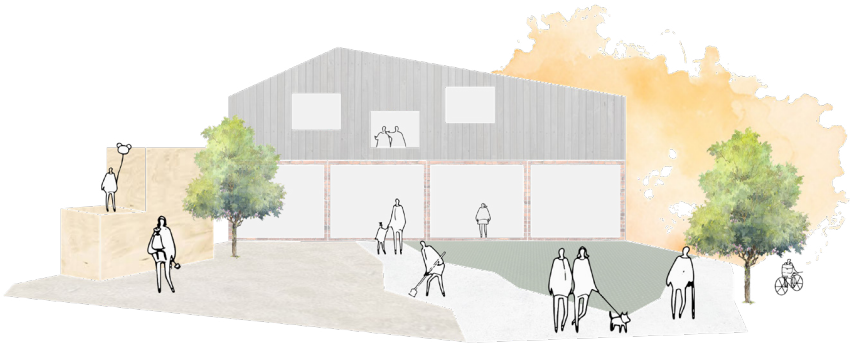


fig. 67. local community spatial needs

USE OF THE SCHOOL

The different users. The school is mainly used by pupils and teachers. Besides educating the children, the teachers also use time for preparation, which leads to an average workload of 37 hours a week, and maximum 45 hours (FOAS & LC, 2018).
The parents may attend the building before and after school to transport their children.
When the school is finished the SFO and youth club starts, and it is possible for the local community to use some of the functions in the school.

The pupil's day. An average school day for the pupils starts at 8.00 and finishes between 14.00 and 15.00, depending on their age (Skole og Forældre, 2020). Throughout the day they have breaks, where some are long enough for stay outside.
The new school includes an SFO, that are open from 6.30 until school, and after school until 17.00 (SUNDskolen, 2019). The youth club opens as soon as the SFO closes, and the older pupils are normally more free, and can come and go by themselves.

Which subjects and when. To get an understanding of how to dispose the rooms for different subjects, it is important to know which classes are using which rooms and how much. The scheme shows how many hours each subject is being teached (Børne- og undervisningsministeriet, 2020).

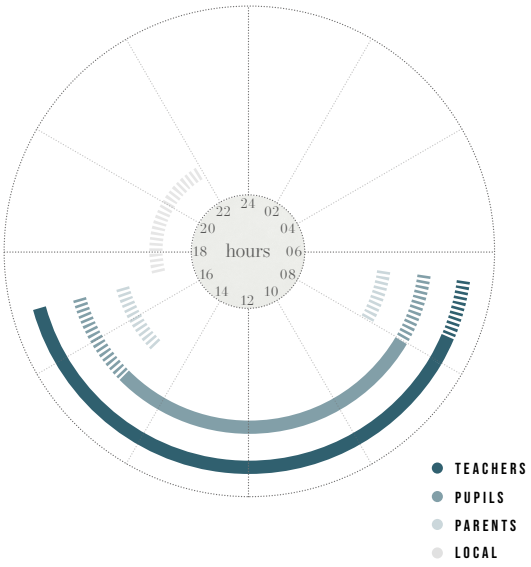


fig. 68. hours per day at the school

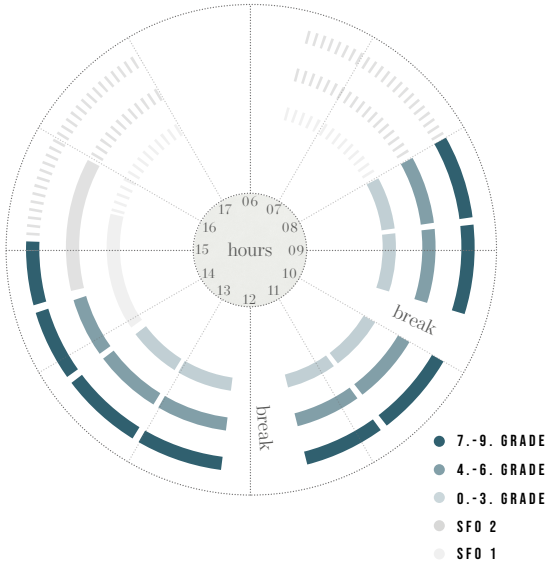


fig. 69. distribution of classes and usage of the school

		minimum average hours per month										
	grade	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	sum
humanities	danish		27,5	27,5	20,0	17,5	17,5	17,5	17,5	17,5	17,5	180,0
	english		2,5	2,5	5,0	5,0	7,5	7,5	7,5	7,5	7,5	52,5
	german or french						5,0	5,0	7,5	7,5	7,5	32,5
	history				2,5	5,0	5,0	5,0	5,0	5,0	5,0	32,5
	religion		5,0	2,5	2,5	2,5	2,5	5,0	2,5		2,5	25,0
	social studies									5,0	5,0	10,0
science	mathematics		12,5	12,5	12,5	12,5	12,5	12,5	12,5	12,5	12,5	112,5
	science & technology		2,5	5,0	5,0	7,5	5,0	5,0				30,0
	geography								5,0	2,5	2,5	10,0
	biology								5,0	5,0	2,5	12,5
	physics & chemistry								5,0	5,0	7,5	17,5
practical	atlethics		5,0	5,0	5,0	5,0	5,0	5,0	7,5	7,5	7,5	52,5
	music		5,0	5,0	5,0	5,0	5,0	2,5				27,5
	visual art		2,5	5,0	5,0	5,0	5,0	2,5				25,0
	craft & design				5,0	7,5	5,0	5,0				22,5
	food course						5,0	5,0				10,0
	elective course								5,0	5,0	5,0	15,0
	assisted training and breaks	42,5	30,0	27,5	25,0	37,5	32,5	32,5	36,5	34,0	34,0	332,0
	sum	92,5	92,5	92,5	92,5	110,0	110,0	110,0	110,0	116,5	116,5	1043

fig. 70. time schedule

SUB CONCLUSION

Because of the future schools role as a gathering point in its local community, the building will experience a lot of different users at different times of the day. Though, the most important is the teachers and pupils relation to the building. Hence, an distinct graduation from private to public functions need to be established. In that way, the pupils will be more attached to their designed home-rooms, and a safe atmosphere is set even though there are other users present.

Besides, it is important to design different zones for different ages.
By spatially appealing to the current state in the different year groups, the architecture may ensure social and educational development, hereby cultivating the idea of feeling safe and at home in school.

The teachers need both privacy for preparation and places to educate the children, with spaces that atmospherically reflect upon the subject.

fig. 71.

NEXT UP...

PRE


-STUDIES

INDOOR INSPIRATION BOARD


fig. 72.


fig. 73.


fig. 74.


fig. 75.

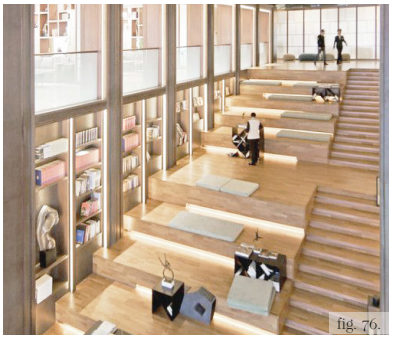


fig. 76.

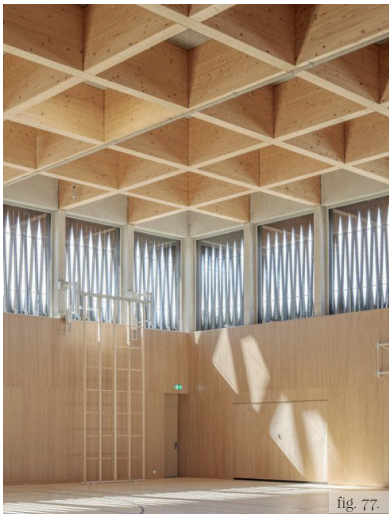


fig. 77.


fig. 78.


fig. 79.

OUTDOOR INSPIRATION BOARD

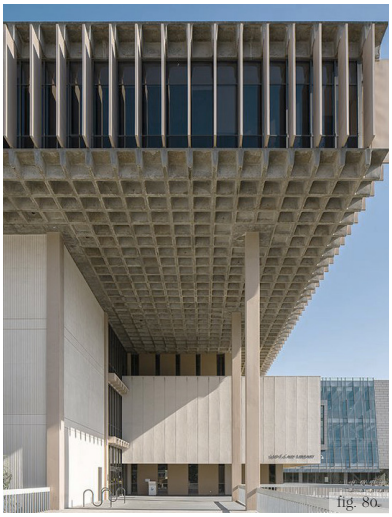


fig. 80.

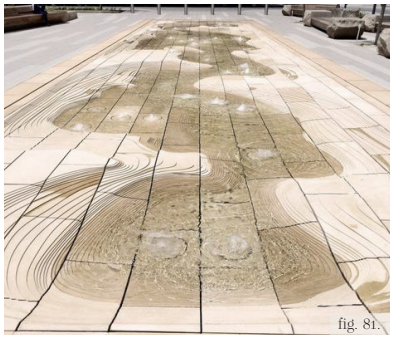


fig. 81.

fig. 82.


fig. 83.


fig. 84.


fig. 85.


fig. 86.


fig. 87.


fig. 88.

FREDERIKSBJERG SCHOOL

ARCHITECTS | henning larsen and GPP
FUNCTION | public school
BUILDING SIZE | 15.000 squaremeter
LOCATION | aarhus, denmark
BUILDING YEAR | 2017
NUMBER OF PUPILS | 965

The architects intention. The design of Frederiksbjerg School is designed to meet the requirements about more movement during the school day from the public school reform. The children is nudged by climbing walls, jungle-tracks and different play equipment to ensure that the walk from A to B will end up with better motoric skills. Hereby the children will be able to increase the learning and get better results in tests (Henning Larsen, 2017.).

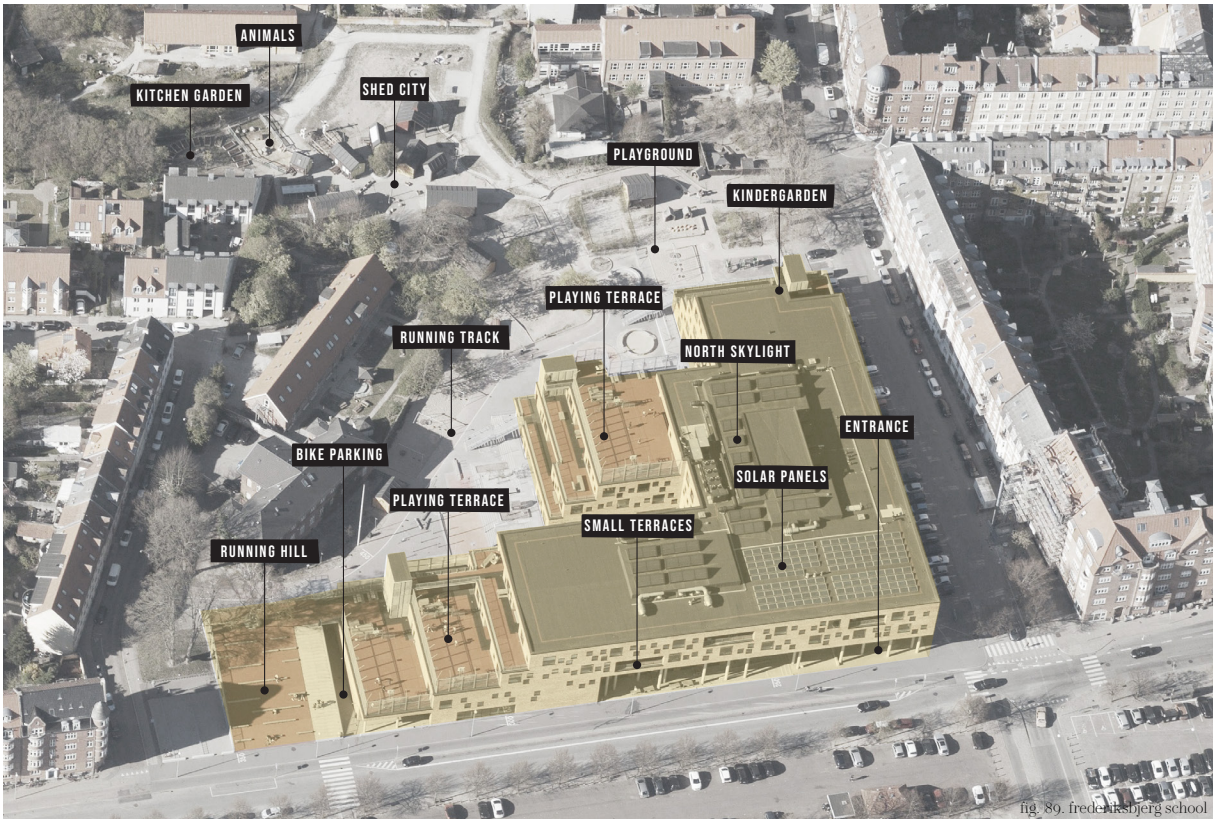


fig. 89. frederiksbjerg school

fig. 90. integrated movement

fig. 91. utilization of walking areas

fig. 92. closed rooms for specific functions

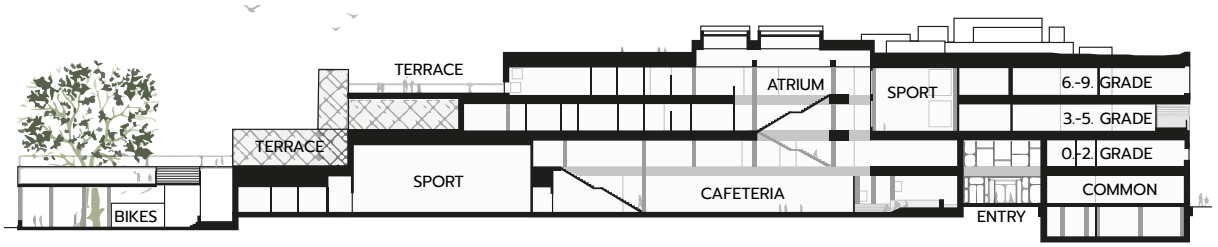


fig. 93. section of frederiksbjerg school. (Arkitekten 1, 2020)

The visit. When arriving outside the building, a forest of tall columns and a rough, brick materiality guides one to the entrance, which is placed secluded in the building volume. In the entrance, a high-ceilinged hall with a great amount of daylight from the windows and skylights, as well as a climbing wall, are what one will meet. In continuation hereof, a common space where all the pupils are eating together in smaller groups. It is clear that the basic idea of the house, is a high level of transparency, with open areas, small niches and glass walls. However, this results in a higher noise level, when pupils are running around the open house during their break and lessons.

The building has an overall division; the pre-preparatory classes (0.-3.) on the base first floor, the in-between classes (4.-6.) on the second floor and the lower secondary education (7.-9.) on the top floor. To avoid the pre-preparatory pupils feeling fear from of the more mature students, the transparency between the floors and rooms breaks this barrier down. From all greater rooms there is a connection to an outdoor terrace, which offer an opportunity for short breaks with fresh air during the day. The windows are displaced to create different light in the rooms and different niches in the windowsill. Around the walking areas, in corners and in smaller niches there are placed different equipment for playing, which offers a more natural way of utilising the breaks for more movement or make the transport more entertaining for the pupils.

THE SCHOOL IN SYDHAVNEN

ARCHITECTS | JJW architects
LOCATION | copenhagen, denmark
FUNCTION | public school
BUILDING YEAR | 2015
BUILDING SIZE | 9.500 squaremeter
NUMBER OF PUPILS | 550

The architects intention. It was to create a school that included the city into the school, and vica versa, hereby generating an active and multifunctional meetingplace. The idea was to create a school with focus on more movement due to the public school reform, and promote the children's learning. The school is a landmark, that both aesthetically and functionally is adjusted to the location near the water and city centre (JJW Arkitekter, 2015.).

fig. 94. spaces for gathering

fig. 95. utilization of roof surfaces

fig. 96. great clarify of functions

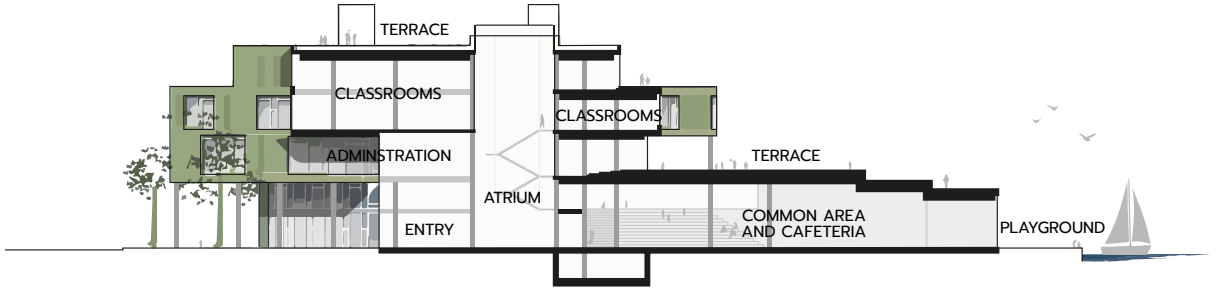


fig. 97. section of sydhavnen. (JJW Arkitekter, 2020)

The visit. The main entrance was easy to find, placed near the access road, with space for bike parking under the cantilevered building volume. A high-ceilinged main hall with glass sections towards the entrance and skylights secured an overview of the building. The centrally placed stairway guides to the different stories, with glass walls facing the atrium for noise reduction. Going deeper into the building, the ceiling is lowered and a large stair for play and gathering appear. In continuation hereof, a space for eating together is placed facing the common outdoor space. All specialised classrooms are placed in the lower floor, making them available for the neighbourhood after the school day ends. All classes have their own classroom connected to a larger area with multiple workstations, kitchen and cluster of toilets for sharing with other classes.

The building is created as a stepped building volume that embraces the schoolyard towards the water. A great amphi-stair connects the school directly with the water, hereby creating an additional learning environment. However, the school is challenged by the water near context due to safety reasons, because of the lack of fencing. All the roof surfaces are utilized as smaller play areas with enclosed fields, playground equipment and seats. It is all covered with wood boards to create a more maritime atmosphere, but a challenge is that it gets very slippery during wintertime. The outdoor spaces are available for the public and the area is well connected to the district.

GRØNDALSVÆNGETS SCHOOL

ARCHITECTS | JJW architects

LOCATION | copenhagen, denmark

FUNCTION | public school

BUILDING YEAR | 2018

BUILDING SIZE | 9.500 squaremeter

NUMBER OF PUPILS | 500

The architects intention. The renovation of the main building aims to maintain the old qualities, but also to energy optimise the school and upgrade the building due to the desired functions. The extension includes two new buildings, that are designed in correlation with the context and the main building. The new building for pre-preparatory classes have a centrally placed amphi-stair for gathering. The other one is a combined sport- and music building, with a sports hall, exercise room and music rooms (JJW Arkitekter, 2018.).

fig. 98. adaptation to the context

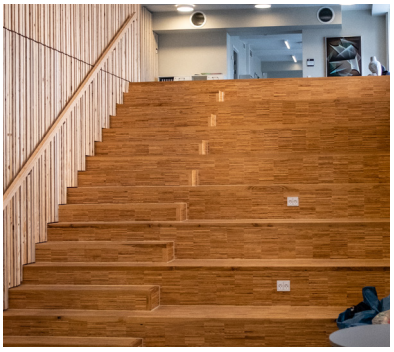


fig. 99. spaces for gathering

fig. 100. specific classrooms but also gathering points

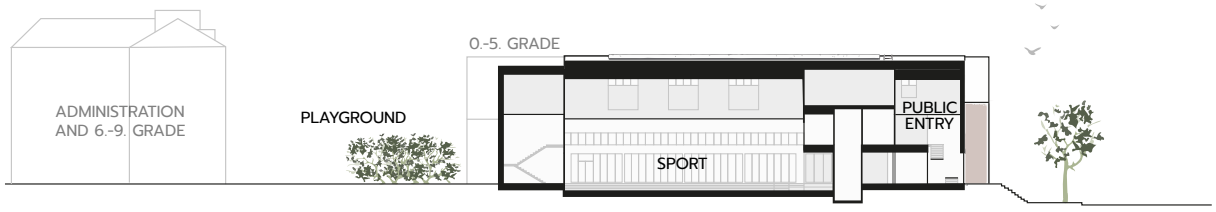


fig. 101. section of grøndalsvængets school. (Arkitekten 2, 2020)

The visit. When observing the school from street level, the scale and tactile sense will is noticed from the beginning. The displaced volumes with pitched roofs and recycled brick facades are melting together with the context and the old multi-storey school building, that lies as a back cloth. The administration and teacher facilities, are placed centrally in the middle of the old building, securing an overview of the schoolyard. All the maintained, old details contribute with history and spirit to the atmosphere. A gangway is added later on to internally connect the old building with the new building for the pre-preparatory classes, because the school is free from shoes.

The school is divided into classes and hereby a need for separated classrooms, with smartboard, smaller window niches, kitchen sink, storage opportunities and a smaller stair for gatherings. The walking areas includes small zones with different themes to create alternative learning environments. Parts of the roof is utilized for kitchen gardens, seating spaces and a playing field.
In the schoolyard, there are small pavillions for planting and animals. These pavilions are learning environments, but also ensuring that all children have access to animals and kitchen gardens even though it is not possible at their home in the centre of Copenhagen. Furthermore, the schoolyard have a lot of playing fields, playing equipment and space for eating or working outside.

WILKES ELEMENTARY SCHOOL

ARCHITECTS | mahlum architects
LOCATION | bainbridge isl. washington
FUNCTION | elementaty school
BUILDING YEAR | 2012
BUILDING SIZE | 5.988 squaremeter
NUMBER OF PUPILS | 382

The architects intention. By organizing the plan as a series of bars surrounding different courtyards, the school is breaking down its own scale. The classrooms, also called the houses, widens into shared learning spaces, seen as the porch in front of the houses. Two running hallways create a circulation ring, which nudges interaction between the users. The building knits itself into the landscape with its finger-form and is made highly transparent, allowing the pupils to work independently while the teacher still has visual contact and overview (Broome, B., 2015).

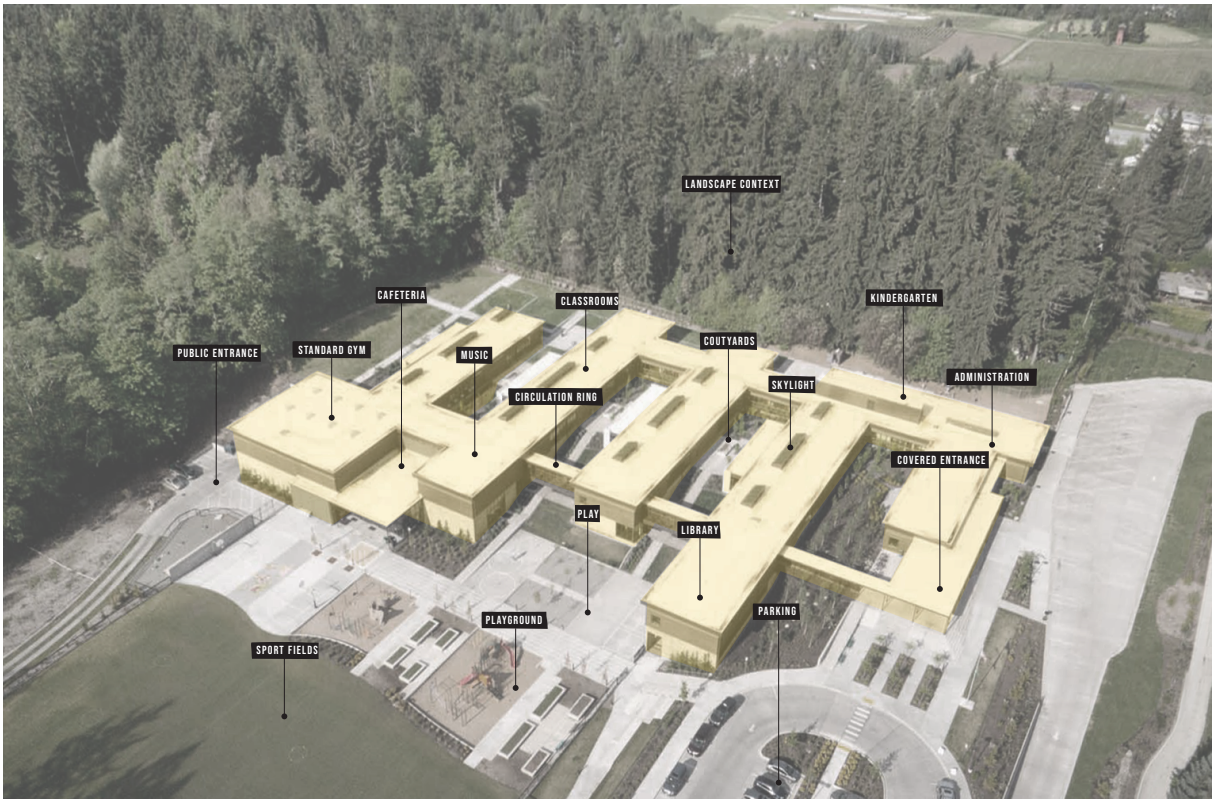


fig. 102. (Bittermann, J.) great circulation for interaction

fig. 103. (Speewest Construction) public accessible space to create a town center

fig. 104. (Bittermann, J.) reflect and promote of the local community

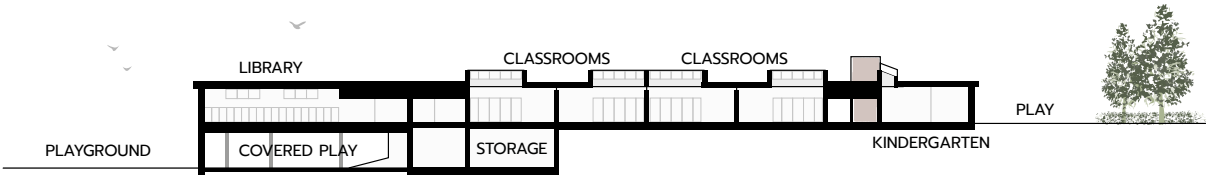


fig. 105. section of wilkes school. (Mahlum Architects, 2020)

The research. Bainbridge Island is an island once dominated by logging, ship building and later on agriculture. The city is proud of these professions, alongside its small-town charm. Therefore, the community expected the school to reflect and promote their way of living (ibid.,).

The building is placed in the landscape by taking advantage of the slightly sloping site. It is placed in an area outside the main town with a low density of houses. Earlier, this part of town had no common meeting point. Now, the new school has become that, by housing a cafeteria, a gym meeting the standards for competitive use, and a library. All of these functions are entered through a public corridor, that can remain open after school for the whole town to use (ibid.).

Dark-fired bricks, concrete and wood are used as materials. At the same time, different colors are utilized on flooring and textiles, so the school appears both serious and playful. The building has multiple sustainable features, including on-site stormwater filtration, wastewater treatment, heat recovery and a heating system exploiting geothermal wells (ibid.). The transparency inside the building erases the border between educational and recreational spaces, as well as creating views to other indoor spaces, out to a rain garden, courtyards and playground. Most importantly, it also fills the building with daylight (ibid.).

SUB CONCLUSION

Through the inspiration boards, the design process slowly begins. Desired features, ideas, forms and atmospheres are presented to establish a foundation for the forthcoming concepts.

The visited case studies gives valuable knowledge on what is working and what is not in modern and innovative schools. All schools shows a strong connection to its place through materials, forms and heights, but in their own way create something extraordinary in its context. This may create a sense of proudness for the children attending the schools.

Wilkes Elementary School is not visited, but is analyzed because of its qualities of acting as a meeting point in a small community, housing public functions and approximately the same size as the future school in Sundby. The circulation system and the way the building creates smaller outdoor spaces will also inspire the coming design proces.

Through the use of common spaces, all schools lay the foundations for project based learning. Though, in three very different ways depending on their size and compactness. Because the new school in Sundby is allowed no more than two storeys, Frederiksbjerg grand atriums solutions won't be realistic. However, a solution might be to combine the silencing features of the school in Sydhavnen and the compactness of Grøndalsvænget, to secure daylight, openness and a focused atmosphere.

As the new school in Sundby is required to by highly area-efficient, the utilization of outdoor learning spaces is a way of saving square meters and likewise nudge the children to come outside and connect with the nature. Also, the use and availability of roof surfaces invites for play, fresh air and outdoor contemplation.

fig. 106.

NEXT UP...


PROGRAM

THE VISION

The vision for the future school in Sundby is to design a building, that not only embraces the pupils and employees needs with a changing atmosphere for different learning zones and focus on the indoor climate, but also awareness of sustainability as an integrated part of the building.

It is crucial that the building reflects the modern way of teaching and adapt to the vision of the State School Reform with an integration of more physical activity. As well as to create an atmosphere that indicates a feeling of well-being for the users, who spend the majority of their time inside the building. At the same time the school should appear as a learning tool in itself, by using visible environmentally sustainable and indoor climate solutions. As the first experienced community in a child's life, the school must disband social classes by recognizing education through hands-on experiments as a more academic way and hereby include more individuals. Furthermore, the school should be a pioneer for more acknowledgement due to vocational educations by making these specific learning spaces more attractive and visible the pupils, parents and community. Additionally, the school should act as a local meeting point for the whole community and encourage for socialisation crosswise social classes for both pupils and adults to build unity and increase the level of well-being, self-realisation and proudness of the place.

All things considered, this master thesis will fulfill the vision for "New School in Sundby", by focusing on a building being the foundation and set the frames for project-based learning, promote sustainability and stand out as a local "power source" in Sundby (Guldborgsund Kommune 2, 2019).

fig. 107.

DESIGN CRITERIAS

The following points is considered requirements that has to be fulfilled in the new school in Sundby.

USER

- Establish classrooms with niches that integrates room in room for concentration, individual immersion and group work
- Design for different age groups with a high degree of spatial legibility, both inside and outdoors
- Design the building with an obvious graduation from private to public, also organizing the internal flow in a way that makes the public functions available for the local community
- Private and preparatory spaces for teachers

LEARNING

- Create different learning environments to secure an inclusive school for both social and academic education
- Courses reflected in the classrooms atmosphere to maintain the pupils focus and curiosity
- Consider spaces for both soft and hard functionalism
- Sufficient daylight in working areas

THE PLACE

- Architecturally connect to the traditions of the place and site, while still creating an iconic building in the city picture
- Promote vocational education by exposing the specialized teaching rooms and spaces
- Make the building welcoming in the direction towards the city of Sundby

SUSTAINABILITY

- Reach Zero Energy Building standard through active and passive strategies
- Fulfill all demands regarding indoor climate in educational buildings
- Integrate the desired energy production in the building design, also making it visible
- Integrate rainwater collection and reuse greywater in the building
- Make clear as many sustainable initiatives as possible in the design to increase sustainable awareness in itself

DESIGN GUIDELINES

The following points are considered important strategies and would highly improve the final result if implemented. Though, they are seen as guidances, and not demands.

USER

- Design social areas for interaction and gathering, as well as natural flows that nudges people together
- Integrated solutions for easily accessible physical activities
- Wind / rain sheltered outdoor spaces to invite and attract pupils regardless of weather
- Offer different outdoor activities

LEARNING

- Outdoor environmental educational spaces that nudge to use hands-on exercises and take possession of more knowledge about natural elements
- Flexible furnishing for easily reorganisation to secure different workflows
- Increase the spaces legibility by designing as many rooms as possible with a high or low degree of flexibility, and avoid something in between
- Utilize relevant parts of roof for outdoor learning, gardens and play

THE PLACE

- Create a sense of proudness for the place through references to the industry, trading activity, historical monuments, etc.
- Silencing outdoor elements towards north and south
- Consider western wind for natural ventilation during summer
- Avoid the feeling of exposure by planting protecting trees and utilize the building mass to create outdoor “safe spaces”

SUSTAINABILITY

- Exploit sustainable materials, with a low embodied energy and consider the lifespan and need for maintenance
- Exploit thermal masses to stabilize the temperature due to the massive heat gain from pupils
- Arrange heavy traffic on the roads north and south of the site, while meeting the pedestrians, bus passengers and bikers from all directions, making it more attractive to leave the car at home.

INITIAL ROOM PROGRAM

SPACE	AREA (M²)	NUMBER OF ROOMS	TOTAL AREA NEEDED (M²)	MAX. PEOPLE LOAD	ACTIVITY LEVEL
0.-6. ZONE / SFO 1					
Classroom	70	14	980	27	■■□
Toilet	2	37	74	1	■□□
Common area / SFO	150	1	150	100	■■□
Small kitchen	15	1	15	5	■■□
Wardrobe + Storage	60	7	420	27	■□□
Storage SFO	30	1	30	-	-
SFO 2 / YOUTH CLUB					
Common zone	350	1	350	100	■■■
Kitchen	20	1	20	5	■■□
Wardrobe	50	1	50	30	■□□
7.-9. ZONE (162 PUPILS)					
Classroom	70	6	420	27	■■□
Toilet	2	12	24	1	■□□
Common area	100	1	100	100	■■■
Small kitchen	15	1	15	5	■■□
Wardrobe + Storage	50	3	150	27	■□□
SPECIALIZED CLASSROOM ZONE					
Natural science zone	250	1	250	60	■■□
Music zone	150	1	150	30	■■□
Food and home	150	1	150	30	■■□
Workshop zone	-	-	-	50	■■□
Visual arts	150	1	150	30	■■□
Design	80	1	80	20	■■□
Crafts	100	2	200	20	■■■
CKR ZONE					
CKR	870	-	-	-	-
FUTURE DAYCARE CENTER					
Interior	1300	-	-	-	-
Exterior	3500	-	-	-	-

DESIRED DAYLIGHT	SOCIAL AVAILABILITY	DESIRED ATMOSPHERE	IMPORTANT ASPECTS
Diffuse	Private	Focused	Implement niches and place for storage, natural views
-	Semi-public	-	-
Playful/combi	Semi-public/private	Home-like	Room in room, zones for gathering, play and contemplation, creativity. Buffer for passive heatgain and natural ventilation.
Diffuse	Semi-private	Home-like	-
Playful/combi	Semi-private	-	Directly connected to outside
-	Semi-private	-	-
Diffuse	Semi-public	Home-like, creative	Room in room, zones for gathering, play and contemplation. Connected to SFO 1, but possible to close off
Diffuse	Semi-private	Home-like	-
Combi	Semi-public	Welcoming	Directly connected to outside.
Diffuse	Private	Focused	Implement niches and place for storage, natural views
-	Semi-public	-	-
Playful/combi	Semi-public/private	Home-like	Room in room, zones for gathering, play and contemplation, creativity. Buffer for passive heatgain and natural ventilation.
Diffuse	Semi-private	Home-like	-
Playful/combi	Semi-private	-	Directly connected to outside
Playful/combi	Semi-private	Focused, natural, exciting	Divided into multiple spaces, directly connected to outside learning environments, including storage
Playful/combi	Semi-public	Focused, exciting	Divided into multiple spaces, including storage
Diffuse	Public	Focused, exciting	Exposed in facade, directly connected to outside
Playful/combi	Public	Inviting, exciting	Exhibition area that connects all workshop related activities
Diffuse	Semi-public	Focused, exciting	Exposed in facade, including storage
Diffuse	Semi-public	Focused, exciting	Exposed in facade, including storage
Playful/combi	Public	Focused, exciting	Exposed in facade, including storage
Will be placed according to the building program (Guldborgsund Kommune 1, 2019) and a part of the total building volume, but not further detailed			
The area for the future day care center will be decided, and the schools volume may reflect upon how this center may be developed			
The area for the future day care center will be decided, and site plan may reflect upon how this area may be developed			

SPACE	AREA (M²)	NUMBER OF ROOMS	TOTAL AREA NEEDED (M²)	MAX. PEOPLE LOAD	ACTIVITY LEVEL
COMMON ROOMS					
Library	230	1	230	60	■ □ □
Archive / Mediatech.	30	1	30	-	-
Communal eating	150	1	150	80	■ ■ □
Kitchen	100	1	100	15	■ ■ □
Storage	30	1	30	-	-
Entrance	20	1	20	2	■ □ □
ADMINISTRATION					
Administration	25	1	25	2	■ □ □
Welcoming center	10	1	10	4	■ □ □
Office: management	12	4	48	4	■ □ □
Office: headmaster	20	1	20	8	■ □ □
IT-center	15	1	15	3	■ □ □
Office: teacher	80	4	320	20	■ □ □
Ped. workshop	15	1	15	1	■ ■ □
Ped.cent. for learning	20	3	60	5	■ ■ □
Break area	200	1	200	100	■ ■ □
Meeting room 1	15	2	30	10	■ □ □
Meeting room 2	30	1	30	20	■ □ □
Wardrobe	50	2	100	20	■ ■ □
Toilet	2	8	16	1	■ □ □
Tech. personel	60	1	60	6	■ ■ □
SERVICE & TECHNICAL ROOMS					
Cleaning / Service	80	1	80	-	■ □ □
Technics	20	6	120	-	■ □ □
SPORT FACILITIES					
Sport hall	1300	1	1300	100	■ ■ ■
Wardrobe	40	2	80	20	■ □ □
Toilet	2	4	8	1	■ □ □
Tribune	100	1	100	100	■ ■ ■
Storage	10	2	20	-	□ □ □

DESIRED DAYLIGHT	SOCIAL AVAILABILITY	DESIRED ATMOSPHERE	IMPORTANT ASPECTS
Playful/combi	Public	Focused, natural	Exposed in facade, opurtunities to “close off” for non school usage
-	Private	-	-
Playful/combi	Public	Welcoming	May also be used for contemplation and group work
Diffuse	Semi-public	Focused, exciting	Exposed in facade, opurtunities to “close off” for non school usage
-	Semi-private	-	Close to the kitchen facilities
Playful/combi	Public	Welcoming, legible	Placed in the heart, offering oppurtunities to move anywhere in the building volume from here. Welcoming center
Diffuse	Semi-private	Focused	Placed in front of the management/headmaster, as a continuation welcoming center
Playful/combi	Semi-public	Welcoming	In connection to the entrance/welcoming center
Diffuse	Private	Focused	Place for small meeting table
Diffuse	Private	Focused	Place for medium meeting table
Diffuse	Semi-private	Focused	-
Diffuse	Private	Focused	Open landscape office
-	Semi-public	-	-
Playful/combi	Semi-private	Focused	-
Playful/combi	Semi-public	Home-like	For staff gatherings, meetings, lunch, etc. Direct connection to outside areas
Diffuse	Semi-private	Focused	The two meetingrooms can form one large
Diffuse	Semi-private	Focused	-
-	Semi-private	-	-
-	Semi-public	-	-
Playful/combi	Semi-public	Focused, exciting	Needs to include wardrobe with showers, small kitchen, storage
-	Semi-private	-	-
-	Semi-private	-	-
Diffuse	Public	Energic, positive	At least the size of a professional handball court. Should include the oppurtunity to be divided in two.
-	Public	-	Accessed through main entrance, direct access to the hall
-	Public	-	-
Diffuse	Public	Energic, positive	As a continuation of the sports hall, with levels for sitting and standing
-	Semi-public	-	May be included under the tribunes

FUNCTIONAL DIAGRAMS

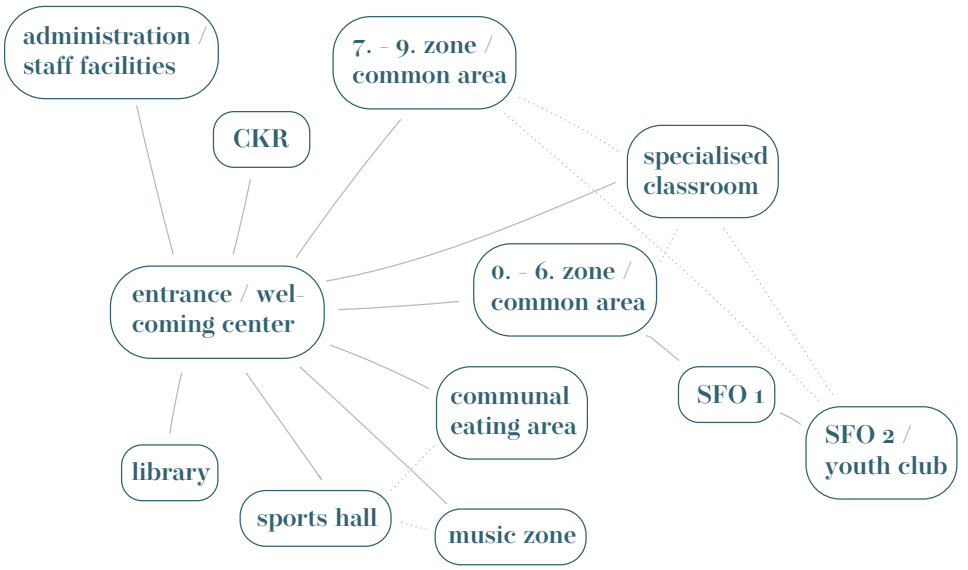


fig. 108. functional diagram

YEAR SECTIONS

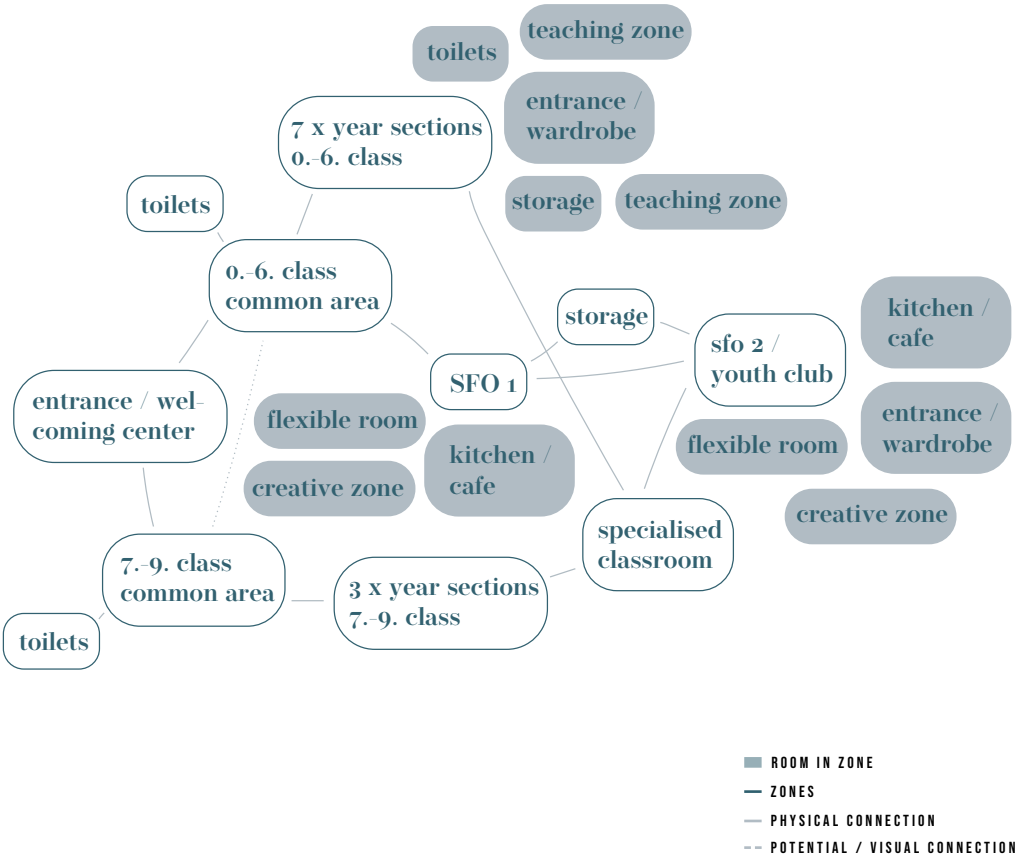


fig. 109. functional diagram

ADMINISTRATION AND STAFF

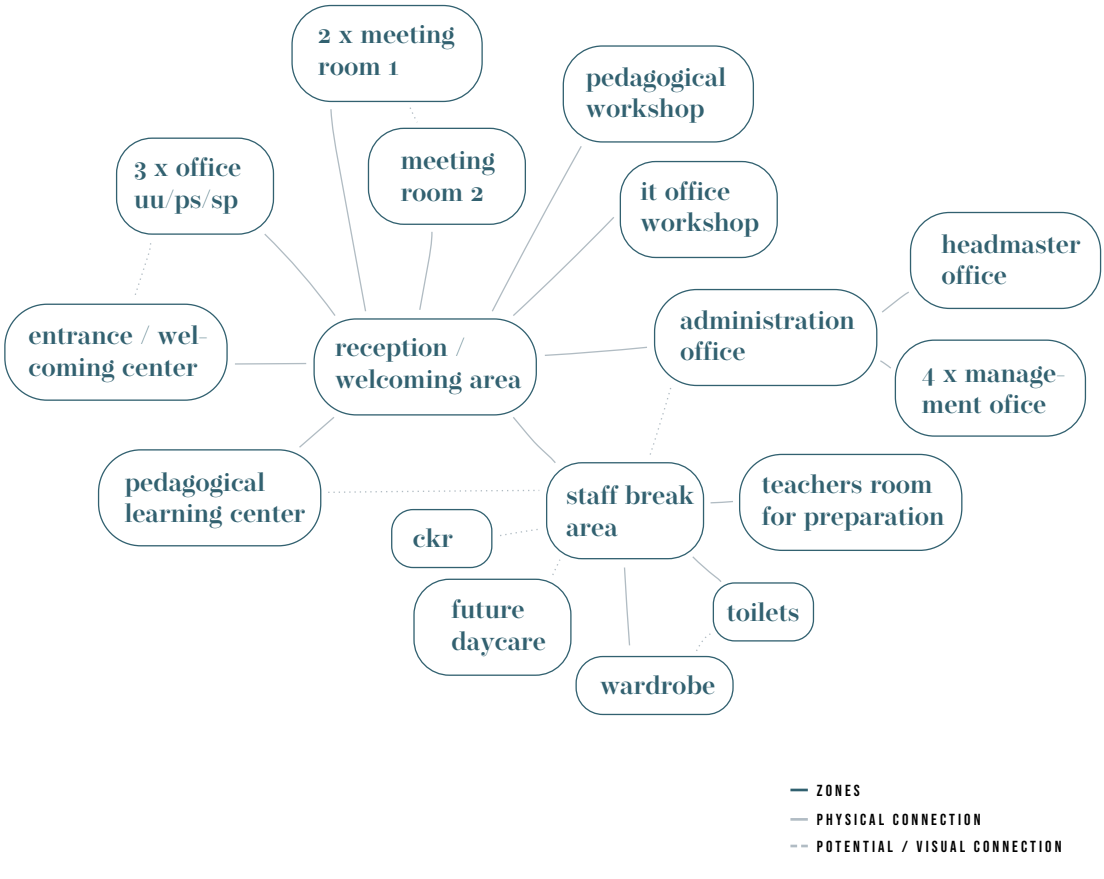


fig. 110. functional diagram

SPECIALIZED CLASSROOMS

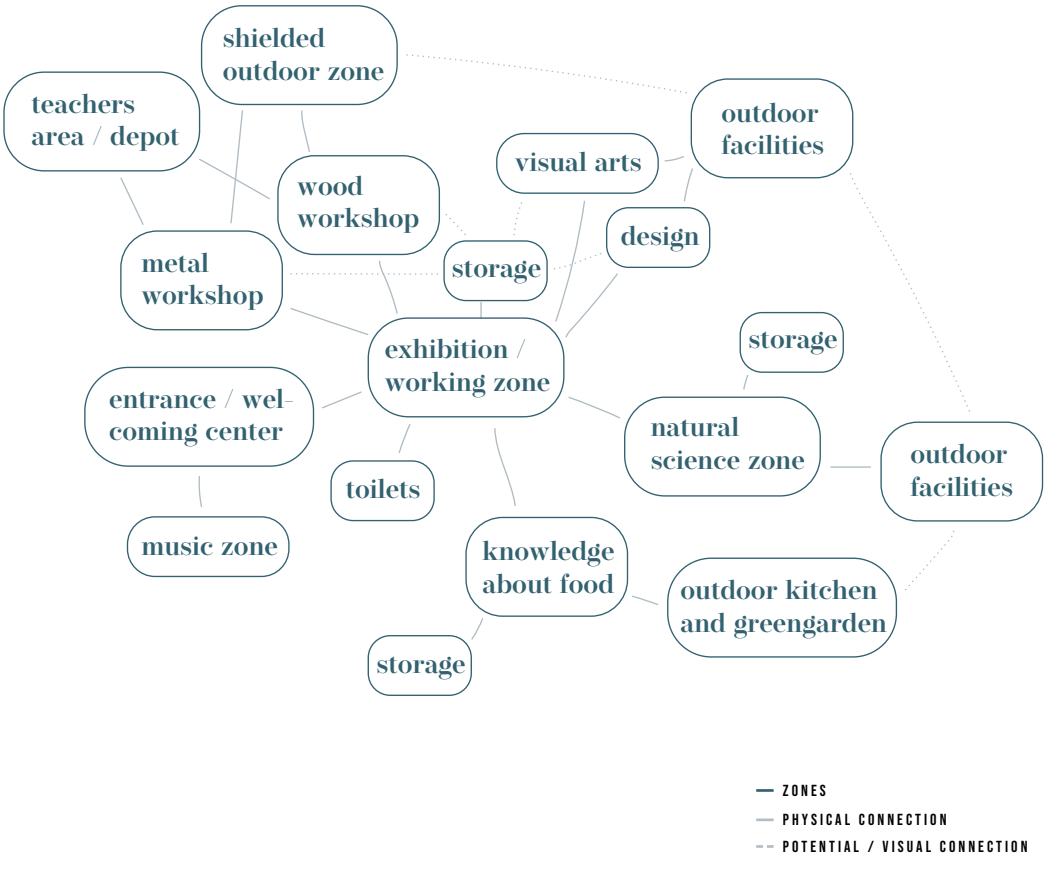


fig. 111. functional diagram

COMMON / PUBLIC FACILITIES

fig. 112. functional diagram

fig. 113. Own photograpy

PRO

NEXT UP...

INITIA

CES

L SKETCHING

INITIAL SKETCHING

In the very beginning of the design process, the site area were analyzed more into detail. Here access roads, different building areas on site and the nearby areas were clarified to get an overview of the possible flows on the site. These informations were used to start generating ideas in the early design phase with foam blocks, as illustrated in fig. 114-119, to get an idea of the square meters and relation to the site area, roads and paths.

The initial sketches, as shown in fig 120, were based on thoughts and ideas, which occurred throughout the development of the program. These sketches investigates different concepts and aspects to study different extremes in relation to the site and context. Furthermore, form models in scale were created to investigate 3-dimensional forms, as shown in fig. 121-150.

All sketches and models were based on the idea of creating an inclusive school, be able to gather the community and relate to Sundby. This resulted in an investigation of different expressions, from more organic to geometric designs. To be able to evaluate the importance of scale and how it affect the environment, the foam models were essential. Furthermore, sustainable aspects, such as rainwater collection, were included in the initial sketching phase. In the very beginning the overall approach were about forming concepts from the outside and work contextual.

fig. 114.

fig. 115.

fig. 116.

fig. 117.

fig. 118.

fig. 119.

GUIDED ENTRANCE

MELTING INTO LANSCAPE

SMALL SCALE

ACTIVE ROOF

CONTRAST

SPORTSHALL INTO GROUND

GATHERING PLATFORM

CENTERED AROUND SPORT

RAINWATER COLLECTION

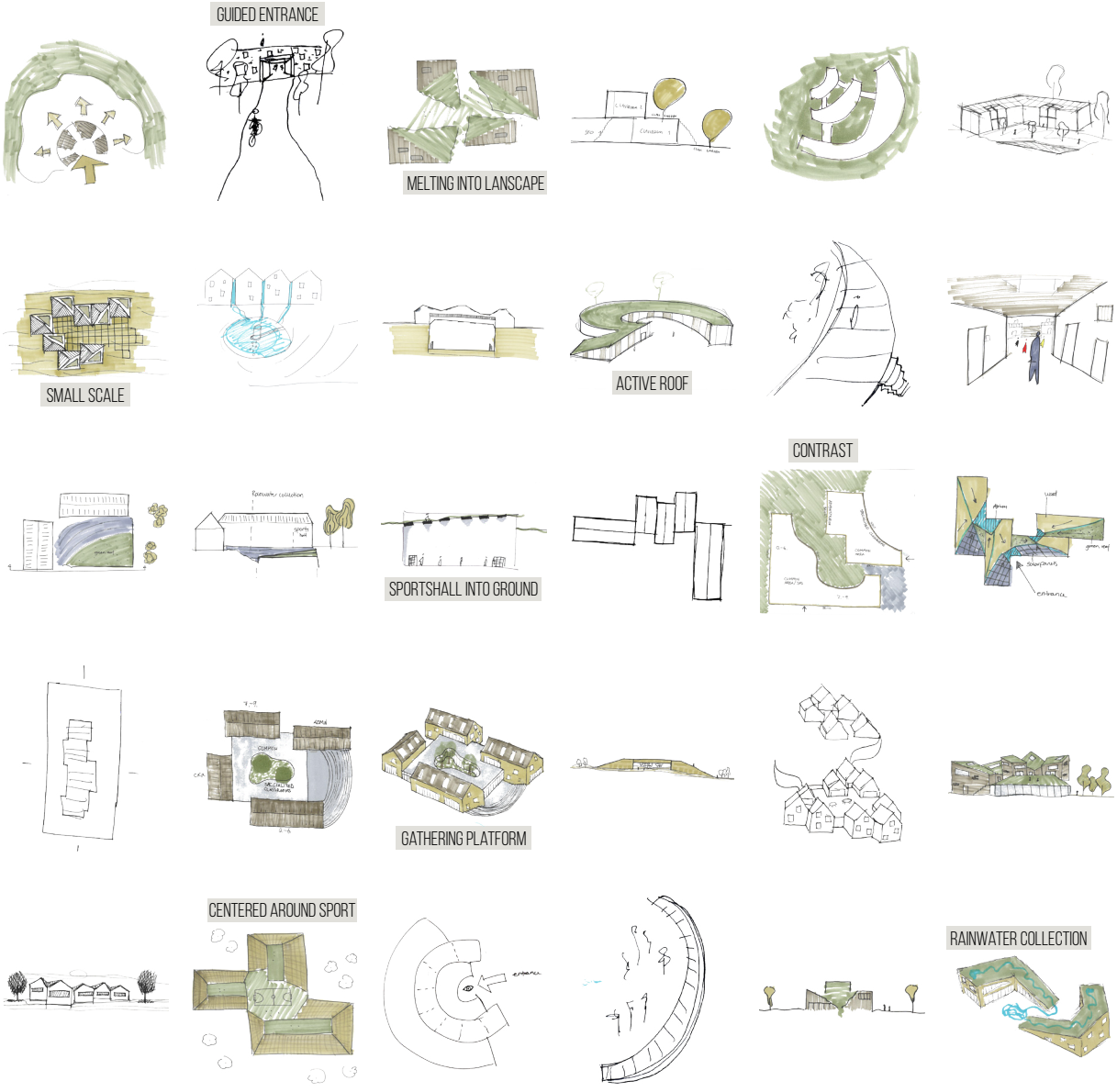


fig. 120. sketches

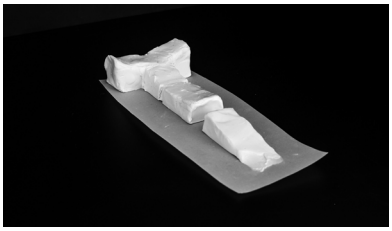


fig. 121. divided base

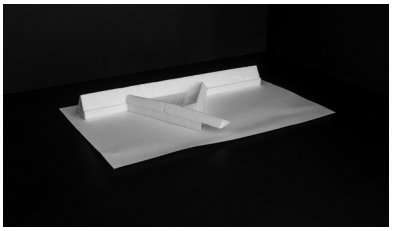


fig. 122. winged triangle

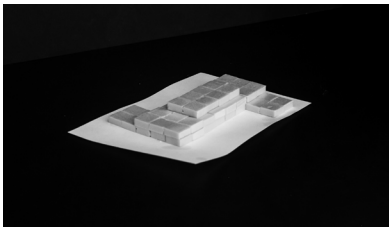


fig. 123. modular system

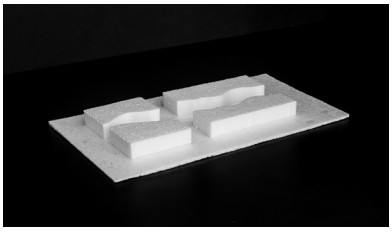


fig. 124. organic courtyard

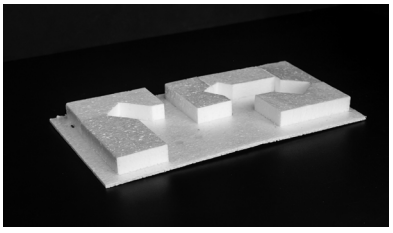


fig. 125. shaped courtyards

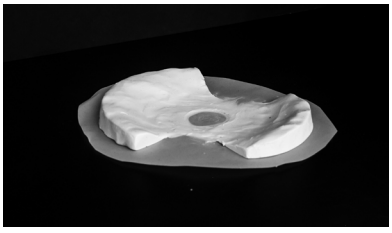


fig. 126. ufo on the bare fields

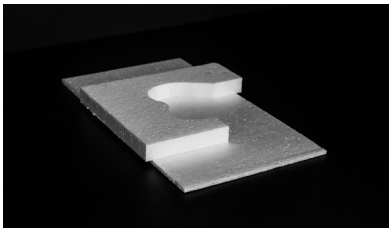


fig. 127. contrast

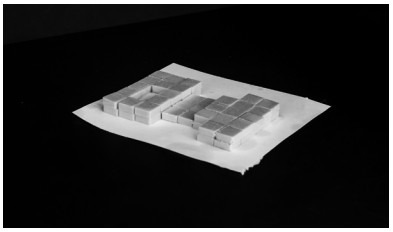


fig. 128. modular system

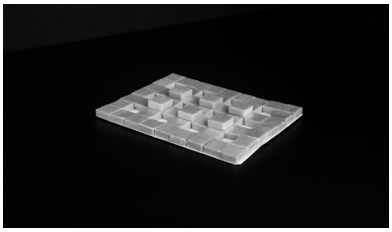


fig. 129. modular system

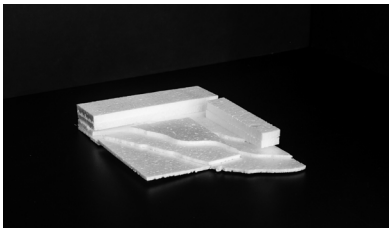


fig. 130. rainwater close to buildings

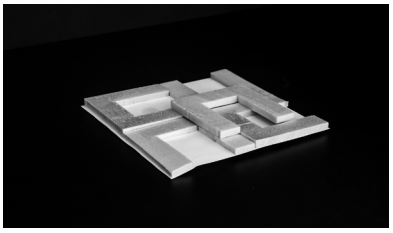


fig. 131. compound bars

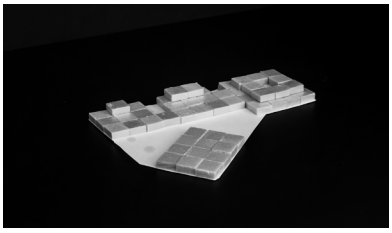


fig. 132. modular system

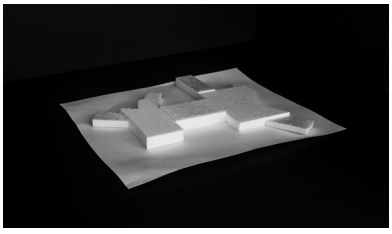


fig. 133. volumes with fingers

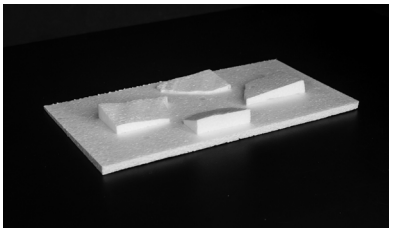


fig. 134. melting into the landscape

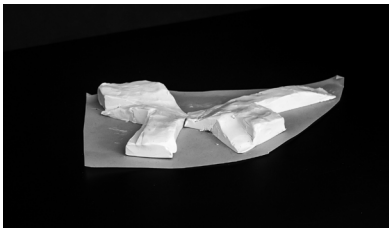


fig. 135. divided into functions

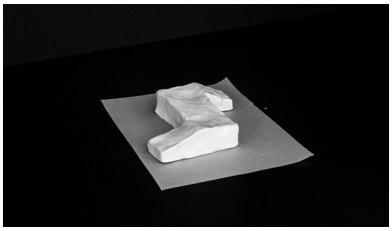


fig. 136. compact volume

fig. 137. base and a z

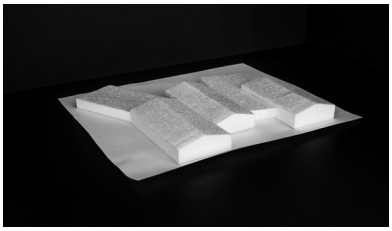


fig. 138. interpreted farm

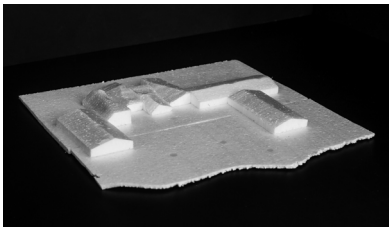


fig. 139. interpreted farm

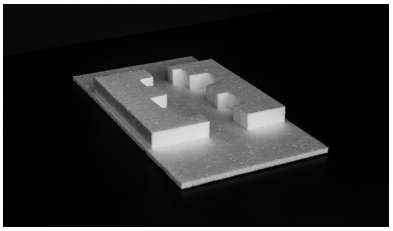


fig. 140. geometric courtyard

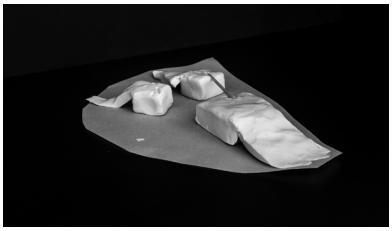


fig. 141. divided volumes with gangway

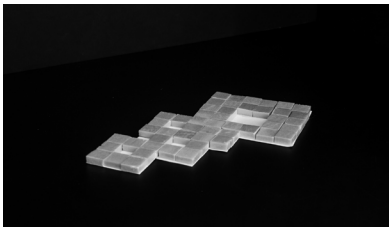


fig. 142. modular system

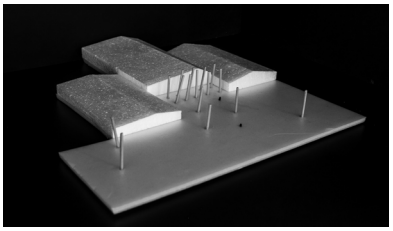


fig. 143. plaza

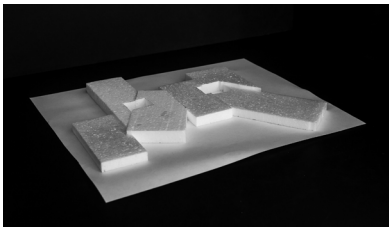


fig. 144. displaced boxes with courtyards

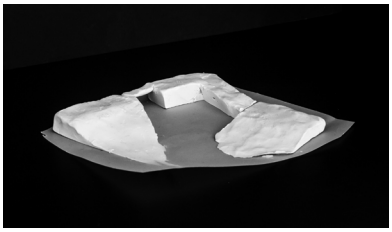


fig. 145. melting into the landscape

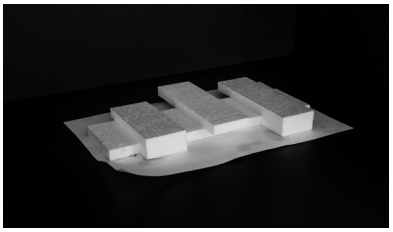


fig. 146. base with bars

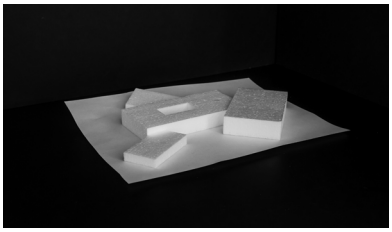


fig. 147. displaced boxes

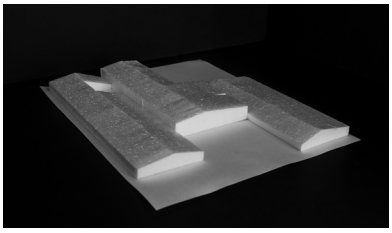


fig. 148. defined plaza

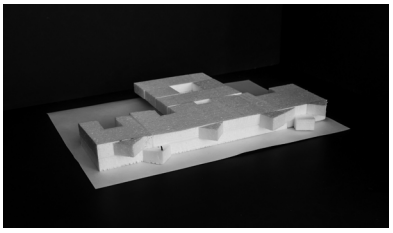


fig. 149. showing functions

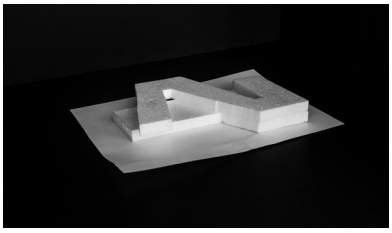


fig. 150. z-concept

INITIAL CONCEPT

The initial sketching phase resulted in a chosen initial concept to be presented at the first scheduled midway seminar. Because of this presentation deadline, an early detailing of the "Z-concept" started to prepare for constructive feedback, but as a result of the corona-crisis, the seminar was cancelled. The Z-concept were designed as two volumes (fig. 157). The base acted as the main volume, including common areas, public functions and shared learning environments. At the top, a more fluid form made space for privacy, classrooms and administrative facilities. The top volume landed at certain spots forming gardens, overhangs and exterior spaces (fig. 156). Though, it was obvious that the early detailing of this somehow provoked concept indicated an aesthetic and functional concept, but with a lack of an analytical approach. Therefore it was a necessity to begin sketching on the basis of other parameters.

From this point the covid-19 situation began to be critical, which started the new routine of working separately.

On the basis of the feedback from both supervisors requesting the concept to be more clear in its functionality and integrated design, sub-studies of the Plaza, internal flow, daylight in the classrooms, energy performance, passive strategies, specialized classrooms and contextuality were made individually. It became clear, that to fulfill the goals of meeting the ZEB-standard and high-quality indoor requirements for a school, the technical aspects should play one of the main roles in developing the concept.

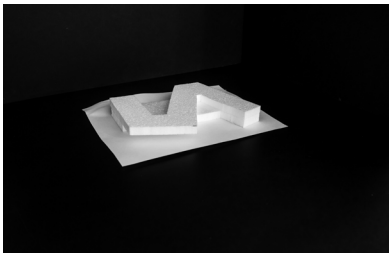


fig. 151. z-concept

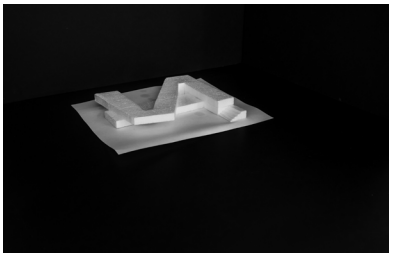


fig. 152. z-concept with gathering stair

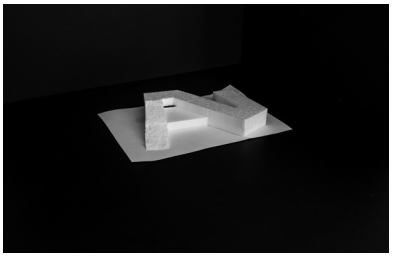


fig. 153. z-concept with active roof

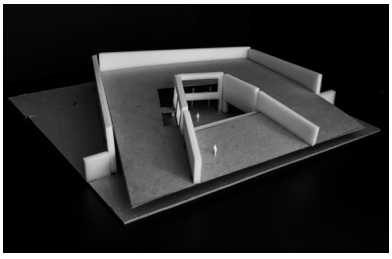


fig. 154. section model of courtyard area

fig. 155. section model of courtyard area

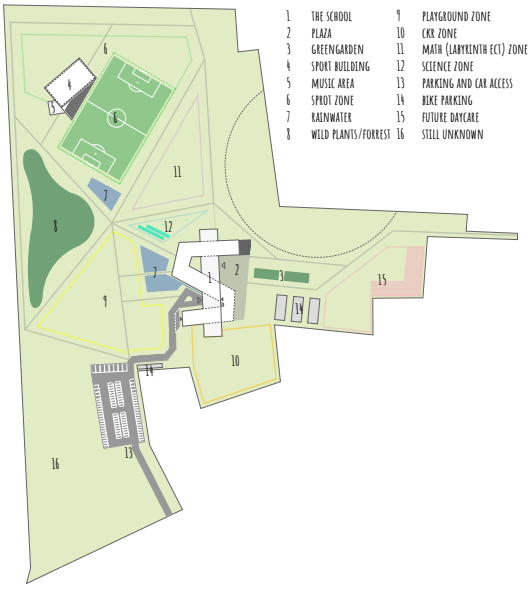


fig. 156. masterplan

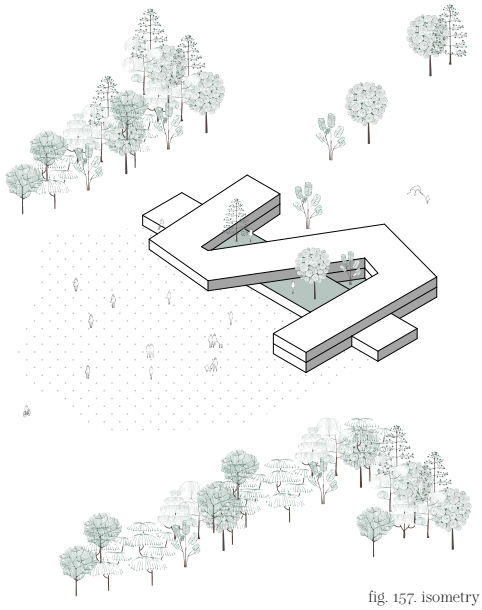


fig. 157. isometry

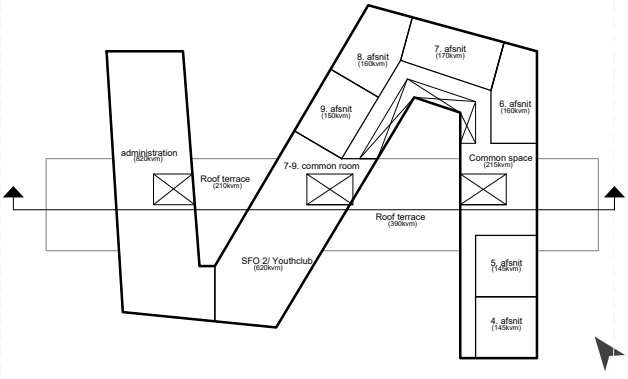


fig. 158. organisation 1. floor

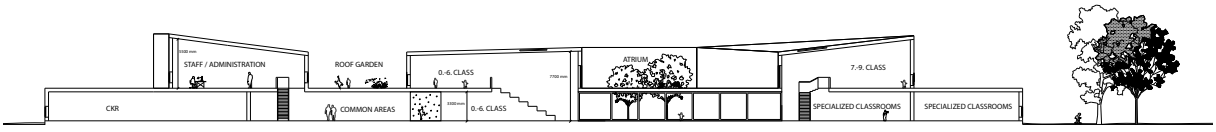


fig. 159. section

ANALYTICAL SKETCHING

The sub-studies helped to get a deeper understanding of the contextuality by respecting Sundby's expectations and still let the building be challenging in its architecture. This balance were further investigated by finding modern references in regards to the materiality and look for solutions for the lack of a local gathering place in Sundby (fig. 165-171).

To investigate quantitative aspects to be able to design with them (and not against them), an analysis of the energy performance in BE18 were made for the Z-concept. This analysis were compared to an analysis of a standard block with the same heated floor area. Concluding no significant difference between the two buildings, further investigations were made in regards to the window areas on the building (fig. 160). They indicated that the amount of glass in the facade should be around 20-30% of the total floor area due to the relation between heat gain and loss. This were furthermore supported by daylight studies and indoor estimations with a 24 hour average analysis (fig. 164). Looking at the temperature, scenario 8 was found most sufficient (fig. 161). Though, investigating the daylight in the spaces, scenario 9 and 10, with skylights in a chimney, were the most optimal (fig. 162-163).

In this phase, strategies for natural ventilation and passive strategies for regulation of the temperature were investigated. How could the group exploit this in an architectural and pedagogical way? This pointed towards for example trombe walls and solar chimneys, and an investigation of how to use this in a school building were made (fig. 173-175).

Lastly sub-studies about how to design the sportshall and its relation to site and the rest of the school were made, in correlation to the building volumes ability to form a public space in front of it (fig. 179-182).

These studies became the stepping stone towards a further development of the classrooms and new concepts with an integration of the required spatial qualities.

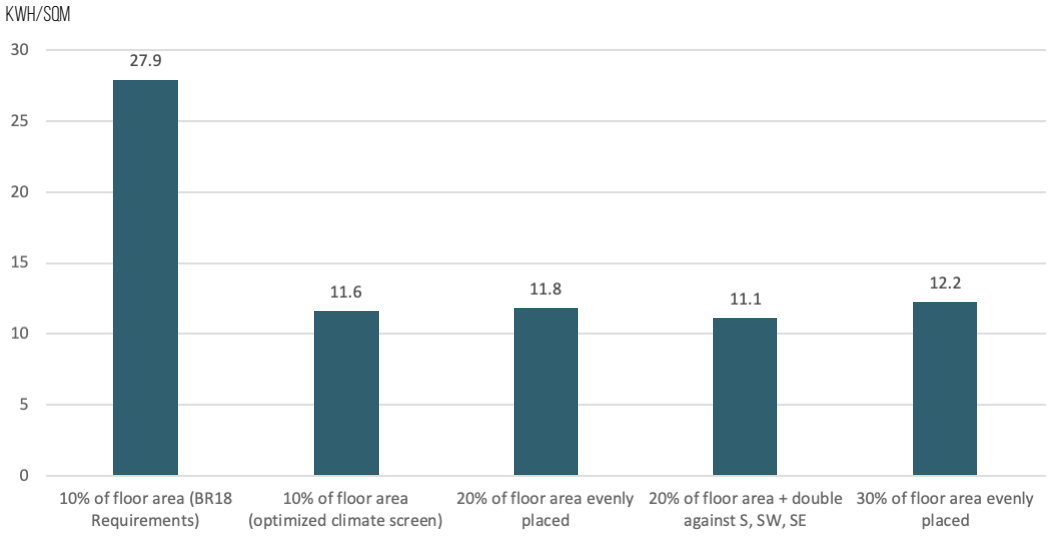


fig. 160. window calculations

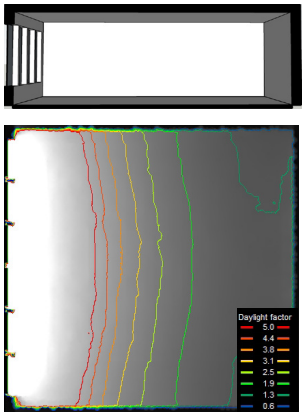


fig. 161. scenario 8 (20% window area, north)

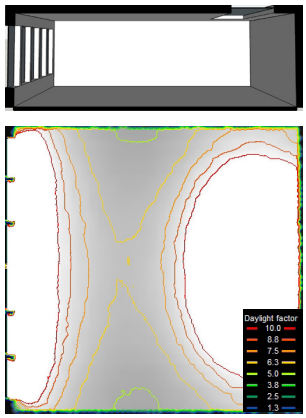


fig. 162. scenario 9 (20% window area, north)

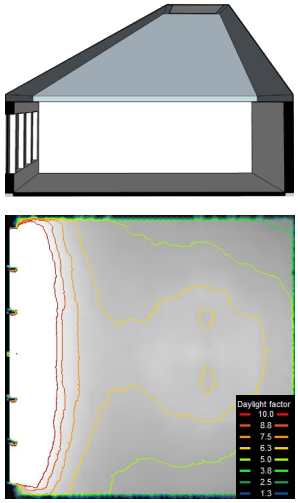


fig. 163. scenario 10 (20% window area, north)

Calculationmonth: August
Personload 8-16: 1700 W
(100% load of 0,8 MET of adult - 2 breaks during the day)

		S	N	E	W
scenario 8 / without chimney and skylight	24 H average	24,5 °C	24,0 °C	24,3 °C	24,3 °C
	max. temp.	26,2 °C	25,6 °C	26,0 °C	26,0 °C
scenario 9 / with skylight	24 H average	27,3 °C	26,8 °C	27,1 °C	27,1 °C
	max. temp.	29,6 °C	29,0 °C	29,4 °C	29,4 °C
scenario 10 / with chimney and skylight	24 H average	26,1 °C	25,6 °C	25,9 °C	25,9°C
	max. temp.	28,2 °C	27,5 °C	28,0 °C	28,0°C

fig. 164. 24 hour average analysis comparison diagram

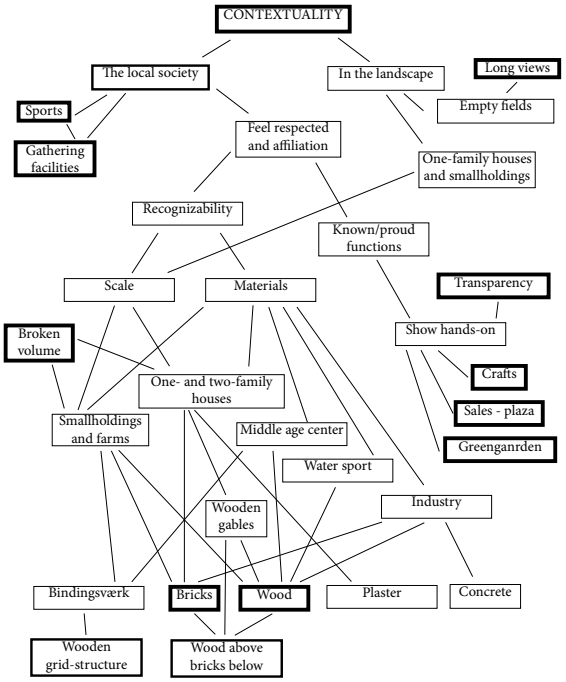


fig. 165. contextuality diagram

fig. 166.

fig. 167.

fig. 168.

fig. 169.

fig. 170.

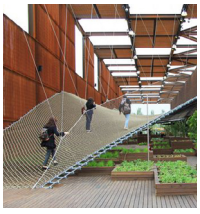


fig. 171.

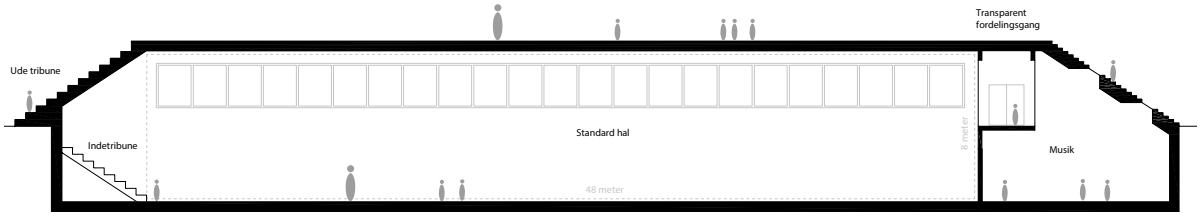


fig. 172. section of sportshall

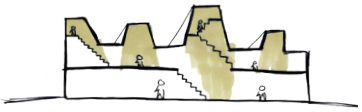


fig. 173. chimney sketches

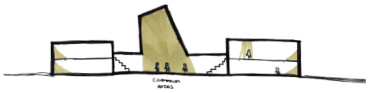


fig. 174. chimney sketches

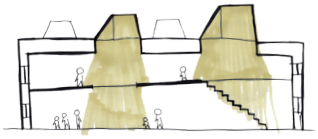


fig. 175. chimney sketches

fig. 176. functionality and flow

fig. 177. functionality and flow

fig. 178. functionality and flow

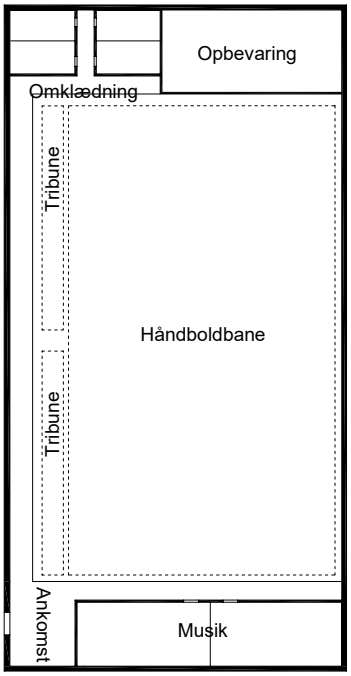


fig. 179. plan of sportshall

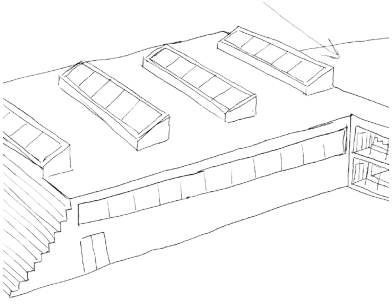


fig. 180. sportshall with skylights

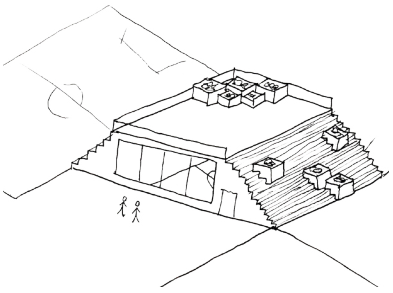


fig. 181. sportshall with gathering stairs

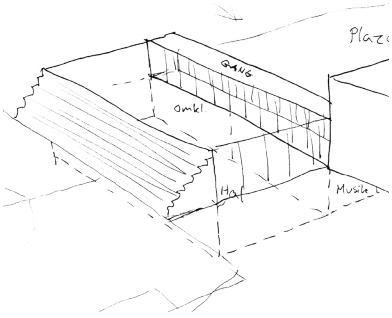


fig. 182. sportshall with stairs and hallway

DETAILING CLASSROOMS

To secure great daylight in all classrooms and the opportunity to stack them on top of each other, new daylight studies without skylights were made with a 7×10m box with different varieties, fig. 187-195. This resulted in different studies regarding how to arrange the classrooms to secure a northern direction for majority of them and a great flow in between, which is shown in fig. 186. Furthermore some section studies on how to create an interesting atmosphere and daylight in the classroom and hallway were made, fig. 184-185. Together with the 24 hour average analysis on the different optimisations of the classrooms and other parameters, an evaluation table (fig. 196) were made, which resulted in the preferred optimisation 9 (fig. 195). These findings were taken into consideration in the further design process.

fig. 183. flow and intergation of small gardens

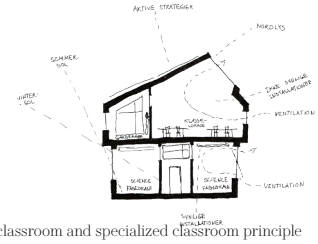


fig. 184. classroom and specialized classroom principle

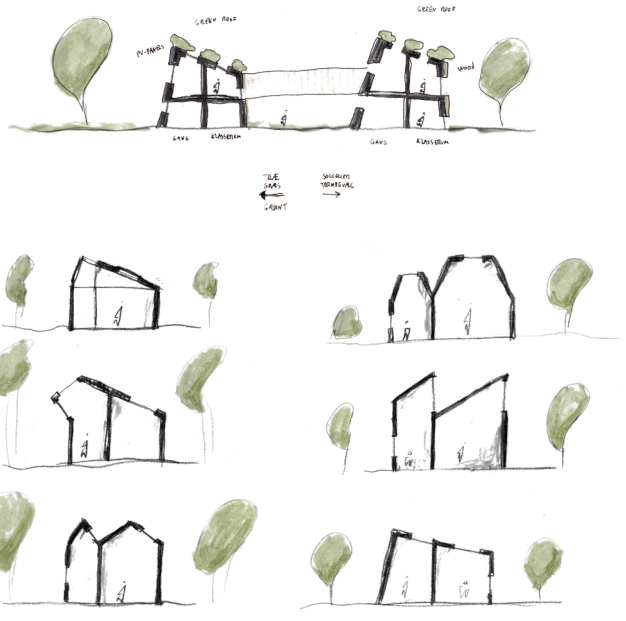


fig. 185. sections of classrooms and hallway

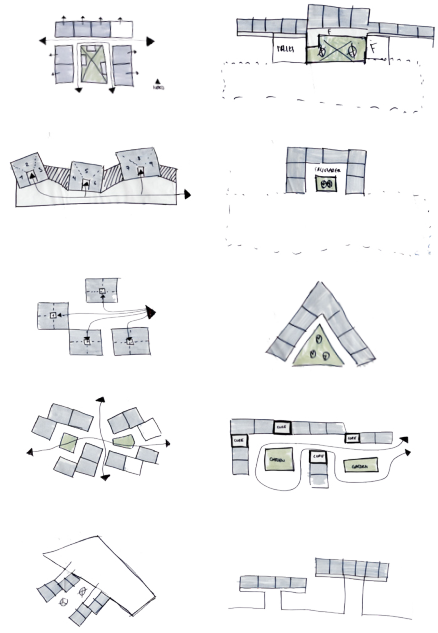


fig. 186. sketches of classroom layouts and flow

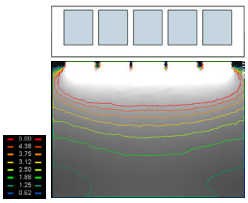


fig. 187. optimisation 1: 2,6 m

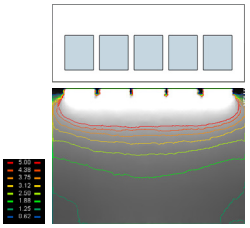


fig. 188. optimisation 2: 4 m

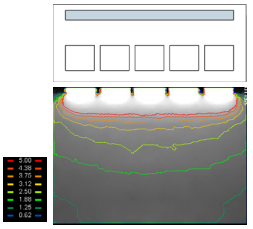


fig. 189. optimisation 3: 4 m, with windowband

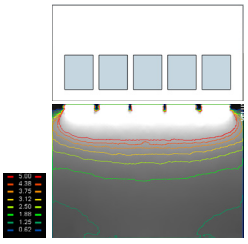


fig. 190. optimisation 4: 5 m

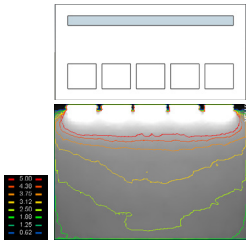


fig. 191. optimisation 5: 5 m, with windowband

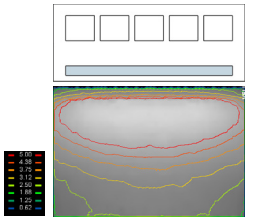


fig. 192. optimisation 6: 4 m, with lower windowband

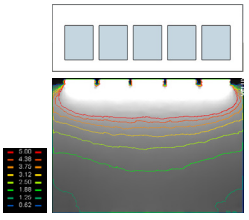


fig. 193. optimisation 7: 3,5 m

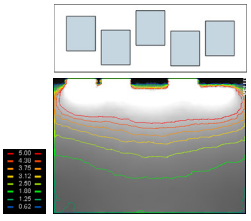


fig. 194. optimisation 8: 3,5 m, playful windows

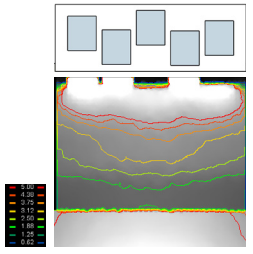


fig. 195. optimisation 9: 3,5 m, with adjacent room

	Room height	Max. temp.	Part of room with 2.5 % dagylightfactor	View from classroom	Window multifunctionality	Rank (heigest number – best)
Optimisation 1	2,6 m	25, 7°C	40 %	good	good	2
Optimisation 2	4 m	25,5 °C	40 %	good	good	7
Optimisation 3	4 m	25,5 °C	30 %	good	good	1
Optimisation 4	5 m	25,3 °C	40 %	good	good	3
Optimisation 5	5 m	25,3 °C	70 %	good	good	4
Optimisation 6	4 m	25,5 °C	90 %	bad	bad	5
Optimisation 7	3,5 m	25,6 °C	40 %	good	good	6
Optimisation 8	3,5 m	25,6 °C	50 %	semi-good	good	8
Optimisation 9	3,5 m	25,6 °C	70 %	semi-good	good	9

fig. 196. window and daylight evaluation table

INITIAL CONCEPTS

On the basis of all earlier investigations regarding flow, daylight and compactness, new concepts were formed as more realistic volumes containing the desired functions from the initial room program. Five concepts (fig. 203-207) investigating different aspects and qualities appeared among them, which was evaluated in an evaluation scheme (fig. 208). The parameters that were included was weighted based on the project's vision and design strategies, and included among other things energy performance, daylight factor, distances, flow and relation to the Agora.

The concept "Merged squares" got the highest total score. At the time, this was the newest concept combining many of the aspects from the four other evaluated concepts. When studying the evaluation scheme, merged squares appears as the most unfavourable in terms of energy performances and distances. Though, considering how new this concept was, the volume used to measure surfaces was far from as compact and optimized as the four others, and therefore it could be justified to go further with the concept.

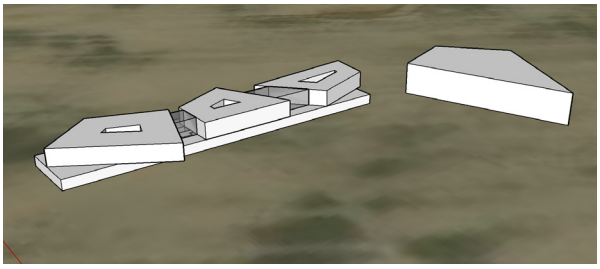


fig. 197.

fig. 198.

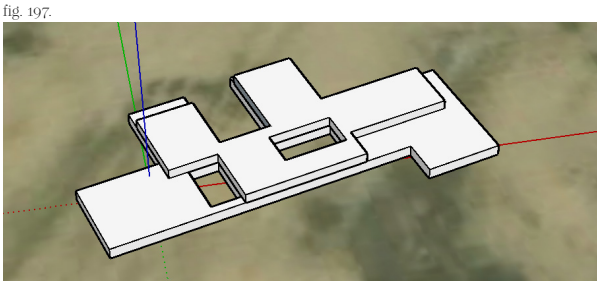


fig. 199.

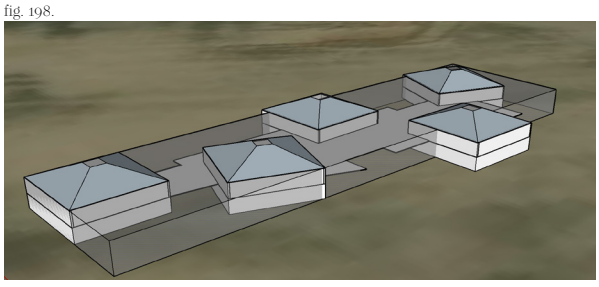


fig. 200.

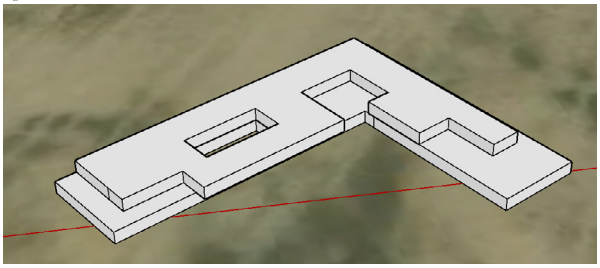


fig. 201.

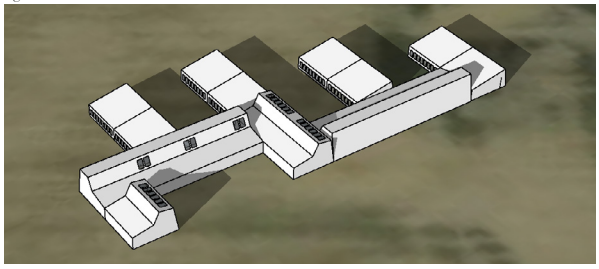
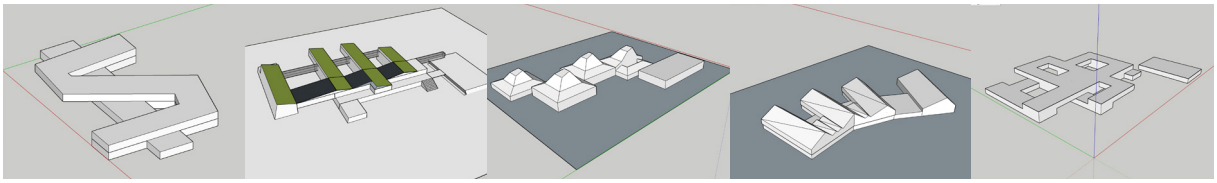


fig. 202.



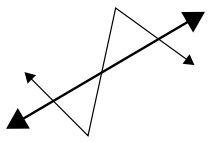


fig. 203. z-volume

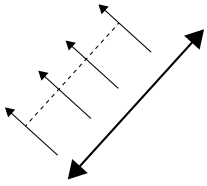


fig. 204. fingers

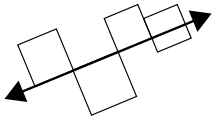


fig. 205. four blocks

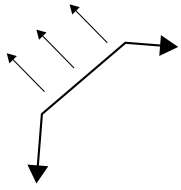


fig. 206. kammen

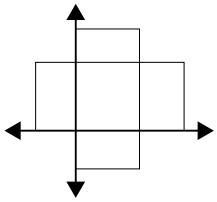


fig. 207. merged squares

	Weighting	Z-volume	Fingers	Four blocks	Kammen	Merged squares
Energy (Be18)	2	2 (12,2 kWh/m2)	1 (17,6 kWh/m2)	2 (15,6 kWh/m2)	2 (16,3 kWh/m2)	1 (17,6 kWh/m2)
Possibility for diffuse daylight	5	2	5	3	3	4
Green views from classrooms	3	4	1	3	2	3
Max distance from classroom to specialized classroom	1	2 (80 m)	1 (116 m)	2 (103 m)	1 (120 m)	1 (120 m)
Max distance from classroom to teacher-office	2	1 (130 m)	1 (134 m)	2 (103 m)	2 (85 m)	1 (130 m)
Flow	4	3	1	2	2	4
Internal sense of community	3	2	2	3	3	3
Readability of functions	3	3	4	4	4	3
Forming of exterior spaces	3	2	4	2	3	5
Relation to Agora	4	1	3	4	2	4
Public accessability	2	3	3	2	3	3
Scale compared to pupils and Sundby	4	1	3	2	3	2
TOTAL SCORE		77	97	97	94	113

fig. 208. evaluation table

DETAILING / DIGITAL MIDWAY

For the digital midway seminar, the concept "Merged Squares" was further detailed and presented in a more visionary manner. The idea was based on two rectangular volumes cutting and intersecting, naturally creating indoor and outdoor spaces, while still maintaining a preferred flow. As the design process developed, the form could easily be adjusted to fit the necessary spaces without losing its identity. Skylights could be placed over common spaces in need of more daylight and distinctive atmosphere. The corners of the building was rounded, displacement were arranged and the whole volume became cladded in wood (fig.215) to make it appear more soft, down to scale and welcoming. Also, a more detailed Be18-calculation was made, stating a energy demand of 27,1 and some excessive heat.

At the presentation a plan representing the zone-strategy (fig. 209-210), a ventilation strategy (fig. 211-212) and internal spatial considerations were displayed (fig. 214).

As the vision of the school was to front 'problem based learning', the feedback from the professor was mainly regarding the lack of so.

The feedback, as well as the groups knowledge of what to do next, became the first step into the synthesis phase. The concept needed to be detailed in terms of roof, plan and form, on the basis of reaching ZEB and sufficient daylight in all educational spaces. Furthermore, the Agora, masterplan and the detailing of construction principles needed to be investigated.

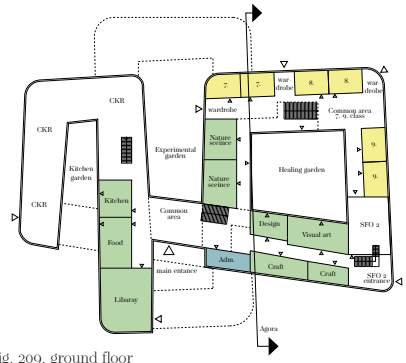


fig. 209. ground floor

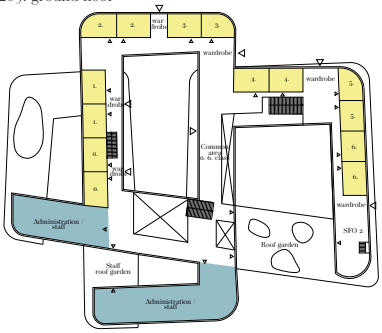


fig. 210. 1. floor

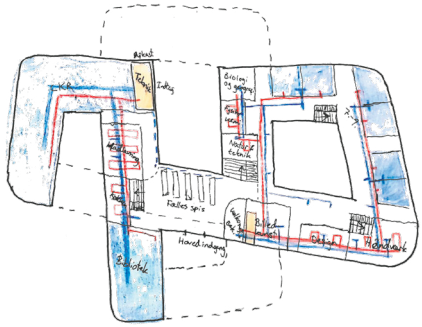


fig. 211. ground floor

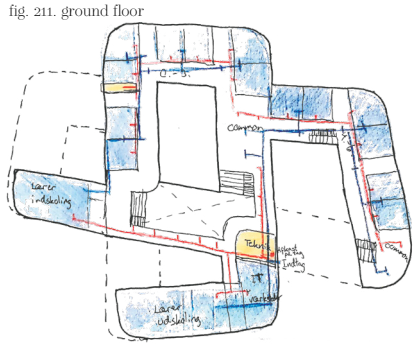


fig. 212. 1. floor

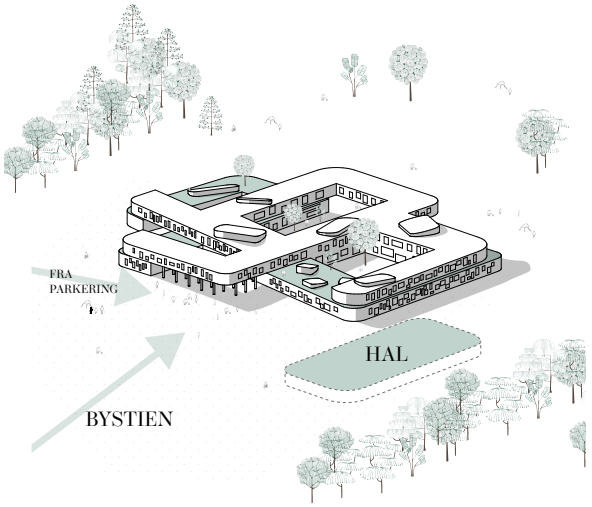


fig. 213. isometry

fig. 214. interior design

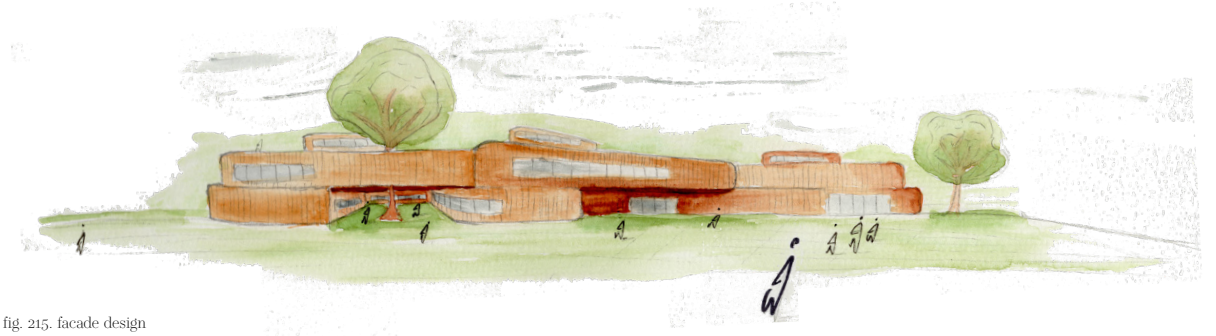


fig. 215. facade design

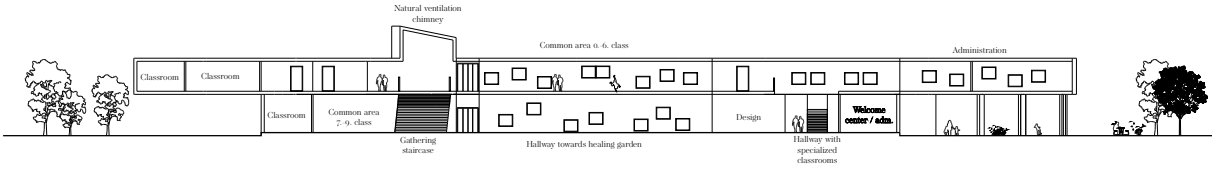


fig. 216. section

NEXT UP...

SYNTHES


SIS PHASE

PROBLEM BASED LEARNING

The new ways of teaching demands for very different spatialities, than what was common in schools only 20 years ago. Problem-based learning encourages for more work in smaller groups, experimentation and independence. This can be solved in many different ways, where the three case studies (ref. pp. 92-96) are different examples on how to implement flexible furniture, group rooms and niches. At the same time, the user-interviews provided insight in the still desired "home-rooms". Proposals on how this could be solved within the concept is seen on fig. 221-227, and a preferred solution was analyzed for both daylight and temperatures (fig. 218).

As seen on the daylight analysis (fig. 217), a new feature in form of a double facade was added to the surfaces facing the internal garden. The double facade secures desired daylight, visual connection and views, while having a lower U- and g-value compared to low energy windows. This prevents heat loss and excessive heat, while still allowing transparency.

The general detailing of the plan in the administration, craft zone, natural science zone and common areas further pushed the volume into its final design.

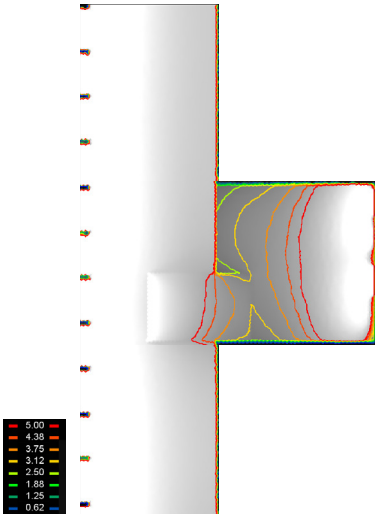


fig. 217. daylightfactor analysis

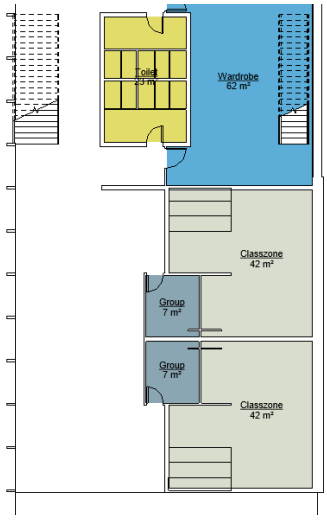


fig. 218. the analysed plan of the classroom and hallway

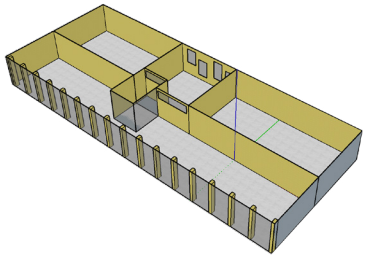


fig. 219. the analysed classroom and hallway

24 hour average temp.	23,6 °C
Max temp.	25,7 °C

fig. 220. result of the 24 hour average analysis

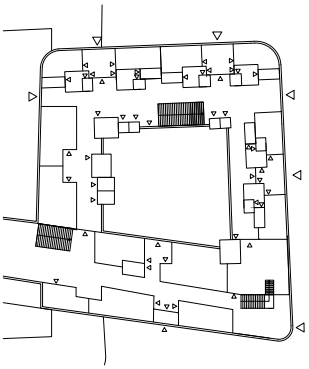


fig. 221. integration of problem based learning zones

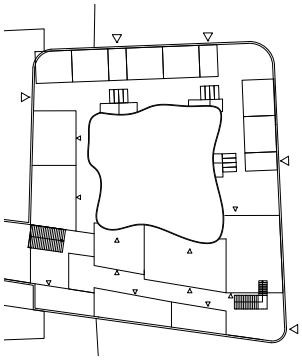


fig. 222. integration of problem based learning zones

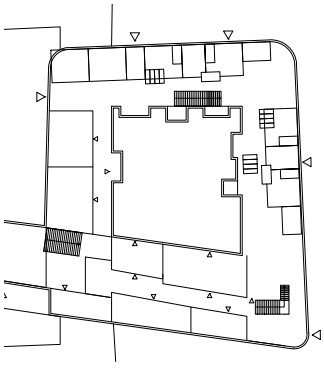


fig. 223. integration of problem based learning zones

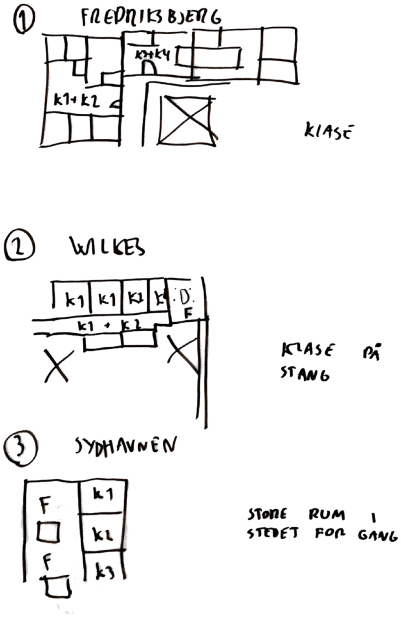


fig. 224. integration of problem based learning zones

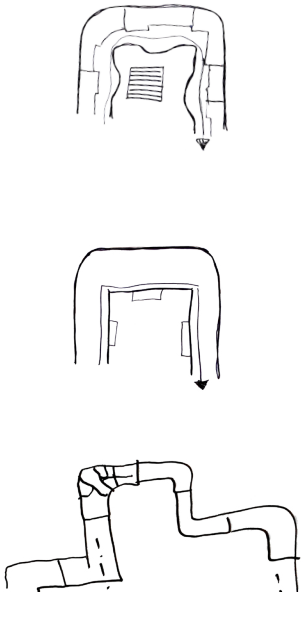


fig. 225. integration of problem based learning zones

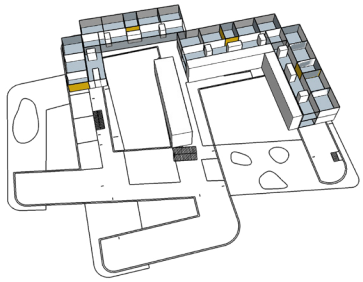


fig. 226. integration of problem based learning zones

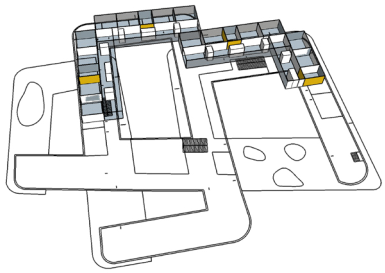


fig. 227. integration of problem based learning zones

DEFINING THE AGORA

To establish a foundation of knowledge needed to the design the Agora, a more theoretical approach by studying Jan Gehl's 12 quality criteria for public spaces (Gehl, J., 1971.) and William H. Whyte's theory of social life in small urban places (Whyte, W. H., 2010.) was used.

Whyte describes multiple aspects regarding the design of a public space, for instance that seating places should face activities, moveable chairs are better than benches, establishment of semi-outdoor spaces makes it more usable regardless of weather and that water has a gathering and calming effect. Most importantly, he states that people do not flock to empty spaces, but rather go places where there are other people. From these theories, the design of a more compressed space suiting the size of Sundby started (fig. 235 and 238).

Gehl is known for describing the twelve criterias that make public spaces good. Furthermore, he has made studies of how we as humans perceive people based on different distances between 0,5-100m (Gehl, J., 2010). With this knowledge, the volumes of the school and sportshall could be experimented with, aiming at a maximum distance of 100 meters between the library and the hall, which is the two most public functions attracting the citizens of Sundby.

Other aspects regarding materiality, the need for pavilions for learning and sharing, and water collection was also investigated (fig. 236-237).

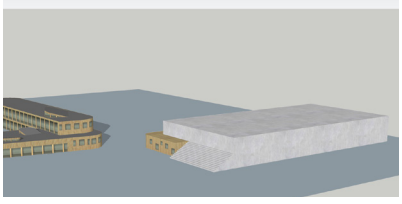


fig. 228. sportshall with gahtering stair and concrete

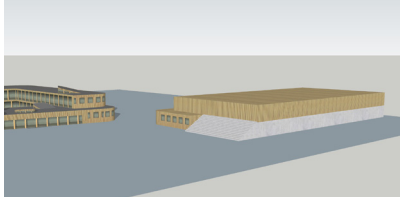


fig. 229. sportshall with a mix of wood and concrete

fig. 230. sportshall with public functions towards Agora

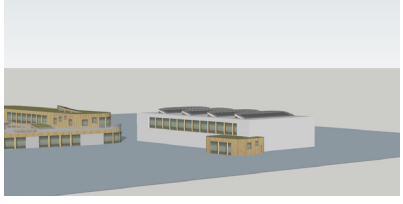


fig. 231. smaller sportshall

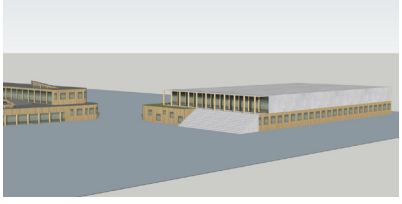
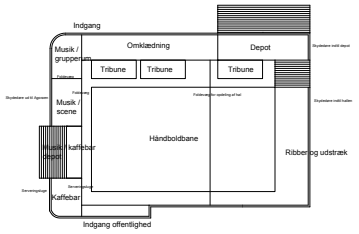


fig. 232. sportshall with gathering stair

fig. 233. sportshall with public functions



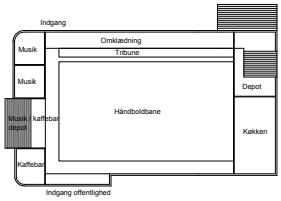


fig. 234. plans of the sportshall

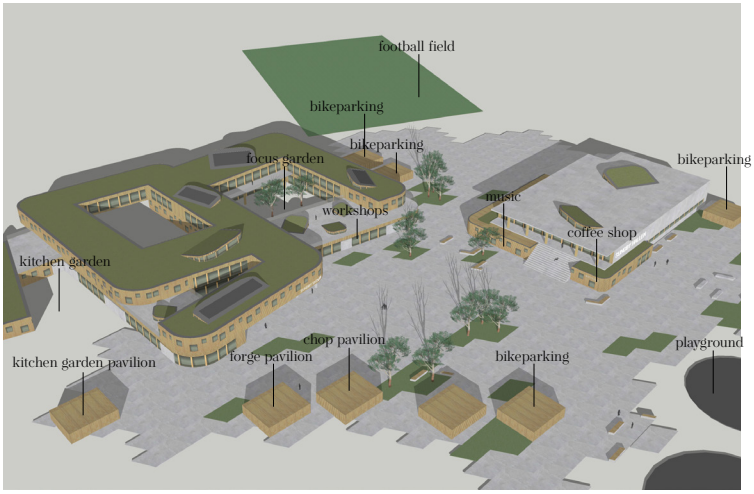


fig. 235. functions around Agora

fig. 236. modular system pavilions

fig. 237. modular system pavilions with reused materials

fig. 238. parking area and courtyard studies

ROOF DEVELOPMENT

At the time the first, more accurate Be18-model was made, the roofs design was still uncertain (fig. 239-244). While aiming towards the ZEB-standard, the concept needed some source of energy production. The idea of solar panels was apparent, because of the sites unobstructed access to sunlight. With the results from the Be18-model, an estimate on how many square meters of PV-panels are necessary to reach the ZEB-standard based on type, direction and angle (fig. 248).

Simultaneously, the internal spatiality strategy in terms of ceilings and materials were beginning to form on the basis of atmospheres and pedagogical effect. The studies concluded visible ventilation in all of the rooms in the nature science and craft zones (fig. 249), while invisible in all classrooms (fig. 247). In the commons spaces, the idea of a wired mesh appeared as a way of maintaining the awareness of the honest materials, while still displaying what a ceiling actually contains (fig. 250). At the same time the false ceiling provides more volume to act as a buffer for heat and CO2, improving the thermal and atmospheric comfort.

In other words would not the roofs form impact the internal spatiality. When studying the table of needed thinfilm-panels (fig. 248), which is considered more sustainable to produce and more efficient in gray weather compared to the two other types, it reveals only a 200 square meter difference between being flat and optimal (45 degrees towards south) to cover the energy demand at this point. Having a roof surface of 3600 square meters, the PV-panels could hereby be the main cladding of the roof, making the building its own source of power for both building electrics and equipment. Different proposals for flat (1.4 degree) roofs were designed thereafter (fig. 245-246).

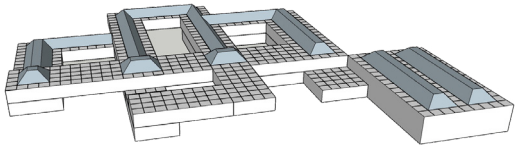


fig. 239. roof studies

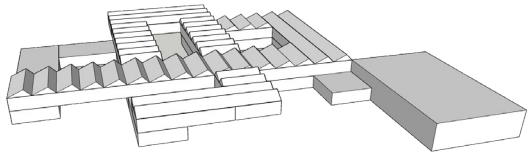


fig. 240. roof studies

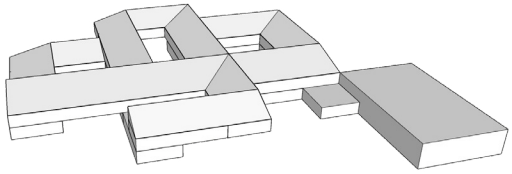


fig. 241. roof studies

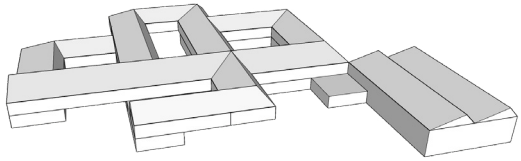


fig. 242. roof studies

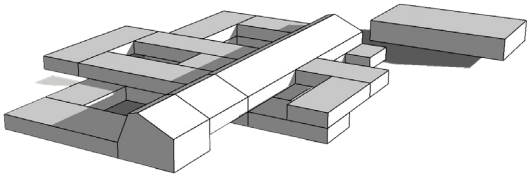


fig. 243. roof studies

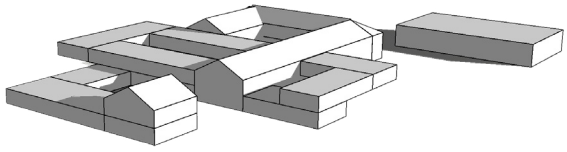


fig. 244. roof studies

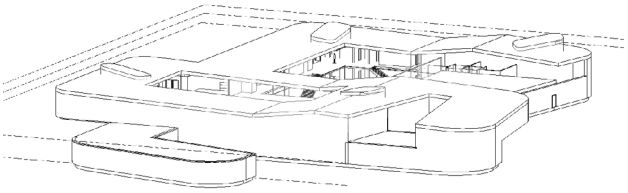


fig. 245. roof studies

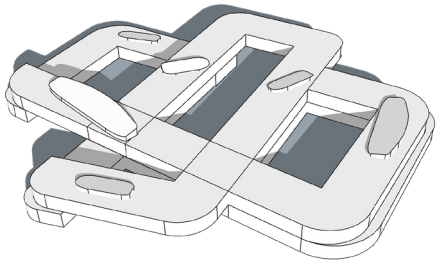


fig. 246. roof studies

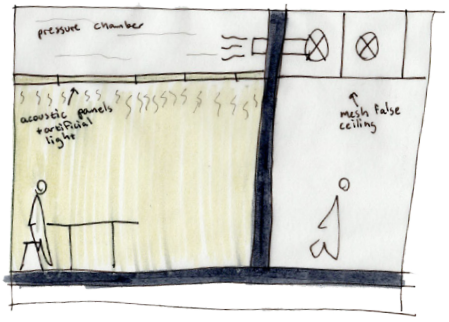


fig. 247. "as a place for concentration, and a unique form of ventilation strategy, the ceilings are designed with acoustic panels allowing fresh air through the gaps".

	M²
East 45 degree - Tyndfilm, højteffektiv	1930,8
East 90 degree - Tyndfilm, højteffektiv	2630,0
East 0 degree - Tyndfilm, højteffektiv	1766,5
East 15 degree - Tyndfilm, højteffektiv	1786,1
East 30 degree - Tyndfilm, højteffektiv	1842,1
South 45 degree - Tyndfilm, højteffektiv	1517,4
South 90 degree - Tyndfilm, højteffektiv	1978,4
South 0 degree - Tyndfilm, højteffektiv	1766,5
South 15 degree -Tyndfilm, højteffektiv	1608,7
South 30 degree - Tyndfilm, højteffektiv	1531,9
West 45 degree - Tyndfilm, højteffektiv	1958,6
West 90 degree - Tyndfilm, højteffektiv	2665,7
West 0 degree - Tyndfilm, højteffektiv	1766,5
West 15 degree - Tyndfilm, højteffektiv	1798,9
West 30 degree -Tyndfilm, højteffektiv	1863,5

fig. 248. solarpanels calculations

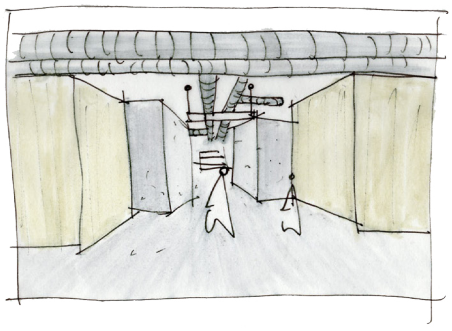


fig. 249. "the visible technical ducts in the ceiling creates a raw, creative and honest atmosphere"

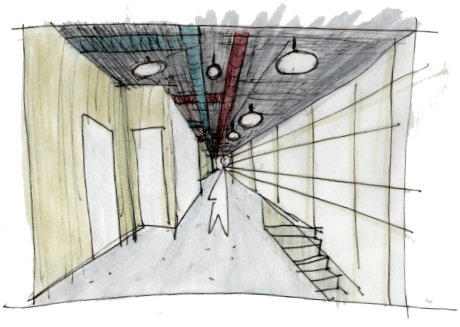


fig. 250. "the ducts can be used for educational purposes, and can be followed into the different rooms through the mesh"

BE18 AND FACADE STUDIES

Be18 has been an important tool to secure that crucial design decisions is in line with the goal to reach ZEB. After the calculation and design of the Z-concept, it could be concluded that because of the buildings internal heat gain, the issue would be to secure sufficient daylight throughout the building, more than achieving passive solar heat gain. Fig. 251 illustrates how Be18 has been fed with more and more detailed information and used as a tool for design, verification and comparison.

The most important places where the calculation was used, was after the Z-concept, during the roof-design phase and at last the design of the final facade.

In the early stages of the concept development, eastetichal and functional studies were made in regards to the general expression of the facade (fig. 252-255). As the process moved forward, the final window design was highly determined by the energy calculation, daylight in the classrooms and the internal perception of the windows (fig. 260-268). Furthermore, studies about how to integrate trombe walls and the double facade as a part of the facade expression, were investigated (fig. 269-273).

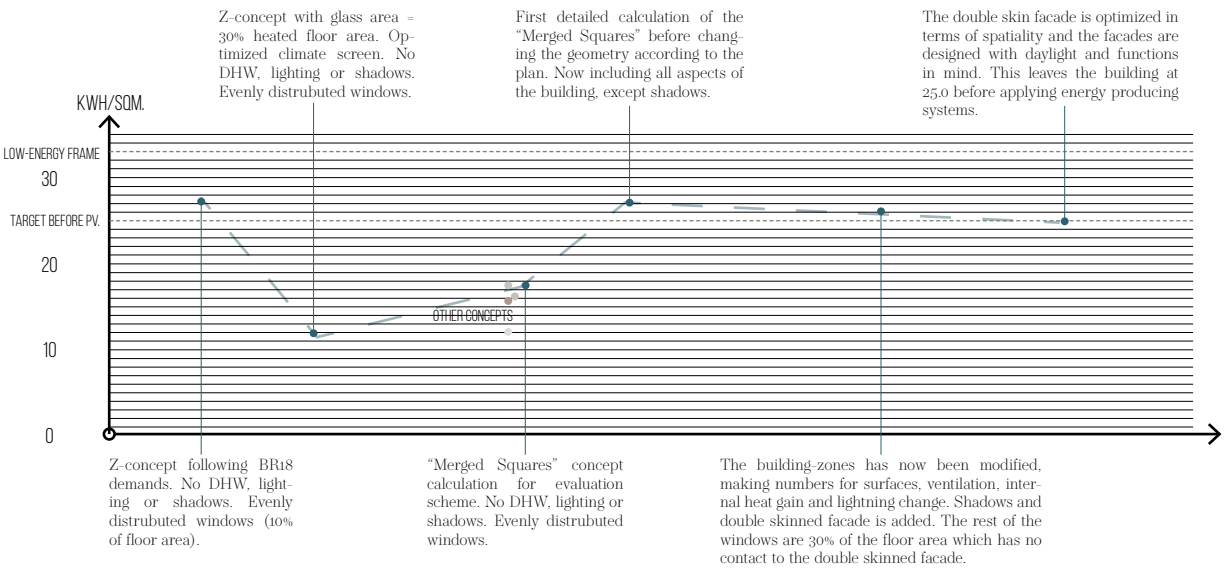


fig. 251. BE18 calculation comparison digram

fig. 252. displaced windows and concrete segments

fig. 253. windows in horisontal lines

fig. 254. displaced windows

fig. 255. displaced windows

fig. 256. windows that underlines the horizontal geometry

fig. 257. displaced windows with frames

fig. 258. displaced windows

fig. 259. displaced quadratic windows

fig. 260. study 1: displaced quadratic windows

fig. 261. study 1: windows from inside the classroom

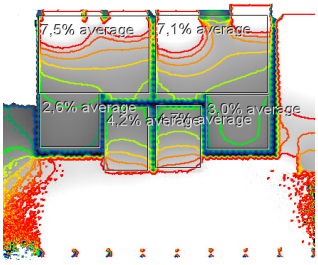


fig. 262. study 1: daylightfactor

fig. 263. study 2: windows that underlines the horizontal

fig. 264. study 2: windows from inside the classroom

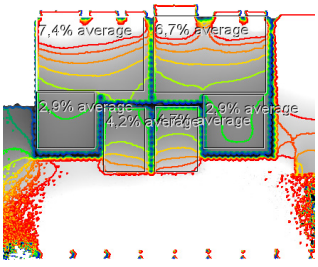


fig. 265. study 2: daylightfactor

fig. 266. study 3: displaced mixed windows

fig. 267. study 3: windows from inside the classroom

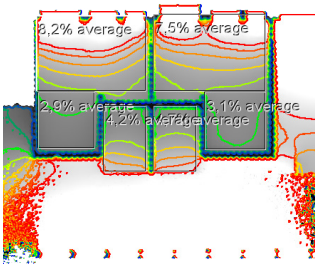


fig. 268. study 3: daylightfactor

fig. 269. south facade with trombe wall

fig. 270. south facade with trombe wall

fig. 271. south facade with trombe wall

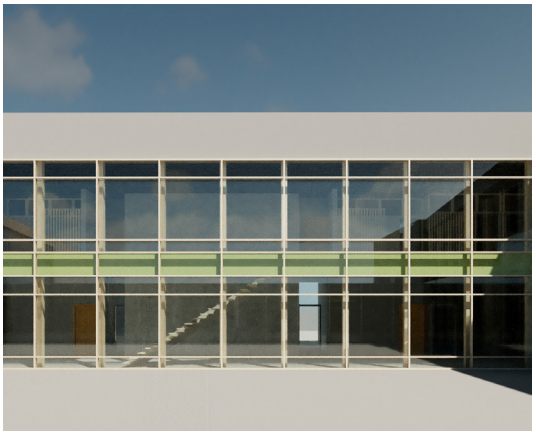


fig. 272. double facade in courtyard

fig. 273. double facade in courtyard

INTERNAL MATERIALITY

The final part of the synthesis phase, before the presentation phase sets in, were more about interior strategies, details, skylights, materials and how the construction would be able to enhance the atmosphere and spatiality. Therefore, studies about the interior spatial atmosphere were investigated. The wood construction of the double facade with perforated wooden boards would be able to create a playful expression in the hallways (fig. 274). Furthermore, studies about how the construction in the common area could be used as division of the room in smallers zones and how the entrance of the building could be created were made (fig. 276-279). Lastly, interior studies of the hallways with spatiality accomodating problem based learning (fig. 280-284).

fig. 274. hallway towards double facade with perforated wood boards

fig. 275. hallway with skylight

fig. 276. common area with columns

fig. 277. common area with column/beam system

fig. 278. common area with visible column/beam system

fig. 279. common area with visible column/beam system

fig. 280. group rooms with glass

fig. 281. group rooms with wooden lamellas

fig. 282. group rooms with horizontal windows

fig. 283. group rooms with horizontal windows and wooden lamella

EPILO

OGUE

LIST OF REFERENCES

Aisinger, P., 2019. Folkeskolen: Forældresamarbejdet er designet til overskudsforældre. [online] Available at: <https://www.folkeskolen.dk/847515/foraeldresamarbejdet-er-designet-til-overskudsforaeldre> [accessed 26.02.20]

Andersson, S., 2002. Bygninger og landskab - spredte tanker om at ligge smukt i landskabet. Kunstakademiets Arkitektskolens Forlag.

Astolfi, A., et al., 2019. Influence of Classroom Acoustics on Noise Disturbance and Well-being for First Graders. [e-journal] Frontiers in Psychology, Vol. 10, 2019-12-13. Available through: <https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02736/full> [accessed 26.02.20]

Barth, I., et al, 2020. Physical activity, mental health and academic achievement: A cross-sectional study of Norwegian adolescents. [e-journal] Mental Health and Physical Activity, Vol. 18, 2020-03. Available through: <https://sfx.aub.aau.dk/sfxaub?sid=Elsevier:Scopus&_service_type=getFullTxt&issn=17552966&isbn=&volume=18&issue=&spage=&epage=&pages=&artnum=100322&date=2020&id=doi:10.1016%2fj.mhpa.2020.100322&title=Mental+Health+and+Physical+Activity&atitle=Physical+activity%2c+mental+health+and+academic+achievement%3a+A+cross-sectional+-study+of+Norwegian+adolescents&aufirst=I.&auinit=I.&auinit1=I&aulast=Barth+Vedøy> [accessed 26.02.20]

Bellomo, A., 2020. Outdoor Experience in Schoolyards Aimed at Widening Learning Opportunities. [e-journal] Research for Development, 2020, p. 33-51. Available through: <https://sfx.aub.aau.dk/sfxaub?sid=Elsevier:Scopus&_service_type=getFullTxt&issn=21987300&isbn=&volume=&issue=&spage=33&epage=51&pages=33-51&artnum=&date=2020&id=doi:10.1007%2f978-3-030-19629-5_3&title=Research+for+Development&atitle=Outdoor+Experience+in+Schoolyards+Aimed+at+Widening+Learning+Opportunities&aufirst=A.&auinit=A.&auinit1=A&aulast=Bellomo> [accessed 26.02.20]

Bjerril, S., 2018. Minister: Fire år med skolereformen: Undervisningen er blevet mindre varieret [online] Available at: <https://www.folkeskolen.dk/648600/fire-aar-med-skolereformen-undervisningen-er-blevet-mindre-varieret-> [accessed 06.02.20]

Bjerril, S. and Møller, E. B., 2019. Minister: Vi er kun halvvejs med skolereformen [online] Available at: <https://www.folkeskolen.dk/826926/minister-vi-er-kun-halvvejs-med-skolereformen> [accessed 06.02.20]

Broome, B., 2015. Wilkes Elementary School by Mahlum Architects [online] Available at: <https://www.architecturalrecord.com/articles/7301-wilkes-elementary-school-by-mahlum-architects> [accessed 25.03.2020]

Bygningsreglementet, 2020. BR18. [online] Available at:<https://bygningsreglementet.dk/> [accessed 04.03.20]

Bygningsreglementet 18, 2020. Bilag 5 - Præ-accepterede løsninger - Undervisningslokaler. [pdf] Available through: <https://bygningsreglementet.dk/Tekniske-bestemmelser/05/Vejledninger/Generel_Brand/Undervisningslokaler> [accessed 16.03.20]

Böhme, G., 1998. Atmosphere as an Aesthetic Concept. Daidalos, Vol. 68, pp. 112-115

Børne- og undervisningsministeriet, 2020. [online] Timetal Available at: <https://www.uvm.dk/folkeskolen/fag-timetal-og-overgange/timetal> [accessed 28.02.20]

Børne- og undervisningsministeriet, 2019. Folkeskolens historie [online] Available at: <https://emu.dk/grundskole/uddannelsens-formal-og-historie/folkeskolens-historie> [accessed 06.02.20]

Børne- og undervisningsministeriet, 2019. Varieret undervisning: Bevægelse. [online] Available at: <https://emu.dk/grundskole/varieret-undervisning/bevaegelse> [accessed 26.02.20]

Bünger, T., 2016. Søndagsavisen [online] Her er Danmarks bedste folkeskole. Available at: <https://www.sondagsavisen.dk/familie-kaerlighed/2016-03-03-her-er-danmarks-bedste-skole/> [accessed 26.02.20]

Danmarks Statistik, 2019. [online] Store geografiske forskelle på uddannelsesniveau. Available at: <https://www.dst.dk/da/Statistik/nyt/NytHtml?cid=28988> [accessed 26.02.20]

Den Store Danske 1, 2017. [online] Guldborgsund Kommune. Available at: <http://denstoredanske.dk/Danmarks_geografi_og_historie/Danmarks_geografi/Danmarks_kommuner/Guldborgsund_Kommune> [accessed 26.02.20]

Den Store Danske 2, 2017. [online] Nykøbing Falster. Available at: <http://denstoredanske.dk/Danmarks_geografi_og_historie/Danmarks_geografi/Falster/Nykøbing_Falster> [accessed 26.02.20]

Center for Indeklima og Energi ved DTU, 2016. [pdf] Indeklima i skoler: WP 1.1. Available at: <https://realdania.dk/nyheder/arkiv/innovation-i-byggeriet/et-godt-indeklima/nyheder/fokus-paa-skolernes-indeklima> [accessed 06.02.20]

Center for Indeklima og Energi ved DTU, 2016. [pdf] Indeklima i skoler: WP 2.1. Available at: <https://realdania.dk/nyheder/arkiv/innovation-i-byggeriet/et-godt-indeklima/nyheder/fokus-paa-skolernes-indeklima> [accessed 06.02.20]

Corner, J. & Cosgove, D.E. (ed.) 1999. The Agency of mapping: Speculation, critique and invention. Reaktion, London, pp. 213-254

Dansk Arkitektur Center, 2017. Hvad er bæredygtighed. [pdf] Available at: <https://dac.dk/wp-content/up- loads/2017/10/Hvad-er-bæredygtighed.pdf> [accessed 24.02.20]

Det Classenske Fideicommis, nd. [online] Udstykningen Hamborgskoven. Available at: <https://corselitze.dk/udstykningen-hamborgskoven/ > [accessed 26.02.20]

DCUM, 2019. Fysisk og æstetisk undervisningsmiljø: Styrk det fysiske og æstetiske undervisningsmiljø. [online] Available at: <https://emu.dk/grundskole/undervisningsmiljo/fysisk-og-aestetisk-undervisningsmiljo/styrk-det-fysiske-og> [accessed 26.02.20]

DMI, 1999. [PDF] Observeret vindhastighed og -retning i Danmark - med klimanormaler 1961-90. p. 260-263 Available at: <https://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/1999/tr99-13.pdf> [accessed 26.02.20]

DMI 1, 2020. [online] Vind i Danmark. Available at: <https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/vind-i-danmark/> [accessed 26.02.20]

DMI 2, 2020. [online] Temperaturen i Danmark. Available at: <https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/temperaturen-i-danmark/> [accessed 26.02.20]

DMI 3, 2020. [online] Nedbør og sol i Danmark. Available at: <https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/nedboer-og-sol-i-danmark/> [accessed 26.02.20]

Doktor, T. 2019. Architecture, Health and Well Being, lecture series. Aalborg University, unpublished.
Eriksen, T., 2016. Sådan foretager man et litteraturstudie. [online] Scribbr. Available at:<https://www.scribbr.dk/struktur-i-din-afhandling/saadan-foretager-man-et-litteraturstudie/> [accessed 12.02.20]

Europa, 2019. Sustainable buildings for Europe's climate-neutral future. [online] Available at: <https://ec.europa.eu/easme/en/news/sustainable-buildings-europe-s-climate-neutral-future> [accessed 20.02.20]

European Commission, 2020. NZEB. [online] Available at: <https://ec.europa.eu/energy/en/content/nzeb-24> [accessed 04.03.20]

FOAS & LC, 2018. [PDF] Aftale - Om arbejdstid [...] Available at: <https://www.uddannelsesforbundet.dk/media/4875/aftale-om-arbejdstid-foas-s.pdf>

Fouad, A. T. Z. and Sailer, K. 2019. The Design of School Buildings: Potentiality of Informal Learning Spaces for Self-directed Learning. 12th Space Syntax Symposium, [e-journal] 164-1, 22. Available through: Scopus <https://www.scopus.com/record/display.uri?eid=2-s2.0-85071502439&origin=resultslist&sort=plf-f&src=s&st1=THE+DESIGN+OF+-SCHOOL++BUILDINGS+Potentiality+of+Informal+Learning+Spaces+for+Self-directed+Learning.&st2=&sid=727b-f476a630a75cc1a5aca8aa215f54&sot=b&sdt=b&sl=115&s=TITLE-ABS-KEY%28THE+DESIGN+OF+SCHOOL++BUIL-DINGS+Potentiality+of+Informal+Learning+Spaces+for+Self-directed+Learning.%29&relpos=0&citeCnt=0&searchTer-m=>[accessed 11.02.20]

Gelfand, L. & Freed, E. C., 2010. Sustainable School Architecture : Design for Elementary and Secondary Schools. Hoboken, N.J: John Wiley & Sons.

Gehl, J., 1971. Livet mellem husene. København: Arkitektens Forlag.

Gehl, J., 2010. Cities for People. Washington. D.C: Island Press.

Gitz-Johansen, T. et al., 2001. Samspil mellem børn og skolens fysiske ramme. Kbh: Rum, Form, Funktion.
Guldborgsund Kommune, 2020. [online] Tal og fakta. Available at: <https://www.guldborgsund.dk/da/Om_kommunen/Tal_og_fakta.aspx> [accessed 26.02.20]

Guldborgsund Kommune 1, 2019. [pdf] Lokalplan 193: ny skole i Sundby. Available at: <http://77.233.253.221/pdfs/guldborgsund/lokalplaner/versioner/193-2019-12-11-Lokalplan%20193%20ny%20skole%20i%20Sundby.pdf>

Guldborgsund Kommune 2, 2019. [pdf] Ny skole i Sundby: byggeprogram. Available at: <https://www.guldborgsund.dk/eDagsorden/committee_190887/agenda_385548/documents/552bda94-e45a-40a3-b4f4-53b190a69858.pdf?fbclid=IwAR1eVkOf2SZ5BAtGbvhaP3y1dPtuHIIYTHQCLUz3-eVntetsmSKCb0RSpok>

Guldborgsund Kommune 3, 2019. [online] Fideicommisset lægger jord til ny SUNDskole. Available at: <https://via.ritzau.dk/pressemeddelelse/fideicommisset-laegger-jord-til-ny-sundskole?publisherId=11287667&releaseId=13578470> [accessed 26.02.20]

Henning Larsen, 2017. Frederiksbjerg Skole. [online] Available at: <https://henninglarsen.com/da/projects/featured/1246-frederiksbjerg-school> [accessed 24.02.20]

JJW Arkitekter, 2015. Skolen i Sydhavnen. [online] Available at: <https://www.jjw.dk/projekt/sydhavnsskolen/> [accessed 24.02.20]

JJW Arkitekter, 2018. Grøndalsvængets Skole. [online] Available at: <http://www.jjw.dk/?projekt=grondalsvaengets-skole> [accessed 24.02.20]

Kirkeby, I. M., 2006. Skolen finder sted. Hørsholm: Statens Byggeforskningsinstitut.

Klimatilpasning 1, 2015. [online] Fremtidens hede- og varmebølger. Available at: <https://www.klimatilpasning.dk/viden-om/fremtidens-klima/klimaaendringeridanmark/ændringer-i-temperatur/fremtidens-hede-og-varmeboelger/> [accessed 26.02.20]

Klimatilpasning 2, 2015. [online] Ændringer i den kraftige nedbør. Available at: <https://www.klimatilpasning.dk/viden-om/fremtidens-klima/klimaaendringeridanmark/ændringer-i-nedboer/ændringer-i-den-kraftige-nedboer/> [accessed 26.02.20]

Knudstrup, M. A., 2004. Integrated Design Process in Problem-Based Learning: Integrated Design Process in PBL. i Kolmos, Anette : Fink, Flemming K. : Krogh, Lone (eds.) (red.), The Aalborg PBL Model : Progress, Diversity and Challenges. Aalborg Universitetsforlag, Aalborg, p. 221-234.

Kommunernes Landsforening, 2013. [pdf] Skolens fysiske rammer. Available at: <https://www.kl.dk/ImageVaultFiles/id_65455/cf_202/Skolens_fysiske_rammer.PDF/> [accessed 06.02.120]

Krieger, M. H., 2011. City in the Twenty-First Century: Urban Tomographies. Philadelphia, USA: University of Pennsylvania Press, 2011

Nanda, U., Pati, D., Ghamari, H. and Bajema, R. 2013. Lessons from neuroscience: form follows function, emotions follow form. Intelligent Buildings International [e-journal]. Available through: <https://www.scopus.com/record/ display.uri?eid=2-s2.0-84885181241&origin=resultslist&sort=plf-f&src=s&st1=Lessons+from+neuroscience%3a+-form+follows+-function%2c+emotions+follow+form&st2=&sid=6fdc729da6e363bf048a29826e2f66ec&sot=b&s- dt=b&sl=85&s=TITLE-ABS-KEY%28Lessons+from+neuroscience%3a+form+follows+function%2c+emotions+follow+form%29&relpos=0&citeCnt=9&searchTerm=> [Accessed 24.02.20]

Larsen, A. K., 2010. En enklere metode - Vejledning i samfundsvidenskabelig forskningsmetode. København: Professionsserien Akademisk Forlag

Lyall, T.W., 2018. Rekordmange fuldfører en ungdomsuddannelse [online] Available at: <https://www.altinget.dk/artikel/171472-rekordmange-fuldfoerer-en-ungdomsuddannelse> [accessed 06.02.20]

Marling, G., nd. Fænomenologi byanalyser, 2018. Skuespilhuset. [online] Available at: <http://www.byplanlab.dk/sites/default/files1/Faenomenologsheet281210.pdf> [accessed 14.02.20]

Matthews, E., et al. 2019. The design and evaluation of the Physical Environment of Young Children's Learning settings. [e-journal] Early Childhood Education jornal, Vol. 48-2, p. 171-180. Available through: <https://sfx.aub.aau.dk/sfxaub?sid=Elsevier:Scopus&_service_type=getFullTxt&issn=10823301&isbn=&volume=48&issue=2&spage=171&epage=180&pages=171-180&artnum=&date=2020&id=doi:10.1007%2fs10643-019-00993-x&title=Early+Childhood+Education+Journal&atitle=The+Design+and+Evaluation+of+the+Physical+Environment+of+Young+Children's+Learning+Settings&aufirst=E.&auinit=E.&auinit1=E&aulast=Matthews> [accessed 26.02.20]

Prince Ea, 2016. I SUED THE SCHOOL SYSTEM !!!. [video online] Available at: <https://www.youtube.com/watch?v=dqTTojTija8> [accessed 17.03.20]

Ploug, N., 2005. Social arv sammenfatning 2005. [pdf] Available at: <https://pure.vive.dk/ws/files/257353/0510_Social_arv_sammenfatning.pdf> [accessed 17.03.20]

Ravn, K., 2018. Fire år med reformen: Heller ikke trivselsmålingen viser fremgang [online] Available at: <https://www.folkeskolen.dk/647287/fire-aar-med-reformen-heller-ikke-trivselsmaalingen-viser-fremgang> [accessed 06.02.20]
Regeringen, 2013. Aftale mellem Regeringen, Venstre og Dansk Folkeparti om et fagligt løft af folkeskolen. [pdf]

Riise, A. B., et.al., 2018. Nationale test efter tre reform-år: Fortsat ingen fremgang [online] Available at: <https://www.folkeskolen.dk/644925/nationale-test-efter-tre-reform-aar-fortsat-ingen-fremgang> [accessed 06.02.20]

Skift-A-kasse, 2019. [online] Nye 2018-tal: Her var ledigheden højest og lavest i Danmark. Available at: <https://www.skift-a-kasse.dk/nye-2018-tal-her-var-ledigheden-hoejest-og-lavest-i-danmark/> [accessed 26.02.20]

Skole og Forældre, 2020. [online] Skoledagens længde Available at: <https://www.skole-foraeldre.dk/artikel/skoledagens-længde> [accessed 28.02.20]

Sonne, F. G. H., 2019. Byggeindustrien er en gigantisk byrde for klimaet: Hvordan gør vi den grønnere? [online] Available at: <https://videnskab.dk/naturvidenskab/byggeindustrien-er-en-gigantisk-byrde-for-klimaet-hvordan-goer-vi-den-groennere> [accessed 24.02.20]

Statens Byggeforskningsinstitut, 2018. Bygningers energibehov. [online] Available at: <https://sbi.dk/anvisninger/Pages/213-Bygningers-energibehov-6.aspx> [accessed 04.03.20]

Steinø, N. 2018. Architectural Drawing: Notation, Reflection, Communication and Presentation. I Representation: Process and Practice Across Design Disciplines (p. 129-135). American University. Aalborg Universitet. [PDF]

Sullivan, W., 2011. Mental Health and the Built Environment Making Healthy Places [e-journal] pp. 106-116. Available through: <https://www.researchgate.net/publication/284577164_Mental_Health_and_the_Built_Environment> [accessed 20.02.20]

Sundhedsstyrelsen, T., 2019. Danskernes sundhed [pdf] Sundhedsstyrelsen. Available at: <https://www.sst.dk/da/ udgivelser/2018/~/media/73EADC242CDB46BD8ABF9DE895A6132C.ashx> [Accessed 24.02.20]

SUNDskolen, 2019. [online] SFO Available at: <https://sundskolen.aula.dk/sfo> [accessed 28.02.20]

Sørensen, J., 2013. 1800-tallet: Folkeskolen bliver født [online] Available at: <https://www.dr.dk/ligetil/1800-tallet-folkeskolen-bliver-foedt> [accessed 06.02.20]

Taylor, A., 2009. Linking Architecture and Education: Sustainable Design of Learning Environments. University of New Mexico Press.

Tucker, R. and Izadpanahi P., 2017. Live green, think green: Sustainable school architecture and children's environmental attitudes and behaviors. Journal of Environmental Psychology , [e-journal] 51, pp. 209-216. Available through: Scopus <https://www.scopus.com/record/display.uri?eid=2-s2.0-85017226254&origin=resultslist&sort=plf-f&src=s&st1=Live+green%2c+think+green%3a+Sustainable+school+architecture+and+children%27s+environmental+attitudes+and+behaviors&st2=&sid=b3ab37bfbf8055491f404e4f0329dc3c&sot=b&sdt=b&sl=124&s=TITLE-ABS-KEY%28Live+green%2c+think+green%3a+Sustainable+school+architecture+and+children%27s+environmental+attitudes+and+behaviors%29&relpos=0&citeCnt=14&searchTerm= > [accessed 07.02.20]

Varieret undervisning: åben skole. [online] Available at: <https://emu.dk/grundskole/varieret-undervisning/aben-skole> [accessed 26.02.20]

Viden til velfærd, 2018. [online] Her bor de udsatte børn og unge i Danmark. Available at: <https://www.vive.dk/da/nyheder/2018/her-bor-de-udsatte-boern-og-unge-i-danmark/ > [accessed 11.02.20]

Videncenter for Energibesparelser i Bygninger, 2018. Energikravene i BR18. En kvikguide til byggefagfolk om Bygningsreglementet 2018. [pdf] Available at: <https://www.byggeriogenergi.dk/media/2236/br18_kvikguide_juli18.pdf> [accessed 16.03.20]

Viltoft, K., 2017. [pdf] Skolebogen: JJW Arkitekters erfaringer med skoler. Available at: <https://www.jjw.dk/?publikation=skolebogen> [accessed 06.02.20]

Whyte, W. H., 2010. The social life of small urban spaces . 7. printing. New York: Project for Public Spaces.
Ågard, D., 2014. Motiverende relationer. Faculty of Arts, Aarhus Universitet. [pdf] Available at: <https://www.gymnasieforskning.dk/wp-content/uploads/2016/09/Dorte-Agard-ph.d.-afhandling-2-014-Motiverende-relationer.pdf> [accessed 12.02.20]

Ågard, D., 2014. Motiverende relationer. Faculty of Arts, Aarhus Universitet. [pdf] Available at: <https://www.gymnasieforskning.dk/wp-content/uploads/2016/09/Dorte-Agard-ph.d.-afhandling-2-014-Motiverende-relationer.pdf> [accessed 12.02.20]

INTERVIEWS

Anonymous 1, 2020. Anonymous 1: Pre-preparatory class. Interview by Jensen, C. [interview] Sundskolen, Nykøbing Falster, 20.02.20.

Anonymous 2, 2020. Anonymous 2: Lower secondary education. Interview by Jensen, C. [interview] Sundskolen, Nykøbing Falster, 20.02.20.

Anonymous 3, 2020. Anonymous 3: Teacher. Interview by Jensen, C. [interview] Sundskolen, Nykøbing Falster, 20.02.20.

Anonymous 4, 2020. Anonymous 4: Teacher. Interview by Jensen, C. [interview] Sundskolen, Nykøbing Falster, 20.02.20.

FIGURES

Figures, illustrations or photographs which are not mentioned in this list, is self produced.

29. DMI, 1999. [PDF] Observeret vindhastighed og -retning i Danmark - med klimanormaler 1961-90. p. 260-263 Available at: <https://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/1999/tr99-13.pdf>

30. DMI 2, 2020. [online] Temperaturen i Danmark. Available at: <https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/temperaturen-i-danmark/> [accessed 26.02.20]

31. DMI 3, 2020. [online] Nedbør og sol i Danmark. Available at: <https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/nedboer-og-sol-i-danmark/> [accessed 26.02.20]

52. Tucker, R. and Izadpanahi P., 2017. Live green, think green: Sustainable school architecture and children's environmental attitudes and behaviors. Journal of Environmental Psychology , [e-journal] 51, pp. 209-216. Available through: Scopus <https://www.scopus.com/record/display.uri?eid=2-s2.0-85017226254&origin=resultslist&sort=plf-f&src=s&st1=Live+green%2c+think+green%3a+Sustainable+school+architecture+and+children%27s+environmental+attitudes+and+behaviors&st2=&sid=b3ab37bfbf8055491f404e4f0329dc3c&sot=b&sdt=b&sl=124&s=TITLE-ABS-KEY%28Live+green%2c+think+green%3a+Sustainable+school+architecture+and+children%27s+environmental+attitudes+and+behaviors%29&relpos=0&citeCnt=14&searchTerm=> [accessed 07.02.20]

72. Virklund Sport, Frederiksbjerg School / Henning Larsen Architects + GPP Architects [Online] Available at: https://www.archdaily.com/799521/frederiksbjerg-school-henning-larsen-architects-plus-gpp-architects/582bf8bae58ece6ce80000a4-frederiksbjerg-school-henning-larsen-architects-plus-gpp-architects-photo

73. Eskerod, T., Ama'r Children's Culture House / Dorte Mandrup [Online] Available at: https://www.archdaily.com/388629/ama-r-children-s-culture-house-dorte-mandrup/51ba8343b3fc4b7669000001e_ama-r-children-s-culture-house-dorte-mandrup_281_dma_12_te-jpg/

74. Studio Bauhaus, AN Kindergarten / HIBINOSEKKEI + Youji no Shiro [Online] Available at: https://www.archdaily.com/781271/an-kindergarten-hibinosekkei-plus-youji-no-shiro/56ac1783e58ecefad30003b4-an-kindergarten-hibinosekkei-plus-youji-no-shiro-photo

75. Nisim, T., King Solomon Elementary School [Online] Available at: https://shanihay.com/public-spaces/198

76. Yeran Architectural Photography, Tianjin Luneng Taishan College / Lacime Architectural Design [Online] Available at: https://www.archdaily.com/868965/tianjin-luneng-taishan-college-lacime-architectural-design/58eb3326e58ecebb93000280-tianjin-luneng-taishan-college-lacime-architectural-design-photo

77. Buschmann, A., Oeschger Schermesser Architekten - Chavully school [Online] Available at: https://www.subtilitas.site/post/183456451619/oeschger-schermesser-architekten-chavully

78. Ikimono Architects, Ikimono Architects divides areas of this japanese house using a wooden grid [Online] Available at: https://www.designboom.com/architecture/ikimono-architects-japan-house-wooden-grid-08-15-2019/?utm_source=designboom+daily&utm_medium=email&utm_campaign=ikimono+architects+divides

79. Liebchen, J., Haus der Kulturen der Welt [Online] Available at: https://housingvillage.wordpress.com/inspiration-2/atelier-bow-wow-urban-forest-2015-1-1-model-photo-jens-liebchen-_-haus-der-kulturen-der-welt-958×559/

80. Woods, J., California State University Dominguez Hills Leo F Cain Library [Online] Available at: https://thespaces.com/tour-the-concrete-landmarks-of-los-angeles/7/

81. Fluedity Design, Eskenazi Health- Healing Waters Indianapolis [Online] Available at: http://www.fluidity-design.com/projects/wishard-memorial-hospital-healing-waters/

82. Pelosi, C., Thistle Foundation Centre of Wellbeing [Online] Available at: https://www.civictrustawards.org.uk/benet/schemes/thistle-foundation-centre-of-wellbeing

83. Playpoint Singapore Pte Ltd [Online] Available at: http://playpoint.asia/projects/punggol-brooks/

84. Richters, C., One Up Two Down / Mccullough Mulvin Architects [Online] Available at: https://www.archdaily.com/871681/one-up-two-down-mccullough-mulvin-architects/591e417be58ecef317000293-one-up-two-down-mccullough-mulvin-architects-photo?next_project=no

85. Hendriks, J., Coöperatie Dakwaarde pergola zonnepanelen [Online] Available at: https://twitter.com/dakwaarde/status/490118866471616512

86. ELBE&FLUT, Der Grasbrookpark am Tag der Eröffnung [Online] Available at: https://www.hafencity.com/de/news/-555-leinen-los-555-fuer-den-grasbrookpark.html

87. JBristolDesigns, Stump Path [Online] Available at: https://www.etsy.com/dk-en/listing/85381138/stump-path?ref=anchored_listing

88. Net zero guide, Renewable Energy project at Rim Of The World High School in Lake Arrowhead California [Online] Available at: http://netzeroguide.com/wind-generator-motor/

93. Arkitekten 1, 2020. Frederiksbjerg Skole [online] Available at: <https://arkitektforeningen.dk/arkitekten/frederiksbjerg-skole/> [accessed 06.05.20]

97. JJW Arkitekter, 2020. Skolen i Sydhavnen [online] Available at: <https://www.jjw.dk/?projekt=sydhavnsskolen> [accessed 06.05.20]

101. Arkitekten 2, 2020. Grøndalsvænget Skole: Skoleeksempel [online] Available at: <https://arkitektforeningen.dk/arkitekten/groendalsvaenget-skole-skoleeksempel/>
[accessed 06.05.20]

102. Bittermann, J., Wilkes Elementary School ~ Mahlum Architects [online] Available at: http://www.bittermann-photography.com/projects/wilkes-elementary-school-mahlum-architects/ [accessed 25.03.2020]

103. Speewest Construction, Wilkes Elementary School [online] Available at: https://www.speewest.com/projects/wilkes-elementary-school [accessed 25.03.2020]

104. Bittermann, J., Wilkes Elementary School ~ Mahlum Architects [online] Available at: http://www.bittermann-photography.com/projects/wilkes-elementary-school-mahlum-architects/ [accessed 25.03.2020]

105. Mahlum Architects, 2020. Wilkes Elementary School by Mahlum Architects [online] Available at: https://www.architecturalrecord.com/articles/7301-wilkes-elementary-school-by-mahlum-architects
[accessed 06.05.20]

166. Aslaksen, E., 2020. Stairway to heaven wood architecture. [online] Available at: <https://www.dwell.com/article/stairway-to-heaven-wood-arkitektur-f57a066a> [Accessed 11.04.20]

167. Ashley Home, 2019. In addition to the burnt wood siding, this modern house also makes use of recycl... [online] Available at: <https://ashley.camasirmakinesi.net/in-addition-to-the-burnt-wood-siding-this-modern-house-also-makes-use-of-recycl/> [Accessed 11.04.20]

168. Ikimono architects, 2020. Ikimono architects divides areas of this japanese house using a wooden grid. [online] Available at: <https://www.designboom.com/architecture/ikimono-architects-japan-house-wooden-grid-08-15-2019/?utm_source=designboom+daily&utm_medium=email&utm_campaign=ikimono+architects+divides> [Accessed 11.04.20]

169. Wieblen, D., nd. Bao Bao - Linehouse. [online] Available at: <https://www.archdaily.com/790710/baobao-line-house/5779dd14e58ece2f88000276-baobao-linehouse-photo> [Accessed 11.04.20]

170. Cobe Limeil, 2012. [online] Available at: <https://www.flickr.com/photos/labanq/9575923163/in/photostream> [Accessed 11.04.20]

171. Designboom, 2020. Brazil pavilion at expo milan 2015 is defined by tensile netted structure. [online] Available at: <https://www.designboom.com/architecture/brazil-pavilion-expo-milan-2015-studio-arthur-casas-05-04-2015/?utm_campaign=daily&utm_medium=e-mail&utm_source=subscribers> [Accessed 11.04.20]