



Høje Taastrup Children's and Culture Centre. Photos: Martin Schubert.

The research speaks for itself: The indoor climate, layout and design of schools is more important for students' wellbeing and learning than previously thought.

In this book, we've compiled knowledge, insights, inspiration and the latest trends on the indoor climate in **the healthy school buildings of the future.**



Healthy indoor climate in schools

Indoor climate in schools: Enhancing wellbeing and learning

It's encouraging that the importance of the physical environment for students' learning and wellbeing is receiving increasing attention. However, both researchers and architects point out that we should give far greater priority to the indoor climate – both when building new schools and renovating existing ones.

Although we know that fresh air, daylight and good acoustics are important for children's wellbeing and learning, the indoor climate in schools is often still regarded as something that needs to be dealt with technically – rather than as part of the educational toolbox. But a shift is underway – such as in Denmark's second-largest city, Aarhus, which **trained its first team of indoor climate ambassadors in 2024**.

The ambassadors were selected from among teachers, educators and managers who have undergone training with the aim of not only improving air quality or installing noise-reducing curtains but also of integrating the indoor climate into their daily educational work.

Because when classrooms are designed with a focus on tranquillity, light and opportunities for concentration, it doesn't just create a better indoor climate, it creates a better school. The project in Aarhus shows that even minor changes to the physical environment can enhance concentration, a sense of community and professional development.

Four elements of a good indoor climate

Although there is a shift in understanding the importance of the indoor climate for learning and wellbeing, many schools still have problems with their indoor climate. According to the Danish Industry Guidelines for indoor climate calculations from the Danish Building Research Institute (SBI), the indoor climate comprises the following:

- **Thermal indoor climate:** The factors that influence a person's perception of heat or cold, both for the whole body and for specific body parts. This includes air temperature, velocity, humidity and surface temperatures within the space.
- **Atmospheric indoor climate:** Concerns the air quality in a room, including the presence of pollutants such as CO₂, humidity and odours.
- **Visual indoor climate:** Covers aspects such as the level of lighting, quality of light, amount of daylight, visibility, glare and artificial lighting.
- **Acoustic indoor climate:** Deals with how sounds and noise affect a person's ability to concentrate.

In relation to the acoustic indoor climate, numerous studies have shown how high noise levels and poor acoustics in classrooms have a negative impact on students' learning ability and behaviour. Research has shown that students in noisy classrooms achieve poorer results in reading, spelling and similar tasks.

A better indoor climate starts here

The benefits of addressing these challenges are significant – both in terms of improved learning and, equally importantly, improved wellbeing among students and teachers.

The good news is that we know what the most important tools are for significantly improving the indoor climate. We have compiled them for you in this publication, where you can also find plenty of inspiration from other European school buildings.

Happy reading!

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Chapter 1 Challenges: These factors affect the indoor climate

Today, there is a widespread understanding that the indoor climate plays an important role in students' learning and wellbeing. Following is some insight into research in this field.



Skovbakke School, Odder, Denmark. Photos: Adam Mørk.

Researchers from the HEAD project (Holistic Evidence and Design) at the University of Salford behind collected data from 153 classrooms across 27 different schools in Blackpool, Ealing and Hampshire in England in the years leading up to 2015 (Barrett et al., 2015). In total, 3,766 students participated and they were measured, surveyed and observed to determine how various design parameters in their classrooms impacted their learning in reading, writing and maths.

The study is still one of the largest and most comprehensive studies conducted to determine how the physical environment in schools affects students' learning.

The main conclusion of the project (summarised in the report '**Clever Classrooms**') is clear:

"The most important finding (...) is that there is clear evidence that the physical characteristics of primary and lower secondary schools affect students' learning progress in reading, writing and maths. This impact is quite significant and accounts for 16 per cent of the variation in overall progress over one year for the 3,766 students included in the study."

In other words: Sixteen per cent of students' learning outcomes are attributable neither to teachers nor teaching materials but solely to the design of their classrooms. The researchers estimated that moving a student from the least effective classroom to the most effective would raise their learning level by 1.3 – which is quite a significant increase when you consider that the average student typically moves up two learning levels in a year.

Acoustic indoor climate: Noise affects short-term memory

There is now solid research documenting the negative effects of noise and poor acoustics on wellbeing and learning at school. In a **literature review from 2013**, the authors reviewed existing research in the field and concluded that 'children were far more affected than adults by noise in tasks that

require speech perception and listening comprehension' (Klatte, Bergström, and Lachmann, 2013). In other words, children find it harder to 'filter out' unnecessary sounds in a noisy environment.

The study also pointed out that noise affects 'non-auditory' tasks, such as short-term memory, reading and writing skills.

This is confirmed by a **British study from 2008**, in which the researchers tested 158 students' ability to solve tasks under 1) a normal noise level; 2) a talking/chatting level; and finally 3) a talking/chatting level with background noise, respectively (Shield and Dockrell, 2008). Not surprisingly, the study showed that students got significantly fewer correct answers in spelling and maths tasks in environments where there was chatter and background ambient noise.

The same British study also examined the effect of noise on students with special needs. The conclusion was that "children with special educational needs proved to be more susceptible to the effects of noise in the classroom during verbal tasks than other children."

In other words, the negative effects of noise and poor acoustics affected students with special needs severely hard. Conversely, this also means that measures to improve acoustics in schools benefit both students with special needs and everyone else.

Visual and thermal indoor climate: Just right

When it comes to the visual and thermal indoor climate – i.e. the importance of light and temperature for students' wellbeing and learning – broadly speaking, it is a matter of finding the right balance.

Daylight in the classroom is healthy and improves academic performance. However, especially in northern European latitudes, many lessons are held while it is dark outside. Consequently, artificial light sources are a particularly important supplement in these regions.



Sluseholmen School, Copenhagen
Photos: Helene Høyer Mikkelsen, architect MAA.



White or neutral-coloured ceilings and walls enhance both natural and artificial lighting conditions. This is because light colours reflect light more effectively. White walls and ceilings also allow indirect lighting, which has a positive effect on students' academic performance.

In the HEAD project, researchers found that the optimal lighting in classrooms was ample natural daylight supplemented by effective artificial lighting. Classrooms with large windows are therefore preferable, provided that the sunlight does not cause glare for the students. This is supported by a 2009 American study, which documented in 71 primary schools that good lighting (from natural and artificial sources) had a positive effect on students' reading vocabulary and results in science subjects.

The same applies to the classroom temperature. Students perform better when there is both fresh air and a reasonable temperature in the classroom. Researchers agree. Nevertheless, the air is too stuffy in many schools.

A previous British study conducted by the country's teacher association showed that in 5 per cent of classrooms, the temperature exceeded 30 °C. In a 2007 study, students reported greater discomfort and their performance and task completion deteriorated because their ability to concentrate declined. The researchers' general recommendation was therefore that cooler temperatures are best for students' learning efficiency (Wargocki and Wyon, 2007).

**Atmospheric indoor climate:
Poor air quality after just 26 minutes**

The air we breathe can affect our performance, wellbeing and health. Sixty per cent of acute respiratory infections in children is caused by environmental factors in their surroundings. This is highlighted by American research from the **National Institute of Environmental Health Sciences and Environmental Protection Agency**.

In the HEAD project, researchers do not point to a single culprit when it comes to influencing students' learning but say that light, temperature and air quality alone account for half of the effect.

Specifically, the researchers measured the air quality in a number of classrooms of various sizes. In the smallest classrooms without ventilation and with 30 students, the CO₂ level exceeded the limit value (over 1,000 ppm) after just 26 minutes. In the largest classrooms, the limit value was only exceeded after 55 minutes. The researchers added that air quality in many classrooms has been challenged in recent years due to energy efficiency requirements, which means that windows cannot or must not be opened.



Understanding the impact of sound in schools

Noise and acoustics have a significant impact on students' learning as well as on teachers' working environment. If you clap your hands in a classroom with good acoustics, the sound should fade out faster than you can say "reverberation time".

Students shouting, rattling chairs, clicking pens, rummaging around after their lunch box, dropping books on the floor or interrupting each other and the teacher. On a normal school day, the ambient noise level in the classroom is high.

It's no doubt obvious to most people that it can be hard for students to learn new things if they're struggling to hear what the teacher is saying. However, according to a [methodology handbook from the Danish Centre for the Educational Environment \(DCUM\)](#) (link to a Danish text), the conclusion is that noise not only affects hearing, it also affects attention, memory and decision-making abilities. The explanation is that when a student fails to hear what's being said at the front of the class, they will unconsciously guess what the teacher is trying to say.

Different kinds of noise

There is therefore every reason to pay attention to a school's acoustic environment and how it can be improved to create a teaching environment that promotes both learning and wellbeing. To understand how this is done, let's first take a closer look at what causes noise in classrooms. This has been investigated by the researchers behind the 'Clever Classrooms' report from the University of Salford.

According to the report, noise in the classroom can be divided into two categories: external noise and internal noise.

External noise is, for example, disturbing noise from a busy road, a communal area or the playground in the schoolyard. This

type of noise can be reduced or avoided if the architect focuses on the impact of the surrounding environment during the design phase of a new school. In other cases, such as school renovations, external noise can be ameliorated by situating corridors, storage rooms or toilets between the source of noise and the classroom.

Internal noise includes both airborne sound generated in the classroom and sounds transmitted from the building itself, for example, from an active HVAC system. Airborne sounds from a rattling chair, a slamming door or speech can be perceived either positively (as just sound) or negatively (as noise). All airborne sounds are reflected from walls and ceilings, and most of the sound that teachers and students hear is reflective. It is therefore crucial that the reverberation time in the classroom is low – so that the sound quickly 'dies out' in the room.

Short reverberation time

For the same reason, authorities in most northern European countries have established legal requirements or recommendations for reverberation times in schools. In Denmark, for example, the requirement is 0.6 seconds in classrooms and 0.4 seconds in rooms for group work. In rooms with ceilings higher than four metres, the sound-absorbing area must be larger than the floor area.

0.6 seconds will typically require a very good sound absorber on the entire ceiling surface and, in rooms with stricter requirements, additional sound absorption may be required.



The Roman Baths and Pump Room, Bath, UK. Photos: James Newton.

Basic concepts of acoustics

Sound and noise

Sound is compression waves that travel through the air. We normally distinguish between sound and noise. We call pleasant, ordered waves sound but categorise chaotic and obtrusive waves as noise.

Frequency

Frequency is an expression of how many times a sound wave oscillates per second. Frequency is measured in hertz (Hz). 100 Hz corresponds to 100 oscillations per second. The frequency of bass sounds is low, while that of treble sounds is high.

Sound pressure

Sound intensity is described using decibel (dB) units. The higher the sound pressure, the higher the decibel value.

If dB measurements are to be comparable, they must be made at the same distance from the sound source.

Reverberation time

Reverberation time is the time it takes for a sound in a room to fade out. In scientific terms, it is the time in seconds it takes for the sound level to drop by 60 dB after the sound source has ceased.

Sound absorption

Short reverberation times can be achieved by using materials which are good at absorbing sound. This property can be described using an absorption coefficient – indicated by the Greek letter α (alpha).

Speech intelligibility

If a room has a long reverberation time, spoken words will not fade out before the next words reach the listener. The result is poor speech intelligibility where it becomes difficult for the listener to understand what is being said. However, if the sound is absorbed with a short reverberation time, there is good acoustics and a high level of speech intelligibility.





Chapter 2 Solutions

How to create better schools

Builders and consultants must do their due diligence and design schools where they balance acoustics, air quality, lighting, design, durability and economy to ensure a healthy, integrated environment. In this regard, it makes sense to choose solutions that solve several indoor climate challenges all at once.



Indoor climate in schools: The most important and latest trends in school construction

There is a growing understanding of the importance of the indoor climate for wellbeing and learning in schools. Here, two experts, Britta Hjuler from Pluskontoret Arkitekter A/S and Klaudio Muca from CEBRA architecture, share their views on the most significant trends in school construction.

Architect MAA Britta Hjuler and her colleagues at Pluskontoret Arkitekter A/S have gained solid experience in both developing and designing learning environments for the future – and award-winning ones at that. The company has acted as a client consultant for award-winning schools such as Frederiksbjerg School in Aarhus and **Erlev School in Haderslev**. As the lead consulting architect, Pluskontoret is currently designing the Hejnsvig School for Playful Learning and transforming the heritage-listed Skovvang School in Aarhus by reimagining its original architecture into new, varied learning environments.

Britta Hjuler has been involved in this area for a number of years and has seen attitudes towards school construction slowly change – **not least during the coronavirus pandemic**:

"Progress in developing the traditional classroom is still slow. However, we are seeing a growing need to find new solutions that support children's wellbeing, new learning spaces that facilitate differentiation, team teaching and co-teaching. And this is necessary because we have a responsibility to develop school buildings that support the new generations of children," she says.

But whereas the coronavirus pandemic forced schools to rethink how they organise teaching and a new reality has now emerged: "Schools are under financial pressure. You can sense that resources are limited," she explains, adding that this is not least due to rising costs for students which require provisions for special education.



Portrait: Britta Hjuler

- Partner at Pluskontoret Arkitekter.
- Specialist in learning environments and translating educational principles into architecture.
- Experienced client consultant and process manager within institutional and school construction.
- Professional focus areas: User involvement, sustainability and learning spaces.



Portrait: Klaudio Muca

- R&D Architect at CEBRA, specialist in neuroarchitecture and learning environments.
- Editor of The WISE Journal and international speaker.
- Professional focus areas: User involvement, educational architecture and digital innovation.

Trend #1:

Schools must find solutions to address the growth in special needs education.

A Danish report from 2023 showed that one in four kroner spent on Danish primary and lower secondary schools is now spent on special educational needs. Or to put it another way: Approximately 25 per cent of the budget is spent on just over 6 per cent of students.

Here, Britta Hjuler warns that schools may end up in a 'vicious circle' where more and more students are referred to resource-intensive special programmes without addressing the reason why the students are not thriving in regular classes. According to Britta Hjuler, an increased focus on the indoor climate can play a role:

“We humans thrive much better when we are consciously stimulated.

"The indoor climate is one of the factors that determines whether children with special needs can be accommodated or not. It's about whether you can thrive," she explains, adding, "the indoor climate is about light, air, temperature and acoustics. Acoustics and the

tactility of materials (that they are warm and pleasant to touch) are particularly important factors that are not always given sufficient weight.

"Does the interior design and choice of materials support the intended learning activities? Does it support the children's wellbeing and have the adults taken ownership by making it cosy?" she says.





Kildemosen Childcare Institution in Kolding, Denmark
Photos: Helene Høyer Mikkelsen, architect

Trend #2:

Focus on architecture
that promotes wellbeing

The importance of interior design for wellbeing is a recurring theme at CEBRA Architecture, where R&D Architect Klaudio Muca is researching what has been termed 'neuroarchitecture' – an approach that uses insights from brain science to create better buildings.

"When we as humans are consciously stimulated, we thrive much better. Therefore, in the long run, it's a better investment to design buildings more consciously, taking into account how architecture affects us as humans – including through our sensory apparatus" says Klaudio Muca, R&D architect at CEBRA.

He and his colleagues therefore systematically look at how the intangible aspects of a building – such as light, sound, air, temperatures and social interactions – can affect users' wellbeing and experience. For this reason, Klaudio Muca and CEBRA work with the concept of 'wellbeing per square metre', aiming, where possible, to design buildings that cater to both different personalities and learning styles.

A good example of such a building is the Skovbakke School in Odder (Denmark), designed by CEBRA. The school's new building consists of four staggered sections that join together in a large common space, where acoustics were a key challenge due to high ceilings and dramatic angles. Their solution was to specify white Troldekt acoustic panels, which ensure quiet acoustics in the common areas. This creates a balanced atmosphere where both teaching and play

“ Research shows that a weekly outdoor school day does not negatively impact academic performance.



Erlev School. Thomas Mølvig, architect.

can unfold naturally within the many dynamic spaces and open areas.

Trend #3:

The indoor climate can also extend to the outdoors

Britta Hjuler points to another trend, which gained momentum during the coronavirus pandemic, where schools are thinking creatively when it comes to increasing wellbeing and improving the indoor climate. "At Ravnbakke School in the town of Nye north of Aarhus (Denmark), where we act as client consultant, their aim is to teach outdoors one day a week. As one specialist consultant and nature guide put it, 'the best indoor climate is outdoors', because it's healthy to spend a lot of time outside. Research shows that a weekly outdoor school day does not negatively impact academic performance. In fact, the research shows that outdoor teaching can help to increase children's motivation," she says.

Klaudio Muca also recognises that nature and outdoor life can play a greater and positive role in school construction and renovation projects. One approach taken by Muca and the other architects at CEBRA is to work with 'biophilic design', which seeks to connect a building's occupants more closely to nature by incorporating natural elements and processes into the building environment. This can include the use of natural materials, such as wood and stone, incorporating plants, water features and maximising natural light. The aim is to improve wellbeing and productivity by creating a visually stimulating and restorative environment.

He comments, "Incorporating nature into construction is not just about having plants and views of the greenery outside. It's also linked to our history as hunter-gatherers in the wild. It's about creating places where you feel safe and sheltered, while still providing good visibility."



Hulahoppen Childcare Institution in Vojens. Photos: Helene Høyer Mikkelsen, architect MAA

Trend #4:

Focus on the low-hanging fruit

Even though budgets are tight, Britta Hjuler urges schools not to neglect the indoor climate. There is still low-hanging fruit that can improve the indoor climate:

"I would recommend focusing on acoustic regulations and lighting," she says, citing Frederiksbjerg School in Aarhus (Denmark), as an example, which conducted a trial with pendant lighting in teaching spaces in 2017.

The trial, which involved researchers from the Royal Danish Academy of Fine Arts' School of Architecture, the Technical University of Denmark, Aarhus University and architects from Henning Larsen Architects, yielded surprising results by switching from general ceiling lighting to focused task lighting from pendants.

By creating focused lighting over the work surfaces, a more intimate space was apparently created, where children felt less need to raise their voices. The students worked in pairs and when the pendants above the tables were switched on, noise levels were up to six decibels lower than

when the general ceiling lighting was on. "This is a significant reduction and shows that there is potential in working with differentiated lighting, which many schools can benefit from," says Britta Hjuler.

Klaudio Muca agrees that schools can achieve much by consciously using both ceiling height and lighting. He refers to the research indicating that brain research shows how ceiling height can affect creativity.

“Roughly speaking, we become more creative with higher ceilings, while we become more practical and grounded with lower ceiling heights.

The same is true of light: "Research into light quality shows that it's not always about maximising the amount of light entering the building. German studies have shown that a slightly darker and smaller room can promote creativity because you feel less monitored and exposed," explains Klaudio.

Transforming school buildings: Schools are getting better at utilising existing spaces

An increasing number of clients aim to preserve as much of the original school as possible, instead of automatically building something new. This is the assessment of an award-winning architect specialising in school construction, who also points out that the new approach places demands not least on the architects themselves.

Kathrine Hegner Stærmose, an architect and partner at the architectural firm AART, together with the rest of the team, entered the competition for **School Building of the Year 2022 for Vrå Children's and Culture Centre in Hjørring Municipality, Denmark**. It is a unique project that will function as a school, cultural and civic centre as well as a library – and one with sky-high sustainability ambitions.

Even though Kathrine Hegner Stærmose has experienced all the opportunities that come

from conceiving a project from scratch, she is increasingly experiencing a different movement in school construction:

"The major trend right now – and this applies not only to school construction, but to construction in general – is the reuse of existing buildings. We see a lot of school renovations and school master plans that aim to utilise what they already have. In other words, how do we renovate and modernise the existing building stock to meet the new requirements for learning environments?"



Vrå School and Kindergarten. Photos: Thomas Mølvig, architect MAA

She adds that an approach could also involve adding extensions to schools that offer new dimensions to the learning environment.

Why has this desire become more widespread among clients?

"I think it's actually a combination of, on the one hand, a desire to be more environmentally conscious and energy-efficient and on the other, a sense of financial prudence. That you may be more cautious with your money and want to make sure you spend it wisely. So you don't just tear down an entire school because it simply had the wrong classroom size or lacked a common area and group rooms. We at AART think this is much more careful and sensible," says Hegner Stærmose.

What demands and challenges do these new expectations present to you as architects?

"Well, it's a completely different task altogether. When building a brand new school, a space allocation plan is typically drawn up

with wants and needs and then we have to design it from scratch and come up with the right concept. With the second type of project, it's about clarifying what the existing building can achieve. We literally have to go out and open doors to find out what's in all of the spaces. This is because the way in which schools use all their spaces is rarely mapped out and optimised so you should take a much more curious approach to it," she says.

She adds that school transformations typically require more user dialogue.

"A project like this can take place in stages, so the change is more subtle," she says.

What are the advantages of such projects?

"There is a whole host of qualities, including architectural ones, that provide a very interesting foundation to build upon. There are many great schools all over the country with different characteristics and high-quality materials. We have a lot of beautiful brick



Vrå School and Kindergarten. Photos: Thomas Mølvig, architect MAA



Portrait: Kathrine Hegner Stærmose

- Kathrine Hegner Stærmose, Architect and Partner at AART Architects.
- Over 12 years' experience at AART, where she specialises in architecture as a driver of social change.
- AART is a Scandinavian, full-service architectural firm.
- Professional focus areas: Sustainability, user involvement, universal design and social inclusion.

schools that are very robust but which are outdated when it comes to requirements for things like daylight and the indoor climate" she says.

Can you give some examples of how you are able to work with existing structures?

"I have great colleagues who are working on some incredibly exciting projects involving the redesign of existing classrooms. This could involve places where students can sit in window seats, on lockers, lie down or sit at a high table. But it can also be about alternating between sheltered and more open seating," she says, adding that it's also about looking at what the possibilities are in the corridors and outdoor areas.

LCA has become a basic requirement

Hegner Stærmose also points out that Life Cycle Assessment (LCA) have become an integral part of school construction.

"Throughout the entire process, we need to keep an eye on our carbon emissions in both the construction and operational phases, so that in all the decisions we make, there is an extra balance sheet to keep track of," she says.

And life cycle considerations also often favour the aforementioned focus on preserving existing structures.

"Admittedly, it's not a school building, but in another excellent project we worked on, we meticulously assessed every element of the existing structure and creatively explored how to repurpose its materials. For example, the ceiling panels, some of which can be turned into acoustic panels that hang from the ceiling. Or light fixtures, where some of the original manufacturers take them back, clean and refurbish them so that they can be reused," she explains.

Hegner Stærmose sees another trend related to the demand for Life Cycle Assessment:

"All tender documents state 'natural, robust materials and surfaces'. The idea of robustness has been around for a long time but what's new is the desire for natural materials," she says, explaining that naturalness can refer to not just biogenic materials but also just using plants and greenery indoors and outside.

Away from "themed-based schools" in favour of indoor climate and wellbeing

Hegner Stærmose generally sees a welcome move away from the "theme-based school buildings" of the past in favour of one more focused on wellbeing, indoor climate and learning.

"There is a lot of focus on how we can positively influence students and teachers, instead of building a star-shaped or circular school with a large communal space," she says.

How Trolldtekt contributes to a better indoor climate in schools

Good acoustics, documented material health and a suitable choice for sports halls and swimming pools. Read on to learn how Trolldtekt can make a difference in the various elements of a good indoor climate.

For over half a century, Trolldtekt acoustic ceilings have been a popular choice for school buildings. First in Denmark but now also in Germany, Sweden, Norway, the UK and across other countries. The ceilings make it possible to address several indoor climate considerations simultaneously, thereby creating better conditions for students' learning as well as for the school's infrastructure and operating economy.

Acoustic indoor climate:

Quiet enough to hear what's being said

Hard, smooth surfaces such as concrete, glass and plaster produce long reverberation times because the sound is reflected many times before it dissipates.

On the other hand, ceilings and wall surfaces with an open surface structure – such as Trolldtekt acoustic panels – cause sound to fade out quickly. This results in a short reverberation time and therefore excellent acoustics. While a concrete ceiling absorbs only 1–2 per cent of sound, a Trolldtekt ceiling, depending on the structure, can typically absorb up to 80–90 per cent.

This optimal effect is achieved by mounting the acoustic ceiling 200–300 mm below the original ceiling and by using Trolldtekt acoustic panels with a mineral wool backing. If you choose the Trolldtekt Plus acoustic panel variant, you get a two-layer acoustic panel consisting of a Trolldtekt cement-bonded wood wool panel with a laminated backing

layer. The backing layer is either a thin acoustic fleece or a layer of sealed mineral wool. Because Trolldtekt Plus consists of both an acoustic panel and a backing layer, both are mounted in one and the same workflow. This gives enhanced acoustics and saves time on the building site.

Trolldtekt Plus acoustic panels also provide high sound absorption in the low frequencies, which helps to ensure good speech intelligibility – a parameter that is particularly important in schools.

Atmospheric indoor climate:

Free of harmful chemicals

Trolldtekt acoustic panels have achieved the international certification Cradle to Cradle Certified® at gold level. One of the certification's categories is Material Health, meaning that the ingredients in Trolldtekt cement-bonded wood wool have been thoroughly analysed. The analysis documents that Trolldtekt does not contain substances that are harmful to humans or the environment. Cradle to Cradle Certified also assesses the ingredients in relation to later life cycle phases and documents that Trolldtekt cement-bonded wood wool can enter a biological and technical cycle at the end of its service life.

Trolldtekt has also obtained several other international indoor climate labels – including Danish Indoor Climate Labelling (under the Danish Technological Institute)



Sluseholmen School, Copenhagen.
Photos: Helene Høyer Mikkelsen, architect MAA

which assesses degassing and particle emissions. Other examples of certifications include Allergy UK's 'Allergy Friendly Product Award' and the German 'Blue Angel', which documents the certified products' impact on water, soil, air and health.

Thermal indoor climate:

Helps regulate humidity

Troldtekt acoustic panels can both absorb and release moisture. This makes the panels suitable for swimming pools and other wet areas (see more under 'In use' below).

Humidity also has an impact on the indoor thermal indoor climate. Because Troldtekt acoustic panels can absorb and release moisture, they also help to ensure an indoor climate where the air is neither too dry nor too humid. Humidity affects the users' experience of comfort in a space.

Visual indoor climate:

High light reflection and cosy spaces

When you choose white-painted or pale Troldtekt acoustic panels, they will reflect a significant amount of light. White-painted Troldtekt panels reflect up to 77 per cent of



Vallensbæk School. Photos: Helene Høyer Mikkelsen, architect MAA

light, while Trolldtekt panels in natural wood reflect around 50 per cent.

Conversely, dark ceilings can also play a role in spaces where there is a need for immersion, creativity and intimacy. "When we enter a space with dark materials, we automatically lower our voices," points out trend researcher Rikke Skytte [in a feature article on Trolldtekt's website](#).

In addition to light, the design and aesthetics of spaces also have an impact on wellbeing throughout the school day. In most spaces, the ceiling is the largest contiguous surface. This is why it makes sense to cover it with a material that not only ensures excellent acoustics but also enhances the aesthetics of the space. Trolldtekt does both and affords architects considerable freedom of design.

Trolldtekt can be supplied in natural wood or as painted panels. In principle, natural wood panels can be painted in any colour to complement the colour scheme used in the school's other interiors.

“ It makes sense to cover a ceiling with a material that ensures excellent acoustics while also enhancing the aesthetics of the space.

In use:

Robust, durable and easy to maintain

Trolldtekt is a robust and durable material that combines the strength of cement with the breathability of wood. As a result, the service life of the acoustic panels is at least 50 years. During that time, the ceilings require only limited maintenance and their service life can be extended with repair and painting.

In addition to ensuring brilliant acoustics in classrooms and common areas, Trolldtekt acoustic panels are also suitable for mounting in school sports halls, changing rooms, shower and swimming pools, for example.

Trolldtekt acoustic panels are certified to withstand ball impacts as per the German standard 'Test for Ball Impact Safety, DIN 18032-3: Sports Halls for Gymnastics and Games'. A wide range of structures featuring Trolldtekt acoustic panels have been tested at the institute in Stuttgart and approved for use as acoustic ceilings and wall cladding in sports halls, where they are exposed to heavy wear and tear and impact, for example when a handball comes flying at full speed.

The accredited Danish Technological Institute has also documented that Trolldtekt can tolerate rooms with a moisture load of up to 98 per cent (+2/-5 per cent). The test was carried out in a room with a temperature of 40 degrees. This means that Trolldtekt has achieved the highest level (D) of CE labelling for water resistance.

In the following chapters of the book, you can find inspiring examples of how Trolldtekt makes a difference to the indoor climate in practice.





Chapter 3 Insights

Smart answers to universal challenges

Significant improvements across multiple indoor climate factors achieved through straightforward architectural interventions. A very special school for students with special needs. Dive into the insights from three distinctive and intelligently designed school buildings.



New Junior School offers a lesson in modern building practices

The new Junior School for the Girls Day School Trust Notting Hill & Ealing High School (London) designed by Architects Hawkins\Brown is a true lesson in sustainability. Rated BREEAM Excellent, the school serves as a model of combining best modern building practices with academic excellence.

The architects worked closely with the school and were keen to see the building as an opportunity to empower the students with knowledge and skills to contribute positively towards the green transition and instil optimism through actionable change.

The result is an educational establishment which takes careful consideration of its environmental footprint, providing high-quality teaching facilities for generations to come. The school is designed to be fully accessible internally and externally. The site includes 14 new classrooms, with additional sixth form classrooms, specialist teaching spaces for music, art, science and computing, a light-filled library with a rooftop lantern, and a large hall suitable for assemblies, performances, PE and events. The addition of a science garden and forest school area adds to the inside-outside learning experience.

“The project team conducted studies of the indoor climate and students' experience of the indoor climate



Inspiring learning environments

From the outset, it was decided to use building materials with as low an environmental footprint as possible. The building has a wooden frame, south-facing photovoltaic panels on the sawtooth roof to catch the most sunlight and supply electricity, north-facing roof lights for daylight with limited solar gain, a highly insulated and airtight building fabric, air source heat pumps and a heat recovery system to keep the heat in the building while allowing fresh air in, and noise-reducing wood wool acoustic panelling inside.

Ms K. Bevan, Head of Junior School commented, "With its environmentally friendly features, the building not only serves as an inspiring learning environment but as a physical embodiment of the lasting impact our girls can make in the realm of sustainability".

Green materials and energy-efficient solutions

With strict government regulations in place regarding acoustics and controlling reverberating sound within educational environments, Anderson Acoustics was



Notting Hill & Ealing High School, London. Photos: Jack Hobhouse.

appointed to provide acoustic advice for the redevelopment of the site. All new school buildings and redesigns must comply with the Government's BB93 Acoustic Standards. Building Bulletin 93 (BB93), part of the Building Regulations, presents minimum standards for school acoustics in terms of sound reverberation time and internal ambient noise levels.

Effective acoustics ensure optimal learning conditions

In order to satisfy the requirements of BB93, new classrooms need to have a reverberation time of <0.6 seconds between 500hz-2000hz. Taking this into account, while also sourcing products that help contribute to acoustic credits Hea05 and Pol05 in order

to obtain BREEAM accreditation, Troldekt acoustic wood wool panelling was specified across many areas to control the acoustics in the building and provide a quiet environment for learning. The result is so effective that some spaces are now used during exams as they're much quieter than the sixth form centre.

Project: Notting Hill & Ealing High School, London

Architect: Hawkins\Brown

Builder: Girls Day School Trust

Troldekt products: Ceiling and wall panels, Troldekt acoustic panels

Colour: Natural wood





Indoor climate in schools: Considerate architecture protects delicate senses

Stensager School in Aarhus (Denmark) is a school for students with special needs. That's why the architectural firm RUM has literally thought outside the box to create a learning environment that simultaneously protects and embraces its young users.

The City of Aarhus decided to build a comprehensive specialist educational facilities at Janesvej in Brabrand. The former Tovshøj School site, covering a total of 11,740 square metres, was renovated and expanded so that the Stensager special school could move onto the site in 2023. The new building also houses a day care centre, leisure facilities, a specialist dentist and an ordinary school dentist.

The ambition was to create a safe and well-functioning environment for a diverse group of students with learning difficulties, profound developmental disorders, autism or other forms of neurodivergence.

“ The ambition has been to create a safe and well-functioning environment for a diverse group of students

The project was tendered as a full-design consultancy package and the City of Aarhus selected RUM – in collaboration with MOE, Rie Ollendorff, and ByplusLand – as the winning team, not least because of RUM's experience from similar projects in Kruså, Randers, Aalborg and Jægerspris.

A diverse user group

Insight from the target group and legislation in this specialised area were valuable, as



a complex task lay ahead. In addition to school children and younger ones in day care facilities, the building's users include sports clubs and dental clinic patients. For that reason, the construction group focused strongly on creating a good flow in and around the building, especially because many of the users arrive in adapted buses or taxis.

"The original Tovshøj School dated from the time when schools were built well in terms of materials and space management. That gave us a good starting point," says Karin Elbek, director and partner at RUM.



Elbek emphasises that it was important to understand the target group's varied needs, cognitive level, reactions and behaviour. For example, some users are sensitive to sounds or sensory input, while others have physical disabilities and reduced mobility.

"The school's staff had done a lot of preparatory work and put together eight different personas that represented the different users. This allowed us to understand them and discuss their needs without becoming too specific. We were also very careful not to focus on a narrow group so that we overlooked the other users."

Significant improvement for the indoor climate

To best accommodate users who are particularly sensitive to sensory stimuli, the design team gave careful consideration to the school's interior design and indoor climate.

Among other things, Trolldtekt ventilation has been installed throughout the school, where fresh air seeps down through the active Trolldtekt panels, which form part of the acoustic ceiling. This provides a more even distribution of fresh air to the room compared to traditional ventilation. At the same time,

FACTS AND FIGURES:

About Stensager School

- Stensager School accommodates 250 students in a total of 30 special classes from years 0-10. It was already at full capacity when the school opened in June 2023.
- In connection with the school, a new day care facility was established on a 1,550 m² site, aimed at 0-6 year-olds with special needs. The day care accommodates 26 children.
- The premises are also used by several sports clubs, including a weightlifting club and team sports for wheelchair users.



the solution is quieter, uses less energy and minimises the risk of draughts by distributing the air evenly rather than blowing it through diffusers.

“ This provides a more even distribution of fresh air to the room compared to traditional ventilation.

The acoustics in the rooms are regulated by various sound-absorbing elements, including Troldekt acoustic panels in the ceiling and perforated wooden walls, where small solid sections break up the hole pattern to prevent visual disturbances and flickering of the eyes. Across the school, for example, uniform wayfinding with pictograms has been set up.

"We've worked in accordance with the modern, up-to-date legal requirements for acoustics, daylight and lighting. The unsolicited feedback we hear from users is that the acoustics are wonderful. They are surprised that it can be so quiet even when large groups are present. So

our focus on light and sound has given quite a big boost to the indoor climate," says Karin Elbek.

The art of shielding without isolating

In addition to the indoor climate, there was also a focus on the school's interior design. Through a series of tangible processes with the working group, RUM was able to define three zones that could form the framework for the interior design: a green comfort zone, a yellow development zone and a red insecurity zone. Using these zones as a guide, the architects put together a learning space that challenges and invites a sense of community without overstimulating or isolating.

“ An important lesson is that what feels safe isn't always what is most enveloping and enclosed.



For some, feeling comfortable lies in space and movement. We also learned that recovery is not only about relaxing but also about recharging your batteries by moving. That was the theme we jointly worked on. We needed to create a framework that could be adapted to the development of the target group, prevent conflict and make it easier for the students to find new friends," says Karin Elbek.

Boxes in the border zone

RUM came up with a number of concrete design proposals that could support their work with red, yellow and green zones. Two themes in particular were consistent.

Firstly, the classrooms in the school were furnished with a number of add-ons to increase flexibility. For example, half doors, curtains, mobile walls and hanging points for swings.

Secondly, the architects invented a concept that attracted a large donation from the foundation A.P. Møllerske Støttefond and called it 'Out of the Box': a series of flexible

elements such as children's houses and boxes that support play and the creation of different environments. They give students the opportunity to participate in a game or to withdraw and immerse themselves.

"We've placed the boxes in what we call the 'threshold' in architectural terminology, i.e. the transition area where different activities or uses meet. In this way, we expanded the yellow and green zones, ensuring that the children can be part of the community without feeling overwhelmed," explains Karin Elbek.

“ They give students the opportunity to participate in a game or to withdraw and immerse themselves.

To ensure the concept is utilised optimally, the school's staff have undergone an extended pedagogical and didactic process, which included the development of a comprehensive

Copenhagen has gained a world-class primary and lower secondary school

At the state-of-the-art Sluseholmen School in Copenhagen, the architecture invites nature in. Creative solutions characterise the project and a new, distinctive Trolldtekt acoustic solution is part of the design.

Sluseholmen in Copenhagen is an up-and-coming neighbourhood for families with children, which requires good school conditions. The City of Copenhagen therefore decided to build a new school that will be best in class in terms of nature, design and connection to its surroundings.

The school is a four-storey building with green terraced landscapes on the staggered roofs on all levels. As a unique solution, a sports hall was built on top of a car park next door, where large glass windows afford students and leisure users views of the city and surrounding nature.





“We invite nature in with large, open staircases both indoors and outside.

JJW Arkitekter designed the newly-built school and commented,

"The school really lives up to the vision of 'the green inner-city school'. We invite nature in with large, open staircases both indoors and outside, and the school faces the canal, where the children can enjoy active outdoor

life. In addition, the building is designed with wooden facades, wooden windows and roof gardens with plants and trees," says Lisbeth N. Olsen, project architect for the school at JJW Arkitekter.

Small plot, big ambitions

The main challenges in the design of the school centred around the location, because the building site is located in a noisy area and has a very limited size. This was solved by building vertically and utilising every square metre," explains Lisbeth N. Olsen. "The limited building space was a useful



constraint on the project, as the creation of active areas on the roofs has become a major asset in one's experience of the school.

“

We focused on sustainability initiatives in the school's construction, and Troldekt's Cradle to Cradle certification was a decisive parameter for our choice of ceiling.

As the building is relatively deep, getting enough daylight in has also been a central

task. JJW Arkitekter solved this by creating three atria that not only provide light for the learning environments but also create a spatial experience.

The load-bearing structures are manufactured from concrete, as are the school's ground floors, which are open to the public around the clock. Both inside and outside, wood takes up a lot of space, and its warmth and glow adds atmosphere to the school and contrasts nicely with the concrete elements.

FACTS AND FIGURES: About Sluseholmen School

- Sluseholmen School broke ground in August 2021 and opened in January 2024.
- The school is located on Sluseholmen in Copenhagen and was designed by JJW Arkitekter.
- Troldekt acoustic panels in natural wood were chosen and mounted in the visible longitudinal T35 profile system. In addition, concealed Troldekt ventilation was chosen.



An acoustic ceiling with a visual direction

Wood is also one of the raw materials used in the Trolldtekt acoustic panels, which are mounted in a visible longitudinal T35 profile system. The visible longitudinal profiles are a brand new solution that JJW Arkitekter and Trolldtekt developed in collaboration and which gives the ceiling a visual direction in the room.

"We focused on sustainability initiatives in the school's construction, and Trolldtekt's Cradle to Cradle certification was a decisive parameter in our choice of ceiling. We also wanted an acoustic ceiling with visible aluminium profiles in a single direction that could be dismantled. Trolldtekt developed a perfect solution, which both the city's operations

manager and our contractor have responded to positively," says Lisbeth N. Olsen.

The suspended Trolldtekt ceiling also features concealed ventilation, ensuring fresh air without draughts or noise.

The ventilation solution has the great advantage of having no visible installations in the ceiling. Along with its acoustic properties, Trolldtekt has a textural quality that, together with the wooden acoustic walls, provides the school's spaces with a friendly, warm and calm atmosphere. This contributes to a good learning environment," says Lisbeth N. Olsen.





Chapter 4 Inspiration

When architecture is best in class

There are many architectural approaches to achieving optimal school design. Varied learning spaces, the use of wood materials and a focus on sound, light and air are some of the cross-cutting elements in the schools of the future. Join us on a tour of a number of successful projects on the following pages.



Beethoven-Gymnasium, Berlin (Germany) A circular classroom points to the future

Beethoven-Gymnasium in Berlin's Lankwitz district has created a unique pilot classroom, showcasing how circular economy principles can enhance educational spaces. Developed in collaboration with students and inspired by the EU 'New European Bauhaus' initiative, the room prioritises eco-friendly materials and renewable energy.



Troldekt acoustic panels in natural wood integrate seamlessly into the sustainable design, providing optimal acoustics and visual harmony within the classroom. Additionally, the classroom is equipped with modern educational technology and sustainable furnishings, creating an engaging and comfortable learning environment for students and teachers alike.

Project: Beethoven-Gymnasium,
Berlin, Germany

Architect: Hochbau Service

Client: District Office (Ba) Steglitz-Zehlendorf

Ceiling and wall cladding: Troldekt acoustic panels (natural wood, ultrafine structure)



Campus Scolaire Millermoaler, Echternach (Luxembourg) Striking new school campus promotes learning

Campus Scolaire Millermoaler in Echternach is an impressive architectural project resulting from a collaboration between Luxembourg-based architects WW+ and the Dutch firm Atelier PRO. The building uniquely combines aesthetics and functionality, creating an ideal educational environment.

Troldtekt acoustic solutions in a subtle RAL 1015 colour and ultrafine structure ensure excellent acoustics and visual coherence throughout the campus. The use of Troldtekt A2 panels and access panels, installed with T35 profiles and structural screws, further enhances durability, safety and ease of maintenance.

The thoughtful integration of acoustic solutions contributes to a pleasant atmosphere, supporting both educational activities and student wellbeing.





Project: Campus Scolaire Millermoaler,
Echternach, Luxembourg

Architect: WW+ and Atelier PRO

Client: Apleona R&M Ausbau Luxembourg
s.a.r.l.

Ceiling and wall cladding: Troldekt A2
panels and access panels (RAL 1015, ultrafine
structure, K5-FN and K5 edge finish)

De Reigers School Campus, Zelzate (Belgium) Historic charm meets modern learning

At the De Reigers school campus in Zelzate, a neoclassical monument from the 19th century has been carefully restored and transformed into a modern and vibrant educational setting. In collaboration with MADE Architects, the restoration is part of a larger masterplan that integrates education, heritage and green space into a unified campus vision.



The architectural focus has been to return the central building's historic facade and interior to its original grandeur, re-establishing it as the visual identity of the school. The restored building now houses a new canteen, kitchen, primary school classrooms, administration and management offices, as well as a gym and multipurpose room.

Troldtekt acoustic panels have been installed throughout key interior spaces, including the sports hall and classrooms, to ensure optimal sound conditions and a calm indoor environment.

Combined with soft natural light and light-coloured materials, the acoustic design supports focus and wellbeing in both teaching and recreational settings.

Project: De Reigers School Campus, Zelzate, Belgium

Architect: MADE Architects

Client: GO! Onderwijs van de Vlaamse Gemeenschap

Ceiling cladding: Troldtekt acoustic panels (natural wood, ultrafine structure)





Firda Campus, Leeuwarden (Netherlands) Real-world learning in a multifunctional setting

Firda's new campus in Leeuwarden is part of the Kooi Stadion – a vibrant multifunctional complex that brings together education, sport and business. Here, students in economic and beauty care programmes develop their skills in modern classrooms and fully equipped salons.



To support focused learning in the active environment, Troldekt Tiles T24 have been installed throughout teaching and training areas. Mounted in a visible T24 grid system, the acoustic panels absorb noise and enhance speech intelligibility – creating a calm and professional atmosphere.

The natural colour and milled surface structure of the panels complement the interior's light wood, glass and soft tones. In addition to good acoustics and visual harmony, the panels offer practical benefits such as

easy access to services above and long-term durability.

Project: Firda Campus, Leeuwarden, Netherlands

Client: Firda

Troldekt solution: Troldekt Tiles T24 (natural wood, Cradle to Cradle Certified® at gold level)

Installation: Visible T24 grid system



KNUDEN Cultural School, Kristiansand (Norway)

New cultural hub designed to inspire creativity

KNUDEN Cultural School's new headquarters opened in 2022 in Kristiansand's Kanalbyen neighbourhood. This vibrant cultural centre welcomes 600 students, offering diverse activities in dance, music, theatre, visual arts, film and photography.

The building's welcoming foyer, linked by a central staircase, uses Troldekt acoustic panels in natural wood, complementing its warm interior, yellow accents and artistic décor. Troldekt line panels in black and white enhance acoustics and provide versatile performance spaces, ensuring ideal conditions for creativity and focused learning.

The thoughtful architectural design promotes interaction and community spirit, creating inviting social spaces that encourage

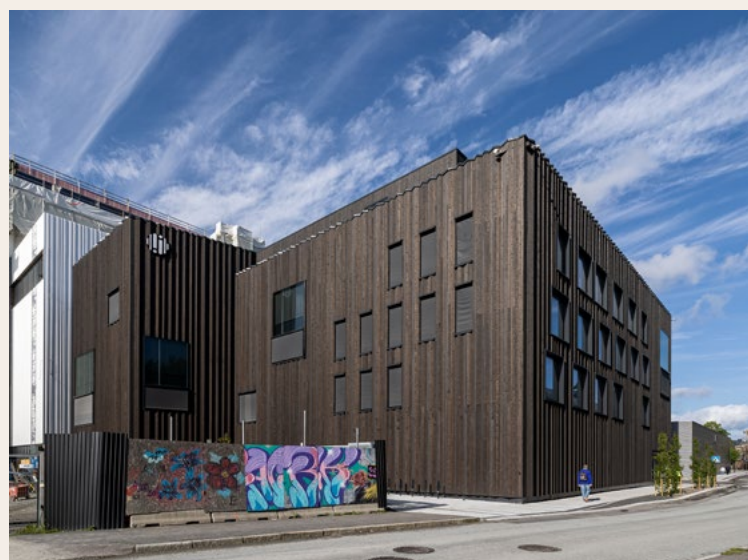
collaboration and creative exploration among students and educators.

Project: KNUDEN Cultural School, Kristiansand, Norway

Architect: Mestres Wåge arkitekter SLP & Alma Eik Arkitektur (interior)

Client: Kristiansand Municipality

Ceiling and wall cladding: Troldekt acoustic panels and Troldekt line (natural wood, black 207, white 101, ultrafine structure)

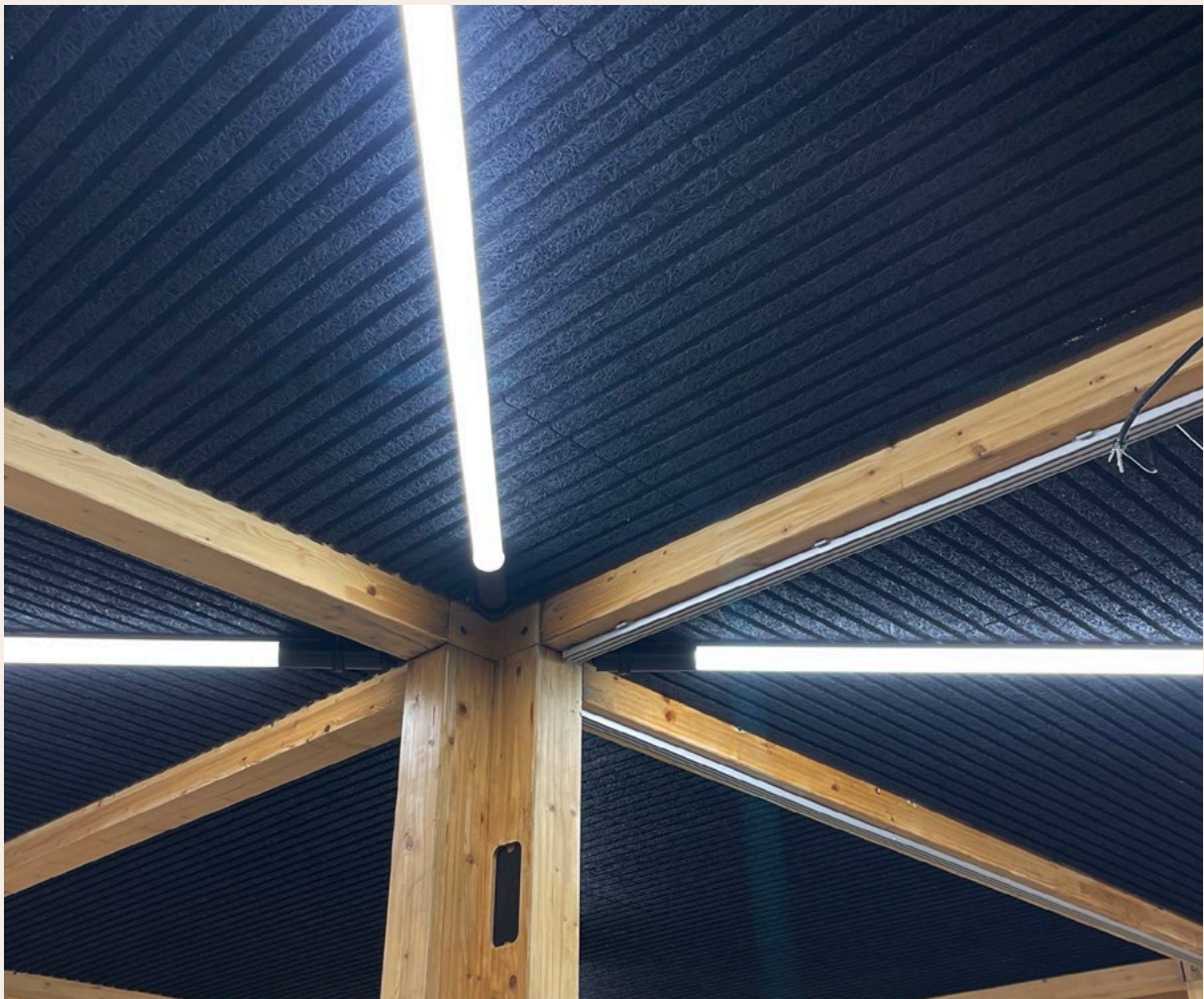


Leipzig International School, Leipzig (Germany) Premiere of circular modular construction in Leipzig

Urban Beta has introduced an innovative modular construction concept called Betaport, first implemented at Leipzig International School. The concept offers adaptable building modules designed to respond easily to changing spatial needs such as expansions or relocations.

Robotically produced modules, incorporating recyclable and healthy materials, ensure flexibility and longevity. Trolldtekt acoustic panels, Cradle to Cradle Certified® at gold level, were chosen to enhance indoor acoustics and aesthetics and support the concept's focus on long-term usability and minimal environmental impact.

The collaboration between Urban Beta and Trolldtekt, initiated in 2022, demonstrates how thoughtful material selection significantly contributes to sustainable, inspiring learning spaces.





Project: Leipzig International School,
Leipzig, Germany
Concept Developer: Urban Beta
Troldtekt products: Troldtekt acoustic
panels, Troldtekt line (black 208, Cradle to
Cradle Certified® at gold level)



University of Twente, ITC Faculty, Enschede (Netherlands) Dynamic educational environment with a minimal climate footprint

At the Faculty of Geo-Information Science and Earth Observation (ITC) at the University of Twente, innovative architecture and responsible material choices combine to create an inspiring educational environment. The building prioritises functionality and adaptability, ensuring it meets both current and future educational demands.



Black ultrafine Trolldtekt line panels installed with structural screws significantly enhance acoustics and visual aesthetics. The panels contribute to a comfortable, engaging space ideal for focused learning and collaborative work, aligning perfectly with the faculty's environmental objectives.

The thoughtful integration of Trolldtekt panels not only improves the indoor climate but also underlines the building's overall architectural quality and commitment to minimal environmental impact.

Project: University of Twente, ITC Faculty, Enschede, Netherlands

Architect: VDNDP

Client: Eissink

Ceiling and wall cladding: Trolldtekt line (black 207, ultrafine structure, U-groove edge finish)

Lysningen School, Viborg (Denmark) Clearing in the forest

At this brand new school, the forest is the theme and wood is the predominant material. It's a welcoming building that greets users with wood columns along the facade.

Lysningen is not just a school, it's also a meeting place and community centre for the local area. Inside the school, there is a clearing in the central atrium, where light filters down between the levels and creates light within the space.

Students from years 4 to 9 move between themed classrooms spread across the different floors. Colour themes provide clarity and physical recognition for different subjects.

Wood is used in the load-bearing structures and on the facade as vertical cladding. Inside, wood is also a dominant material, giving the school a clear identity and a welcoming feel. Troldekt acoustic panels and vertical wooden strips have been mounted on many of the wall surfaces in the atrium.

There are small breakout spaces and seating areas on all floors facing the atrium. To ensure excellent acoustics for both conversation and concentration, Troldekt was used on ceilings and selected wall surfaces.





Project: Sluseholmen School, Copenhagen

Architect: JJW arkitekter

Client: Byggeri København, ØKF, City of Copenhagen

Ceiling and wall cladding: Troldekt Plus (natural wood) mounted in a visible longitudinal T35 profile system

Integrated Comprehensive School (‘Gesamtschule’ or IGS) in Rinteln (Germany) Award-winning new school building in wood

The new IGS Rinteln building in the Weserbergland region of Lower Saxony has absolutely nothing in common with the ‘typical’ school building, which many people associate as a concrete block from the 1970s. What makes the school unique is that the building, with a usable area of over 5,000 square metres, is created almost entirely of wood.



Wood is also a prominent feature indoors and, in combination with lots of glass, it makes the whole school light, natural and inviting. The seating and student lockers in untreated wood were designed especially for the school by bez + kock architekten. Dark green, textured rubber flooring, polished concrete slab tiles and dark door and window frames combine to create a colourful contrast to the light-toned wood.

Between the visible wooden beams on the ceiling, and also partially on the walls,

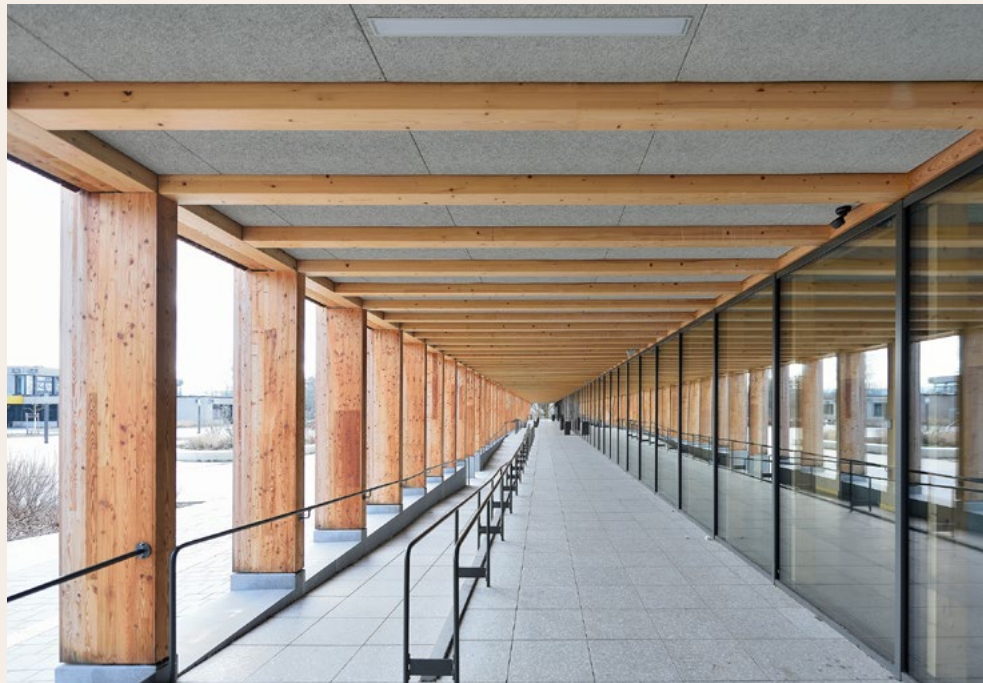
Troldekt acoustic panels were mounted, which serve as a visual finishing touch to the overall design and also testify to the acoustic effect in the school's daily life.

Project: Integrated Comprehensive School (IGS), Rinteln, Germany

Architect: bez + kock architekten
Generalplaner GmbH, Stuttgart

Client: Schaumburg District, Stadthagen

Ceiling and wall cladding: Troldekt acoustic panels (natural wood and custom colour)



Hallernas School in Stenungsund (Sweden)

Bright school draws inspiration from nature

North of Gothenburg is the village of Hallerna in Stenungsund Municipality. Around 450 students, from years 7 to 9, now have a new setting for their daily lessons. The students come from various schools up to year 6 and they are now continuing their education at the newly-built Hallerna School, completed in 2023.

Hallerna School is located in a scenic, green, hilly setting surrounded by pine trees – which served as the inspiration behind the school's architecture and choice of materials.

On the outside is a facade consisting of light wood and sheet metal, as well as a glass entrance area. There are good outdoor facilities with hiking trails and an outdoor teaching room. Inside, there are open and inviting rooms with windows all around the building, ensuring constant daylight and a direct view of the surrounding scenery.

The interior design is contemporary, with the emphasis on quality and light, warm colours combined with the use of wood and Trolldtekt acoustic ceilings in cement-bonded wood wool. The more than a thousand square metres of Trolldtekt acoustic panels – mainly painted white – are mounted on a visible T-profile system, which creates visual structure in the large ceiling surfaces and thus also contributes to the spaces' design.





Project: Hallerna School in Stenungsund Municipality
Architect: D Office arkitekter
Client: Stenungsund Municipality
Ceiling and wall cladding: Trolldtekt acoustic (white 101 and black 207)



Erlev School in Haderslev (Denmark) A forest of columns with clearings

A new primary and lower secondary school has been built in Haderslev Syd, which is visionary on several levels. For one, the column-beam system and facades are made of wood. With an area of 6,500 square metres, Erlev School is one of Denmark's largest wooden structures in recent times. In addition, the teaching is based on the educational philosophy developed in New Zealand about student-centric learning and flexible open learning environments.



The new school, which was named School Building of the Year in Denmark in 2021, is organised into seven year-group clusters. A cluster is a varied learning environment for a maximum of 70 children in a year group from years 0 to 6.

The architecture matches the high level of ambition and the great diversity of spaces is connected by smooth transitions. The

acoustic environment is also outstanding, with extensive use of white-painted Trolldtekt acoustic panels with a fine texture.

Project: Erlev School in Haderslev Syd, Denmark

Architect: Arkitema

Client: Haderslev Municipality

Ceiling and wall cladding: Trolldtekt acoustic panels (white 101)

Høje Taastrup Children's and Culture Centre (Denmark) New school brings together several facilities

In January 2023, the newly-built Høje Taastrup Children's and Culture Centre opened its doors to a new type of school. The building covers 9,500 square metres and incorporates a crèche, kindergarten, after-school club and school up to Year 6 as well as the municipal music school, visual arts school and drama school.

Both the interiors and exteriors of Høje-Taastrup Children's and Culture Centre are based on the same types of materials – brick, concrete, wood and glass. Inside, it is decorated in light and airy shades with plenty of daylight and the four so-called cultural clusters' distinct designs stand out clearly.

Several variants of Troldekt acoustic solutions were chosen for the ceilings to contribute to a

healthy indoor climate with pleasant acoustics. Around the school's common areas, Troldekt in natural wood is used. In the halls, grey Troldekt acoustic panels are mounted as a wall solution.

Høje Taastrup Children's and Culture Centre was named School Building of the Year in Denmark in 2023.





Project: Høje Taastrup Children's and Culture Centre

Architect: Christensen & Co. Arkitekter and Kjaer & Richter Architects

Client: Høje-Taastrup Municipality, Denmark

Ceiling and wall cladding: Troldekt acoustic panels (natural wood and natural grey)

Sandarnas School in Gothenburg (Sweden) Young meets old in newly built school

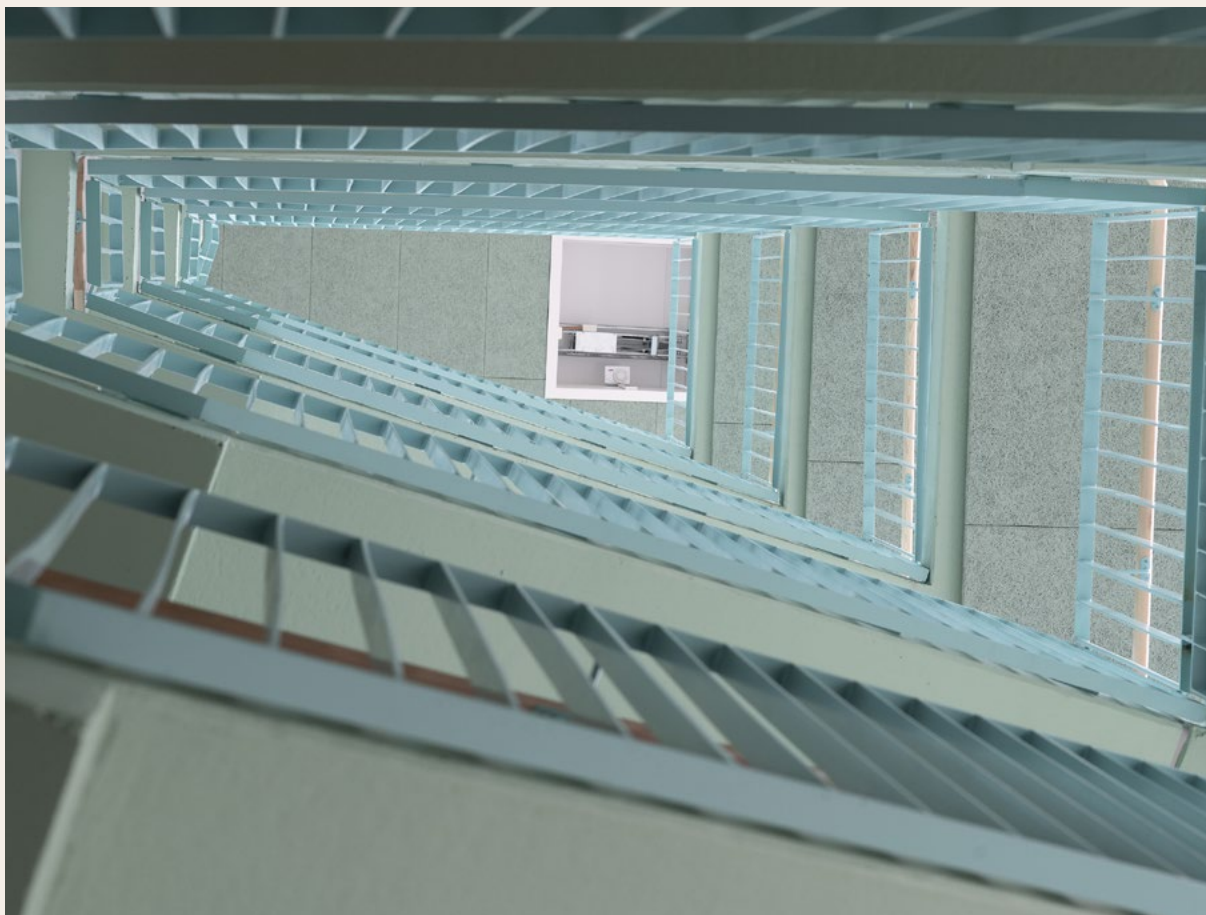
Sandarnas School in Gothenburg shares a building and communal facilities with the city's care home. In this way, several generations are housed under one roof in architecture that focuses on a feeling of togetherness with a healthy indoor climate.

The project is the first of its kind in Sweden, where young and old alike share a dining room, sports hall and outdoor areas. The school, which can accommodate 400 students, is spread over the first to third floors, while the care home, with approximately 100 apartments for the elderly, is located on the fourth to eighth floors.

Indoors, educational efforts have been made to make it easy to find one's way around all parts of the school. Natural materials, especially light-coloured pine panels, are used

throughout the building's interior. Bright and calm colours enliven and facilitate orientation and each floor has its own colour scheme.

In those parts of the school that are particularly exposed to noise, such as the dining hall, music room and creative rooms, Trolldtekt line design solution was chosen for the walls. Other communal areas feature classic Trolldtekt ceilings. Both schools and care homes require robust materials and a big plus is the ability to paint or replace individual Trolldtekt panels as needed.





Project: Sandarna Primary School in Gothenburg

Architect: what! arkitektur

Client: Hemsö Property Developer

Ceiling and wall cladding: Troldekt acoustic panels and Troldekt line design (custom colour)

Huseby School in Trondheim (Norway)

Bright school draws inspiration from nature

At the start of the 2021 school year, the Huseby schools in Saupstad-Kolstad opened their doors to 14,500 square metres of new facilities in the Trondheim Municipality. The complex comprises a primary and lower secondary school, an upper secondary school, a sign language centre and a school of the arts, as well as reception classes for international students.

From the outset of the project, one of the requirements was that high-quality materials had to be used to ensure that Huseby School would remain functional for many years to come. The school project is also part of the area's general urban renewal. The buildings are constructed of wood both inside and outside, with wooden cladding on the facades, interior wooden walls and panelling and wooden furniture.

Troldtekt acoustic panels were chosen for both the classrooms and communal areas, as well as for the corridors and toilets. The classic white-painted Troldtekt acoustic

panels were chosen to create an environment that supports a calm and pleasant school day. At the same time, the panels, which are essentially wood and cement, fit well into the school's overall design.

The school has achieved BREEAM (Building Research Establishment Environmental Assessment Method) environmental certification in the category Very Good and several environmental measures have been integrated – the building site was fossil-free, the school is mainly built of solid wood, the the building is designed in accordance with Passivhaus principles and has photovoltaic cells on the roof.





Project: Huseby School in Trondheim, Norway

Architect: SPINN Arkitekter, Filter arkitekter, Norconsult and Grindaker

Client: Trondheim Municipality

Ceiling and wall cladding: Troldekt acoustic panels (white 101)

Central Foundation Boys' School in London (England)

Classic architecture with modern comfort

Central Foundation Boys' School in London has undergone extensive renovation and expansion, combining historic charm with modern requirements for acoustics and functionality. The 150-year-old school has been expanded with a new science building, a new partially underground sports hall and the old existing chapel has been transformed into a creative centre for art.



To solve problems with poor acoustics in the sports hall and the music and drama rooms, Trolldtekt acoustic panels were chosen for all ceilings.

Because the project involved several listed buildings, it was challenging. During the construction period, 13,000 square metres of upgrades were carried out, and the project was completed in a decade-long partnership with the school. It remained open throughout the construction process, which was carried out in two phases.

The BREEAM Excellent rated building won a prestigious National Civic Trust Award for 2024.

Project: Renovation and expansion of Central Foundation Boys' School, London

Architects: Hawkins\Brown

Client: Central Foundation Boys' School

Ceiling and wall cladding: Trolldtekt acoustic panels (natural grey)



Feldballe Friskole, Rønne (Denmark) Extension built from bio-based materials creates a good learning environment

In the village of Feldballe on Djursland, the independent school has been given an extension that not only expands the school's facilities but also serves as an excellent example of how bio-based building materials can be integrated into modern architecture.

The architecture of Feldballe Friskole is dynamic, with four platforms on two levels, where the rooms flow together and create a natural connection between teaching, play and community. Saddle roofs and grey-toned facades give the building a welcoming appearance, while wood-clad sections add warmth and contrast to the raw materials.

Acoustics have been a key challenge in the large common room and along the open corridors. To ensure a pleasant sound experience, white-painted Troldekt acoustic

panels were used, which both absorb sound and contribute to a calm visual experience. The combination of Troldekt acoustic and Troldekt Plus acoustic panels supports the school's open plan design and ensures an excellent acoustic environment, even in rooms with high ceilings and sloping surfaces.

The building marks a new era for learning environments, where architecture supports flexibility, wellbeing and modern teaching methods.





Project: Extension at Feldballe Friskole,
Rønne, Denmark
Architect: Henning Larsen Architects
Client: Feldballe Friskole
Ceiling and wall cladding: Troldekt Plus
acoustic panels





Chapter 5 Documentation: Indoor climate in building certifications

The DGNB, LEED, WELL and BREEAM building certifications are gaining ground in the built environment and can also be applied to school buildings. Indoor climate plays a central role in all certifications, but different elements are weighted differently. Read more on the following pages.



Building certification is gaining ground. This helps to ensure a fact-based and holistic approach to building with consideration for both people and the environment.

The indoor climate plays a central role in the widespread certifications and researchers at the Department of Civil Engineering at Aalborg University (Denmark) **have compared the specific weighting of the indoor climate** in each of the widely used certifications (Rohde et al., 2019).

The comparison includes DGNB, LEED, WELL, BREEAM and LBC certifications.

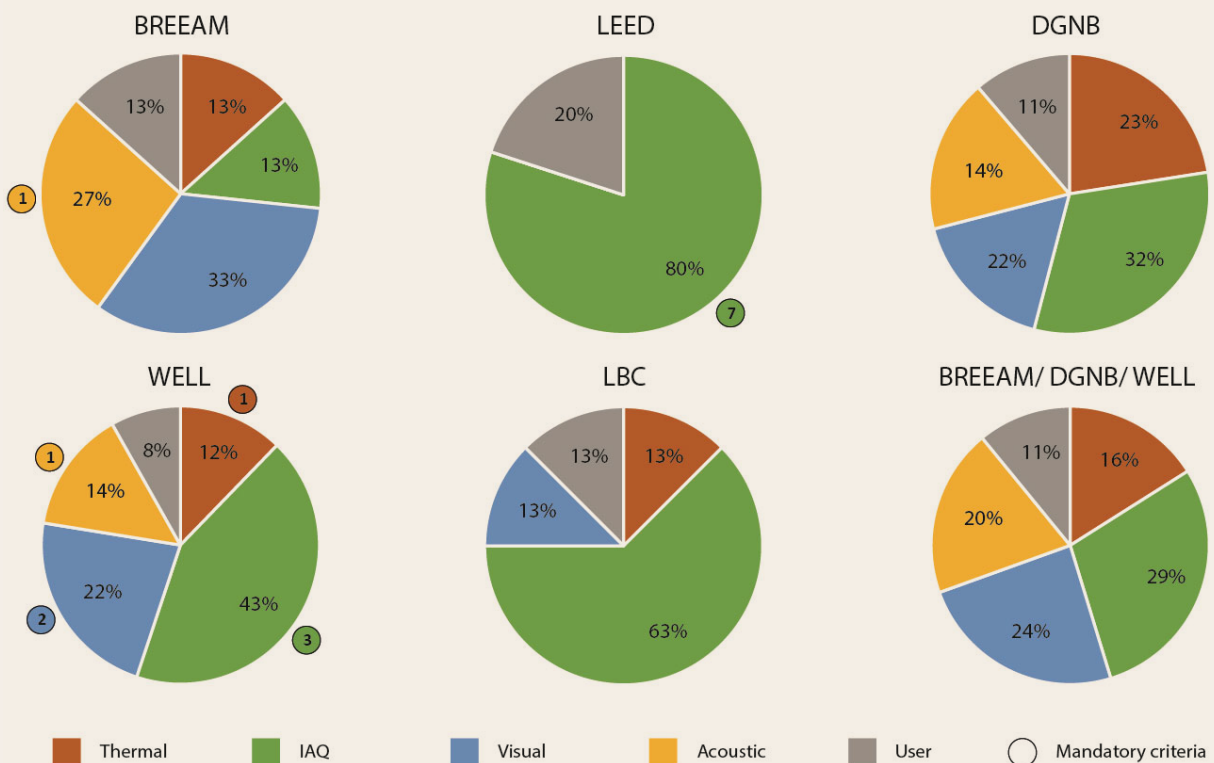
In their comparison, researchers from Aalborg University consider the four different areas of indoor climate and also examine how users themselves influence the indoor climate.

Not all areas are weighted equally in all certifications, as the comparison clearly shows.

Overview: The overall weighting of the indoor climate

The pie charts below show how the various aspects of indoor climate are weighted in each of the four schemes. As can be seen, LEED has completely excluded three of the key areas, so the other certification schemes are more suitable for a complete assessment of the indoor climate.

The researchers conclude that DGNB, supplemented by WELL, provides the most holistic assessment of the indoor climate.



The researchers conclude that DGNB, supplemented by WELL, provides the most holistic assessment of the indoor climate.

How Troldekt contributes to the certifications

Troldekt acoustic solutions have a positive impact when a building is to be certified, including for a number of criteria within various areas of the indoor climate.



In collaboration with Ramboll, Troldekt has documented how its acoustic solutions contribute positively to the various criteria in DGNB, BREEAM, WELL and LEED.

In practice, Ramboll has prepared documentation packages to help consultants assess Troldekt's specific contributions. However, the weighting of the acoustic solutions in a specific building is always based on the building in question, including the other material choices.

[Download the documentation packages here](#)

[Read the brochure 'Troldekt and certified buildings'](#)

Find more inspiration

Visit us online

At www.troldekt.co.uk you'll find information, inspiration and documentation about Troldekt acoustic solutions. In our [reference section](#), you can also see a larger selection of schools with Troldekt panels from a wide range of countries.

Read the feature on the healthy schools of the future

In our [online feature section](#), you can read about both challenges and structural engineering solutions in modern schools. Here you'll find interviews with experts and architects, among other things. The feature page is continuously updated with new content.

Subscribe to our newsletters

Are you looking for the latest knowledge and inspiration in the areas of indoor climate, certified buildings and innovative acoustic solutions? [Then sign up for our online newsletter.](#)

Book a meeting

[Our experienced project consultants](#) are ready to talk to you about acoustic solutions for your next school construction project.

List of references

More inspiration for your school construction project

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More inspiration for your school construction project

- [Case: Erlev School: Magnificent wooden school is Denmark's best](#)
- [Article: Better school buildings post corona](#)
- [Case: Vrå School and Kindergarden is School Building of the Year 2022](#)
- [Inspiration: Dark ceilings invite calm and intimacy](#)
- [Inspiration: Acoustic solutions for certified buildings](#)
- [Inspiration: See all our magazines and brochures about acoustic solutions](#)
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