

A classroom scene with a whiteboard. On the left, a young woman with blonde hair, wearing a grey hoodie and blue jeans, stands looking at a book. In the center, a young boy with brown hair, wearing a blue plaid shirt and blue jeans, stands on a stack of books, holding a white marker. On the right, a man with long brown hair and a beard, wearing a dark grey shirt and blue jeans, sits on the floor with his legs crossed, using a silver laptop. The whiteboard in the background has three equations written on it in blue marker.
$$W_{light} = ((465 \times 0,93) \times ((1800 \times 0,13 \times 0,75) + (200 \times 0,75))) / 1000 = 315,9$$

$$W_{parasitic} = ((5 \times 6760) + (1800 \times 0,13 \times 0,75)) / 1000 = 33,8$$

$$W_{total} = 315,9 + 33,8 = 349,7$$

PEDAGOGICS OF LIGHT

We know how to stimulate learning

FAGERHULT



The earth is as flat as a pancake.

Being right-handed is better than left.

We can't afford new lighting.





La Salle College, Western Australia
Architect: Parry & Rosenthal | Photographer: Rob Frith



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PEDAGOGICS OF LIGHT (AUSTRALIA)

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Higher levels of ambient lighting = better results

It's a well known fact of life that light makes us feel good. Light affects us not just in a visual sense, but biologically and emotionally as well. New research has shown that good lighting actually increases job satisfaction in learning environments. Fagerhult's head of research, Tommy Govén, explains how.

How can lighting affect study results?

"Our research shows that higher levels of ambient light, that is indirect light reflected via the ceiling and vertically against the walls, make the students more alert and puts them in better mood. Our tests also show that pupils who get to work in this light get better results during the dark period of the year as well. The great thing is that this type of lighting is extremely easy to create and doesn't need to cost more either. By selecting good luminaires, with daylight control and presence detectors, you can compensate for the higher light levels."

How can you prove the connection?

"The concept of light being good for people is nothing new. It's something we feel "instinctively". We become more alert, more cheerful and more focused. We are exactly like flowers that turn to face the light! The inhabitants of the Nordic countries in particular are conscious of how the darkness can affect their energy and mood. What is new however, is that at last we have the opportunity to measure and prove the effect of light – both natural and artificial – on a purely scientific basis. In 2002 a researcher at Brown University in the USA discovered what became known as a "third receptor" in the eye's retina. This 'Third Receptor' is what transmits light impulses from the eye to the pituitary gland, which influences the secretion of stress and sleep hormones. There is, therefore, also a clear connection between light and hormone balance."



Humans are exactly like flowers that turn to face the light!

What is VBE?

“Good lighting must be adapted to human nature. That’s why we developed an evaluations system, the VBE Index, as the basis for our research. VBE is a acronym of Visual, Biological and Emotional, the three ways in which light affects us. The visual concerns the provision of the right light which helps us to see well and be able to read and work. The Biological is about how light affects the secretion of hormones in our bodies, in other words how tired or how alert we are. The emotional aspect of light is, of course, how it affects us on a purely emotional basis”.

What makes Fagerhult’s research so unique?

“That we actually studied the effect of artificial light on a biological basis by measuring hydrocortisone and melatonin levels, during a whole school year. This approach provided a completely different assurance to alternative research focused exclusively on interviews, which are based on instantaneous, subjective values. This aspect wasn’t neglected in our study however, we

supplemented the biological aspects with regular studies of the students emotional response throughout the year.”

And your next project?

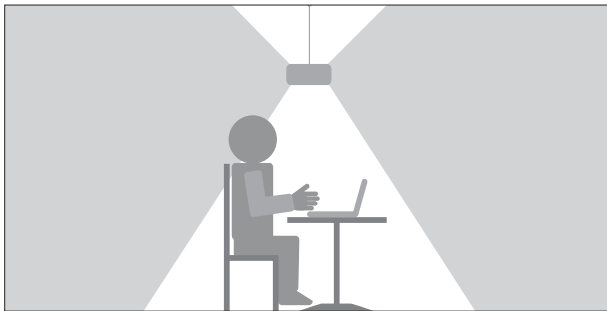
“The next project is being run in a high school in Sweden where we are aiming to create a model for energy efficiency in schools. Similar to the previous study, our research will focus on how students performance, alertness and well being are affected over an entire academic year but this time via LED light. To help facilitate these objectives we have created a custom luminaire developed specifically for this project. The most exciting aspect of this study is that the students are older and in a hormonally unbalanced age.”

How does LED fit into the picture?

“Our latest research findings show that LED technology gives a light that is perceived to be “brighter and better” than the light from a T5 fluorescent lamp, even if the lux-meter show the same value. This paves the way for even better lighting in our schools, with even greater energy savings.”

Four research projects: Proof of the effects of ambient light

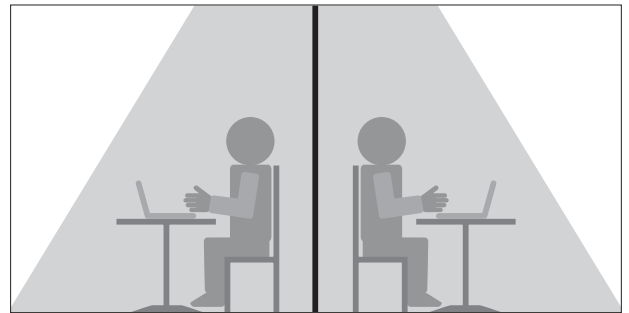
Believing is one thing; knowing is something else. At Fagerhult we have always maintained that only direct light on the working surface is not enough. That's why we have worked with combinations of direct and indirect light that also illuminate the ceiling and walls. Four different studies, undertaken during a ten-year period, confirm our view.



1. The optimal work light.

In collaboration with Jönköping University, 2001.

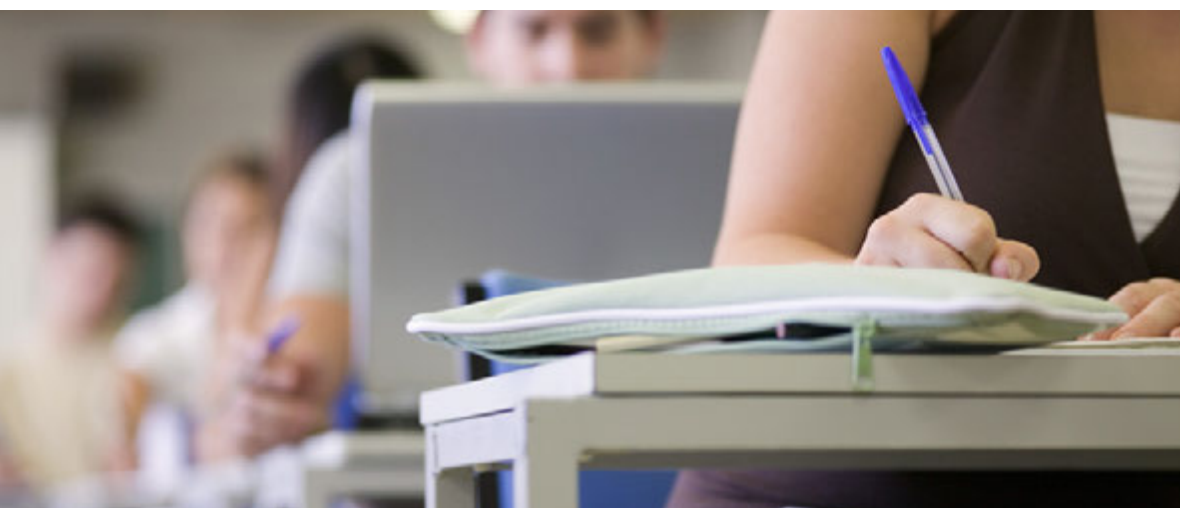
What light distribution is the most agreeable in a work situation? The study took place at Jönköping University and the aim was to determine what light distribution the people participating in the study preferred – both visually and emotionally. The study space was lit solely by luminaires, completely without incidental daylight. The result confirmed that a combination of direct and indirect light – which not only provides sufficient light levels on the work surface, but also creates ambient light by illuminating the ceiling and walls (vertical light) – was preferable.

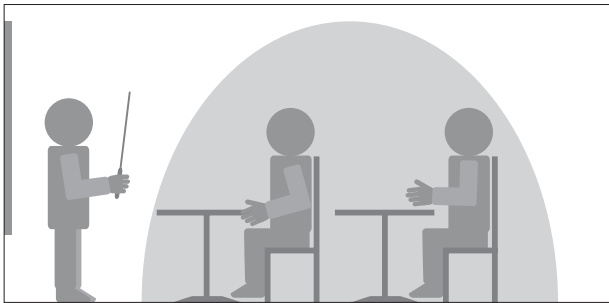


2. The effect of ambient light on alertness and well-being. In collaboration with the Faculty of Engineering (LTH), Lund University, Åhus 2007.

How does incidental light affect human well-being? The study investigated how people are affected by working in a room with three different levels of ambient light and colour temperatures. As in the earlier study, there was no daylight. During the test the participants' visual, biological and emotional reactions were studied by means of interviews and measurements of cortisol and melatonin content.

The study showed that ambient light is highly significant not only for the visual task, but also for emotional state and alertness. The most positive reactions were registered at an incidental light level of 100 cd/m^2 and a colour temperature of 3000–4000 K.

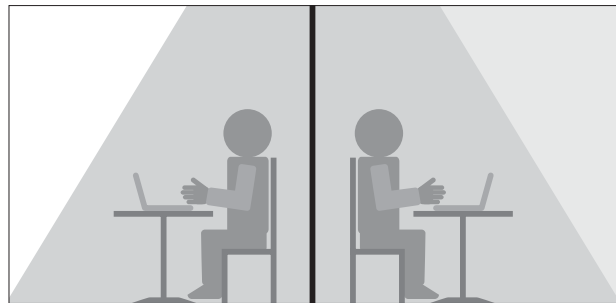




3. The effect of ambient light on learning.

In collaboration with the Faculty of Engineering (LTH), Lund University, and University College London. London 2009–2010.

The study took place at a primary school in London. The aim was to investigate how the pupils were affected by working in a classroom with a greater proportion of light on the walls and ceiling. The classroom had daylight and the lighting was designed with daylight and presence detectors to optimise energy consumption. The pupils' performance, alertness and well-being (Visual, Biological and Emotional) were studied over a period of a whole year with the help of interviews and hormone measurements. The results were then compared with pupils who followed the same school schedule in identical classrooms with standard lighting. The study showed that the pupils in the test classroom, with a higher level of ambient light, were not only more alert in the morning but also achieved better results in mathematics, reading and writing, especially during the dark period of the year.



4. Opportunities for energy savings with LED.

In collaboration with the Faculty of Engineering (LTH), Lund University. Åhus, 2011.

The aim of the study was to investigate how people are affected by working in LED light. Exactly as before, Visual, Biological and Emotional aspects were studied by means of interviews and hormone measurements. The study confirmed earlier surveys showing positive effects in connection with higher levels of ambient light. It also showed that those participating in the study perceived the light from LED as brighter than from a traditional T5 light source, which presents opportunities for energy savings. Fagerhult has therefore taken the initiative in commissioning a new study, being conducted during 2012–2013 in a Swedish high-school, which aims to identify the optimal working levels for LEDs.

Learn more! Research reports and summary articles at our web site.





Deakin University, Victoria





Principles for lightsettings in the control rooms in the London-study.



Principles for lightsettings in the experimental rooms in the London-study.

Break the rules. Dare to use more light

In Australia and New Zealand the aim of our standard AS/NZS 1680 is to create a visual environment in which essential task details are made easy to see and adverse features which may cause visual fatigue are either excluded or appropriately controlled.

As suggested in AS/NZS 1680.1, it is recommended the design should focus on the improvements in lighting quality rather than the provision of higher illuminances. However tests conducted by Fagerhult have shown higher levels of illuminance within educational environments can increase productivity and attention levels in students.

Lighting of the working area

Australian lighting standards state various recommendations regarding minimum illumination levels for educational and training facilities. Important factors to be addressed when creating a suitable environment for educational purposes are the nature of the tasks which will be conducted within the room, the distribution of light, the efficiency and the finishes which have been used on the walls and ceiling.

Australian standards do not have a set lux level for vertical lighting of walls, although tests have shown that the amount of vertical light on walls can contribute to a student's attention levels, well being and increase productivity in the



classroom. Reflectances of walls also play an important role in contributing to the comfort and appearance of the room. The contribution of wall reflectances to the illuminance of the working plane is relatively small, except in areas which are adjacent to the walls.

Another aspect to consider is the amount of indirect light upon the ceiling. The properties of a ceiling affect both the viewer's perception of a room and contribute to the illuminance on the working plane. Australian standards do not have a set lux level for ceilings within educational environments, but do have a maximum luminance for luminous ceilings stated in AS/NZS 1680.1, Clause 8.3.4.8.



The average luminance of the ceiling should not exceed 0.5 kcd/m² when viewed within the range of the appropriate angles, the maximum luminance at any point on the ceiling should not exceed 1.5 kcd/m².

Recommended lux levels

As the task being performed within the area is a crucial element to take into consideration, it is important the luminance of the task area is sufficient but in many cases the visibility of the task depends on the way in which light is applied. AS/NZS 1680.2.3 states the recommended lux levels for educational facilities which vary due to the wide

range of tasks which are involved.

See below the appropriate lux levels for common educational areas according to AS/NZS 1680.2.3:

- General Use - 240 lux
- Examinations - 240 lux
- Laboratories - 320 lux
- Lecture rooms - 240 lux
- Reading rooms - 320 lux
- Sewing rooms:
 - (a) General - 320 lux
 - (b) Task area - 800 lux



Better light without increasing consumption

Enhancing the ambient lighting in the classroom produces an increase in well-being and better academic results – without increasing energy consumption. New solutions with daylight and presence control optimise energy usage and compensate for increased levels of ambient light.

At the same time as Fagerhult undertook the study in London 2009–2010 (read more on page 9), a parallel study was also done on energy consumption. The study compared

energy usage in two similar classrooms – one had a new lighting system with daylight and presence detectors and the other had traditional lighting with manual power switches. The results showed that the an efficient and functional lighting control system made possible a definite improvement in the quality and quantity of lighting in the experiment classroom. Despite increased ambient lighting levels energy consumption could be reduced by over 30 % at a constant horizontal illuminance on the work tables.

By consciously optimising energy usage, you also make a contribution to the environment, both locally and globally.



The environment – to practise what you preach

The decision to install an intelligent control system that takes into account daylight and presence is not only related to health and financial aspects. By consciously optimising energy usage, you also make a contribution to the environment, both locally and globally. As always when

it comes to lighting, the greatest environmental impact is related to energy efficiency. At a time when there is ever greater focus on environmental education, lighting is a way to show that you practise what you preach.

Learn more! Research reports and summary articles at www.fagerhult.co.uk.



The Friends' School, Tasmania





Lighting classrooms

The quality of lighting in a classroom is essential to assist visual tasks and maintain attention levels. Students rarely spend the whole day with their focus solely directed at the desk. This is due to the constant interaction between the student, teacher, fellow pupils and the teaching surface (whiteboard, chalkboard or an interactive screen). This means the students gaze is constantly moving about the classroom and their focus is frequently changing. Student's eyes can be susceptible to becoming strained or tired due to contrasts between the lighting of the work surfaces, walls and ceilings; this is why it is important to ensure the appropriate concentration of light is distributed throughout the room. Inadequate lighting can also create difficulty for the student to focus on the teacher, causing the students concentration levels to fall.

As many classrooms require good visual communication for teachers and students to interact it is good practice to consider cylindrical illuminance. Cylindrical illuminance affects our ability to interpret faces, objects and what is

happening around us, good cylindrical illuminance creates an effective working environment within educational settings.

Classroom checklist

- Who will use the room?
AS/NZS 1680.2.3 states that until students are around 6 to 8 years old, they cannot achieve the acuity (the ability to detect fine detail) that older students can. It is important that the limits of the visual system for younger students are taken into consideration by the designer.
- What tasks will be performed?
Areas which involve reading as one of the main tasks require good uniformity of light whereas areas involving practical and intricate tasks require high levels of light and for areas involving work with colours and design the colour rendering properties of the light source are vital.



Luminaire solution – DTI

DTI is a distinctive luminaire with a combination of direct and indirect light distribution for a varied environment. The luminaire both meets the need for a perfect task light on the table surface while at the same time providing indirect light on the ceiling and the walls. DTI can be supplied with Fagerhult's wireless e-Sense Connect.



Luminaire solution – Lento

Lento is a whiteboard lighting solution developed specifically for this purpose. The light distribution is via lined diffuser, which reduces indirect reflections on the board. This approach also minimises the risk of glare for pupils or teachers when turning their attention towards the board.

Lighting control in the classroom

Programmable controls in a classroom allow the lighting to be adjusted according to user and usage requirements. Lighting can respond either manually or automatically, and different scenes can be created. Maximum and minimum light levels, and on/off functions can be changed and adapted. Within a classroom the controls solution should contain an absence-detection function, with the lighting

turned on manually. This ensures lights are switched off when the room is empty, while also protecting against the luminaires being switched on when not required.

Fagerhult's e-Sense controls system is ideal for educational institutions. Available with a range of functions, such as absence detection, daylight linking and pre-set lighting scenes, the system is designed for quick and easy installation – saving both time and money.





Lighting for Lecture theatres

Lecture theatres are usually characterized by a stepped floor which can be steeply raked; these features are designed to improve the line of sight. Each step should be defined by the use of aisle lighting to provide a contrast between the step and its riser. When lighting a lecture theatre it is important to create a contrast and a focal point where the lecturer or speaker is slightly brighter than the backdrop of the theatre. This can be partially achieved by the appropriate use of surround and directional lighting but also by the choices made about the surrounding reflectances.

Lighting control in Lecture Rooms

The control panel should be located by both the lecturer's position and by the doors. It is likely that scenes would include full lighting for entrance, exit and note taking and a reduced light level for slides or films.



Luminaire solution – Pleiad SLD G3

Pleiad SLD G3 is an energy-effective LED-based downlight that handles demanding lighting tasks even in large rooms with high ceilings. Its unique Anti-Glare Control ring ensures a glare free light, while the high calibre LED's offer exceptional colour consistency. The longevity of the light source is a big advantage in this type of environment.



Luminaire solution – Pleiad LED Wallwasher

Pleiad LED Wallwasher provides a lot of light on the walls without glare. It's even distribution contributes towards a dynamic environment that emphasis the character of the room. Being an LED solution, the life-span of the light source helps minimise the maintenance required.

Lighting for IT rooms

Recommended lux levels for IT areas vary depending on the detail of the task involved. According to AS/NZS 1680.2.2 table E1 tasks with average detail will generally require 320 lux whereas tasks that involve work with fine detail require 600 lux. It is recommended the background of IT rooms should achieve 160 lux as the main focal point will be on the task involved and not necessarily the surrounding area, although if the background area is significantly lower than the task area discomfort / glare can affect the worker.

Lighting control in the IT room

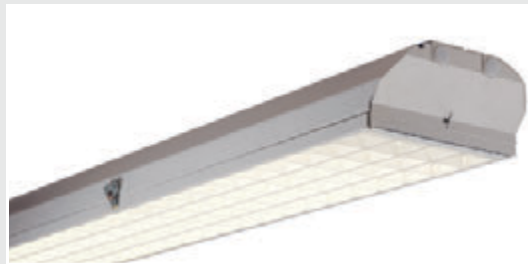
Lighting in IT rooms should be manually switched on and automatically switched off. It is important to switch the lights on manually as the room may only be used for short and irregular periods. Switching them off automatically is essential to ensure low energy consumption and that the lighting is on only when necessary. After the last detection in the room the lighting can remain on for a set number of minutes before it is switched off. Some IT rooms border two classrooms, and switching and control can then take place from both doors.





Lighting for sports halls

It is important to realise sports halls and Indoor multi-purpose areas can involve several types of sports and activities. These activities will determine the recommended levels of illuminance. As stated in AS/NZS 2560.2.2, areas for recreation and training will generally require a minimum of 300 lux and 0.5% uniformity to be satisfactory for the tasks being undertaken. Activities at a competition level will require 500 lux and 0.7% uniformity to be sufficient. When lighting sports halls or multi-purpose areas special consideration should be given to the main types of sports and activities being undertaken within the space and the difficulty of the tasks involved. Fittings used in sports areas should be able to withstand impact and should be protected by a wire guard or a tough transparent cover to avoid damage.



Luminaire solution – Excis

Eagle Lighting Australia suggests using the Excis, as it can be dimmed to various lux levels to suit a range of sports and levels of play, such as training or competition.

The Excis has a wire reinforced louvre which is durable and protects the light source, this makes the Excis an ideal fitting when looking to provide the right option for indoor sports halls and multi-purpose areas.

The avoidance of the visual distraction is important in any sporting activity, and especially so in activities such as basketball and badminton, where competitors have to pick out fast moving objects above head height.

Disability glare must be avoided, fluorescent luminaires give little direct glare and have a much lower surface brightness than HID, so offer less contrast that may dazzle a player, referee or even a spectator.

T5 fluorescent luminaires on HF control gear also offer significant reductions in lamp flicker compared to conventional HID high bay luminaires due to the T5 lamp running at 40kHz.

Sports hall checklist

- What activities are taking place?

Numerous sports can be undertaken within a sports hall. While a general lighting level of 300 lx will be sufficient for most activities there are some exceptions. For instance, if the hall will be used for cricket practice the high speed and characteristics of the ball require a higher lighting level (750 lx is recommended). Equally, sports halls are often used for exams where 500 lx is more appropriate.

Lighting control for sports halls

A control system is useful in a sports hall. Intensive yet irregular activities are held and the hall is often left without supervision for long periods. With the help of an occupancy

detector that switches off the lights after a period of inactivity it is possible to make significant energy savings. The ability to create different scenes is crucial as not only are sports halls used for activities other than sports, but the light level used for school and college sports can differ to that needed for training and matches in leagues and competitions. It is common for a sports hall to be divided into several sections with the help of partition walls, so that parallel lessons can take place in smaller areas. Automatic division of the lighting with the use of partition walls is possible with a control system. From a design perspective, when lighting controls are used the switching should, where possible, be installed in an office rather than the hall itself to safeguard against damage.



Ringwood Heights Primary School, Victoria

Lighting for circulation areas

Corridors have a key function that affects both logistics and perception. Providing a visually stimulating route throughout the space is essential for orientation, circulation and as a means of escape. Attention should be given to the ceilings and walls to avoid creating an environment which appears lifeless. Consideration should be given to illuminances in adjacent spaces to avoid notable changes between areas. Vertical illuminances should also be considered for the recognition of people and the detection of obstacles. Uniformity is a significant factor within corridors as good uniformity will prevent a 'light dark' effect.

Corridor checklist

- What size is the corridor?
In corridors with a high footfall, ceiling mounted luminaires reduce the risk of damage compared with wall mounted variations. In wider corridors, 3.5 m +, the placement of a wallwasher on the outer edge of the ceiling help avoid a lifeless space.
- Uniformity or drama?
Most corridors require uniform distribution of lighting. This avoids pools of light upon the floor and a 'light dark' effect.
- Avoid glare!
Luminaires that are too specular run the risk of glare as you move along the corridor.





Luminaire solution – Vidi

Vidi is innovative corridor lighting solution with a large proportion of incidental light for a more varied experience and a clearer sense of space. Vidi ceiling helps orientation in the communication area via a combination of direct light towards the floor and indirect light towards the ceiling. Vidi corner creates vertical incidental light that accentuates the walls and increases orientation without creating a gloomy corridor feeling.



Luminaire solution – Pleiad SLD G3

Pleiad SLD G3 is an effective LED downlight with excellent light ergonomics. Its high light output is exceptionally shielded, well suited for communication areas. The high colour quality is also important for applications such as corridors where the continuous line will bring the disparities to the fore.







Lighting of cafeterias and dining rooms

Cafeterias and dining rooms should provide a warm, welcoming and relaxing break from the working environment. Different sections of the room can be separated by the use of various types of lighting such as suspended luminaires above eating areas to create physical spaces for socialising, whilst servicing counters and checkouts can be emphasised by their own lighting.

Lighting control for cafeterias and dining rooms

By including a control system in this space, you can create a variety of scenes that change the character of the room depending on its use. Fully lit for meals during the day or dimmed to a lower level in the evening to create a warm and intimate feeling.



Luminaire solution – Pozzo

Pozzo is a range of decorative luminaires that uses natural light as its role model. Their large opal louvres provide generous, luminous surfaces that spread the light effectively, even out towards the walls, without causing glare.

Lighting libraries

Libraries can range from very basic rooms to complex rooms with various task areas. Focus should be given to the lighting of bookshelves and visibility of the spines of the spines of books. Study and reading areas will generally need 320 lux due to the nature of tasks being conducted. Task lighting above study desks can be useful to distinguish its purpose and provide suitable light for reading, writing and studying. A well lit library will make it easy to navigate and find the right shelf.



Luminaire solution – Liverti

Liverti is a luminaire with a round beam that provides a good direct light with a certain proportion of indirect light out towards the walls and ceiling. The range includes both large suspended variations for higher ceilings and ceiling-mounted variations for mounting in smaller rooms and mezzanines.



Luminaire solution – Libraline

Libraline is bookshelf lighting system that has been specially developed for libraries. The luminaires high quality light distribution ensures that even the lower shelf positions are well-lit.



Guides and Legislation

Introduction

AS/NZS 1680.1 Section 2 General Requirements of Good Interior Lighting, Section 2.1 The Importance Of Quality Lighting

Lighting of the working area

AS/NZS 1680.2.3, Part 2.3 Specific applications – Educational and training facilities

AS/NZS 1680.1, Section 8.3.4.8 Maximum luminance's for luminous ceilings and indirect lighting system

Recommended Lux Levels

AS/NZS 1680.2.3, Part 2.3 Specific applications – Educational and training facilities, Appendix D Table D1

Classroom Checklist

AS/NZS 1680.2.3, Specific applications – Educational and training facilities, Section 3.2 Special considerations for very young observers

Lighting of Lecture Theatres

AS/NZS 1680.2.3, Specific applications – Educational and training facilities, Section 10.14 Lecture Theatres, Section 10.15 Auditoriums and General purpose halls

Lighting of Sports halls and Indoor Multi-purpose areas

AS/NZS 2560.2.2 Part 2.2 Lighting of Multi-purpose Indoor Sports Centres Table 2

Lighting of Circulation areas and Corridors

AS/NZS 1680.2.1, Specific applications – Circulation spaces and other general areas

Lighting of Libraries

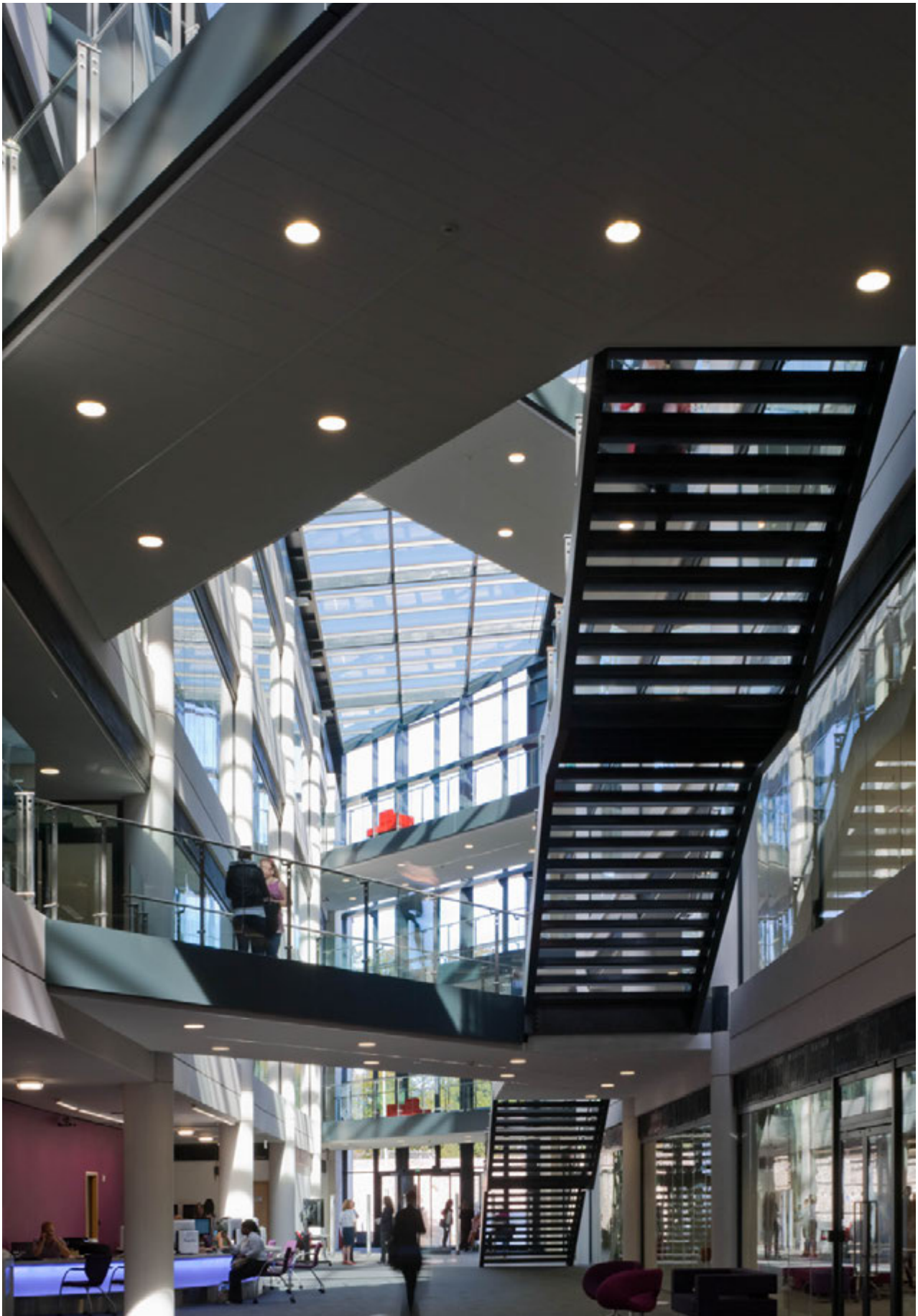
AS/NZS 1680.2.3, Specific applications – Educational and training facilities, Section 10.19 Libraries and Learning Resource Centres

Lighting of IT rooms

AS/NZS 1680.2.2, Specific applications – Office and screen-based tasks, Appendix E Table E1

Lighting of Cafeterias and Dining rooms

AS/NZS 1680.2.1, Specific applications – Circulation spaces and other general areas, Appendix D Table D1



Fagerhult develops, manufactures and market professional lighting systems for human environments.

Our operations are run with a constant focus on design, function, flexibility and energy saving.

Fagerhult is a member of the Fagerhult Group, the largest lighting group in the Nordic region and a leading company in Europe.

We have offices in more than 15 countries and production units in Europe, China and Australia.

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