Fördergemeinschaft Gutes Licht

Good Lighting for Schools and Educational Establishments 2

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Learning is a life-long process. In modern knowledge society, in a world becoming increasingly complex and high tech, we need to be prepared to keep on acquiring new knowledge and learning new skills.

From kindergarten to university, vocational school to adult education centre, there are a host of institutions available to help us do this. They deliver the basic education we need, they help us build up our knowledge of mathematics and languages, sciences and subjects vital for our career, they teach us problem-solving skills and techniques for learning.


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One important requirement for successful life-long learning is the right educational environment: a school which recognises talent and ability, encourages active and independent learning, makes education an enjoyable experience and motivates both students and staff.

Motivation and a sense of wellbeing, architecture and lighting, good visual conditions and efficient learning - these things are closely connected, as the solutions presented as examples in this booklet will show.

Learning environment and life environment

Germany has a population of more than 80 million - and 39 million of them are enrolled at some kind of school or educational establishment. So 49% of the population - nearly every second person - spends time in a learning environment.

For a number of years, the Organization for Economic Cooperation and Development (OECD) has been studying the way we learn. At regular intervals, a quarter of a million schoolchildren in 32 countries are tested in three key areas: reading, mathematics and scientific literacy. The results of the surveys are published in PISA (Programme for International Student Assessment) studies.

One of the most important things about the PISA studies is that they identify successful educational models. Comparison of the various countries and their respective education systems reveals marked differences - differences which provide answers to the question: "How can we learn effectively?"

When children first start school, most of them are ready and willing to learn. How that willingness is encouraged, stimulated and shaped into an attitude for life depends on lots of factors: the learner, the teacher, the social environment formed by parents, friends and colleagues - and the educational infrastructure in terms of human resources, premises and technical facilities.

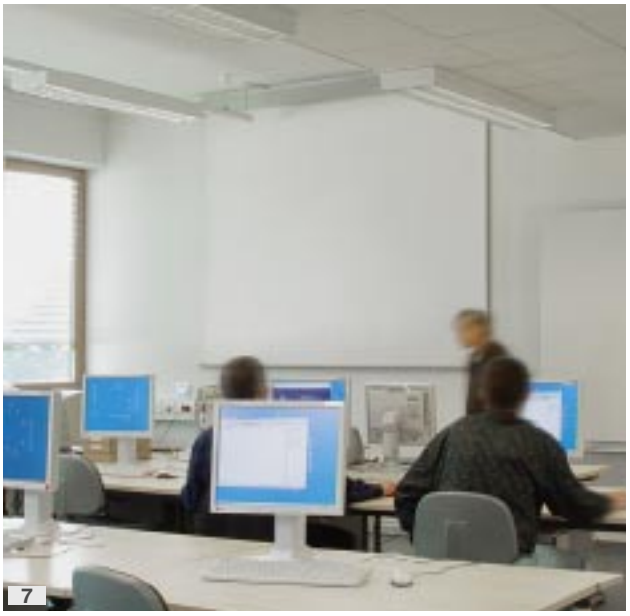
The PISA studies show there is a connection between success in education and a motivating school environment. Students who identify with their educational environment, who like going to school and feel at home there, enjoy learning, overcome learning difficulties more easily and do better at school.

So students have to be stimulated and encouraged. To learn well and effectively, we need to enjoy learning; it needs to be a pleasurable experience. And age makes no difference. Wherever we learn - from kindergarten to university, at vocational school or adult education centre - the need for motivation is of paramount importance.

Innovative schools are required - schools which provide a motivating environment for active and independent study, schools which promote individual talent and ability instead of just presenting a rigid one-size-fits-all curriculum for large groups. Inflexible forms of education and training need to make way for dynamic life-long learning, where study and skill acquisition are seen as a permanent part of putting what has been learnt into practice.

The innovative school also sees itself as part of our life environment, however, a place for both study and recreation, where people learn together but also share experiences. A school which is geared to this offers students and teachers the chance to work more flexibly together, to identify strengths and weaknesses and develop life-long learning strategies.

The PISA studies also show that a positive learning environment promotes motivation. A school with well-designed premises and well-equipped classrooms, with computers and specialised literature, libraries and multimedia resources, boosts students' readiness to participate actively in the learning process. So an investment in the school environment is an investment in the future of the knowledge society.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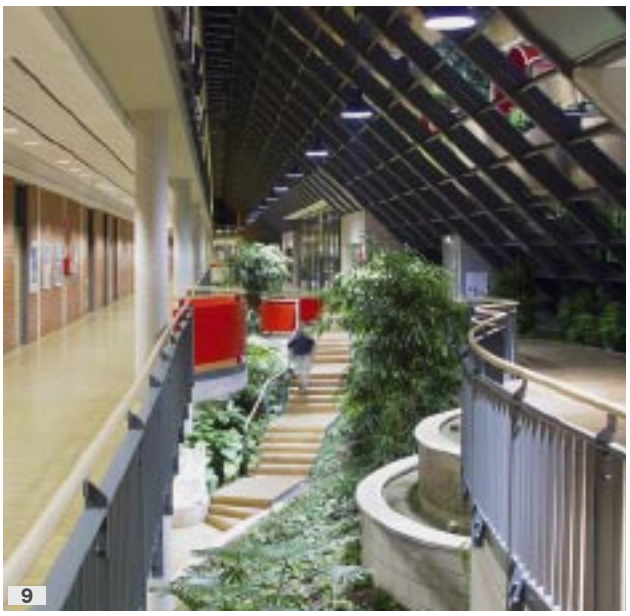
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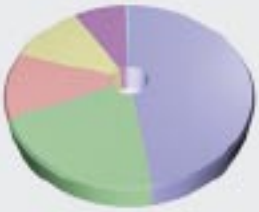
Education in Germany

39 million people of all ages in Germany are enrolled at schools, universities and other educational establishments. 20 million children, pupils and students attend the country's more than 100,000 kindergartens, schools and universities. Nearly half of these educational establishments are day care centres, catering for more than five million children. The smallest group of educational establishments - the country's 355 universities - are attended by over 12.8 million students.
Almost exactly as many people are in further education: 19 million Germans and foreign nationals in Germany regularly attend courses at adult education centres, upgrade their occupational qualifications at chambers of industry and commerce or pursue courses of study at open universities.



Kindergardens, schools and universities

day care centres	48,203
nursery and primary schools	20,695
secondary schools	12,079
vocational schools	11,372
other schools	8,667
universities	355

(figures indicate actual number of establishments)

Children, pupils and students at

kindergartens and crèches	5,169
nursery and primary schools	3,600
secondary schools	6,449
vocational schools	2,773
universities	1,868

(figures indicate numbers of persons in thousands)

Adults in further education at

state-funded adult education centres	9,392
other adult education centres	8,534
chambers of industry and commerce	596
chambers of handicrafts	278
distance-learning institutes	121

(figures indicate numbers of persons in thousands)

All data taken from the basic and structural statistics (Grund- und Strukturdaten) published by the Federal Ministry for Education and Research and the school statistics compiled by the German Federal Statistical Office

We experience our environment first and foremost through our eyes. 80 percent of the sensory impressions we receive are visual. Too much or too little light, glare or distorted colours impact on what we perceive, distract our attention and cause visual fatigue.

In all areas of life and throughout the working world, good and appropriate lighting is a prime requirement for enabling us to see clearly, enjoy a sense of wellbeing, perform concentrated fatigue-free work and perceive and interpret important information and our surroundings correctly. This calls for good, professional lighting design.

Below are some of the key factors that need to be considered for good lighting design.

Illuminance
In daylight, the illuminance of an illuminated surface is between 10,000 lux (overcast sky) and 100,000 lux (bright sunlight). Indoors, we need to make do with much less light. For writing and reading, it is generally enough if artificial lighting provides 500 lux illuminance; for drawing or other visually demanding tasks, illuminance should be at least 750 lux. For more information about illuminance values and the requirements of the relevant industrial standard, DIN EN 12464-1, see page 46.

The values set out in the standard, however, are minimum requirements. Most people find a higher level of illuminance more agreeable and more motivating. In winter especially, when the levels of daylight entering a room are lower, more light is needed to avoid fatigue and loss of concentration.

Brightness distribution
When we are in a room, our gaze incessantly switches from near (desktop) to far (walls). Where there are marked differences in brightness between these two zones, our eyes face the constant need to re-adapt and thus get tired more quickly. Visual performance and sense of wellbeing diminish.

Where the differences in brightness are not marked enough, however, the room makes a monotonous impression. It is recommended here that desktop luminance should not be less than 1/3 of the luminance in the immediate surroundings. For more remote parts of the room, the difference in luminance should be 1/5, max. 1/10.

Glare limitation
Glare is one of the most unpleasant visual problems of all. Being dazzled by a general-diffuse lamp or the reflection of a window on a computer screen affects our visual acuity and impedes our performance. Direct and reflected glare can be largely avoided by good room and lighting design.

Modelling
Without light we cannot see an object at all, without shadow it is just a two-dimensional image. Only where light comes from the right direction and where the depth of shadow is correct can we perceive objects as 3D images and gauge distances. To recognise three-dimensional objects, surfaces and structures, we need light and shade.

Glare

Glare is one of the most disturbing side-effects of lighting. Direct glare caused by marked contrast differences between very bright and very dark surfaces or due to unshielded lamps in our line of vision place a strain on our eyes and lead to fatigue and mistakes through loss of concentration. To avoid direct glare from lamps, care should be taken to select only luminaires which are suitable for workplace lighting. Direct glare limitation is indicated by a UGR index, which should be 19 *(Fig. 13)*.
Equally unpleasant and fatiguing for the eye are frequent switches between bright and dark room zones, e.g. between window and desktop *(Fig. 15)*. This can be avoided by correct positioning of desks, light-control blinds and good lighting *(Fig. 14)*.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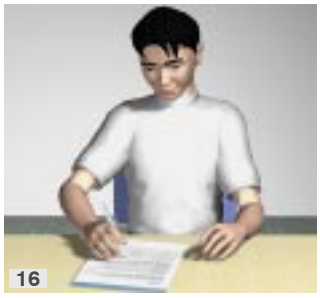
Shadowing

Where there is light, there is also shadow. To ensure that shadows do not impede our view when writing, the light should fall - for a right-handed person - from the left *(Fig. 16)*. If the light comes from the right, we write in the shadow of our own hand *(Fig. 17)*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Light and colour

The way we perceive colours under artificial light depends on the colour rendering properties of the lamps. Lamps with good colour rendering properties produce natural colours *(Fig. 18)*, lamps with poor colour rendering properties cause colour distortion *(Fig. 19)*.


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Reflections on paper

Especially where glossy materials are used, poorly shielded luminaires cast disturbing reflections *(Fig. 21)*. Well shielded luminaires avoid this effect and permit all materials to be studied with ease *(Fig. 20)*.


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More information is contained in booklet 1 of this series, “Lighting with Artificial Light“.

Vertical illuminance

Schools and educational establishments are communication-intensive places where clear identification of faces and information is essential. The key lighting requirement here is vertical illuminance, i.e. uniform bright illumination of vertical surfaces such as blackboards or three-dimensional objects such as people's faces.
For blackboard lighting, wallwashers are a particularly suitable choice because they illuminate the writing surface uniformly without casting shadows or reflections *(Figs. 22 and 24)*. Where additional board lighting is not provided, shadows are cast onto the writing surface *(Figs. 23 and 25)*.
Direct lighting from above often causes undesirable shadowing on faces *(Fig. 27)*. In consultation zones, this shadowing is reduced by asymmetrical or direct/indirect lighting *(Fig. 26)*.


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Bright walls

Good wall and entrance lighting helps people get their bearings in a room, makes for better contrasts and emphasises room zones. It also makes the room look a livelier, more interesting place *(Fig 28)*.


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Direct/indirect lighting

Luminaires with direct and indirect lighting components permit free arrangements of desks, reduce the risk of reflected glare and create a more agreeable lighting atmosphere *(Fig. 30)*.


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Reflections on monitors

Where luminaires are poorly shielded or wrongly positioned, visibility is impaired by disturbing reflections on monitors and losses of contrast *(Fig. 33)*. This is avoided by good lighting design and good luminaires *(Fig. 32)*.


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Light for learning

Many educational establishments today consist of large complexes of buildings with lots of special classrooms, events and sports halls, cafeterias and refectories, administrative offices and conference zones. Schools, in particular, meet this description because a growing number of them now spread classes throughout the day.

Every room in a school or educational establishment serves a particular purpose, for which there are special architectural solutions with special lighting requirements. Examples of systems which meet those requirements are found on the following pages of this booklet.

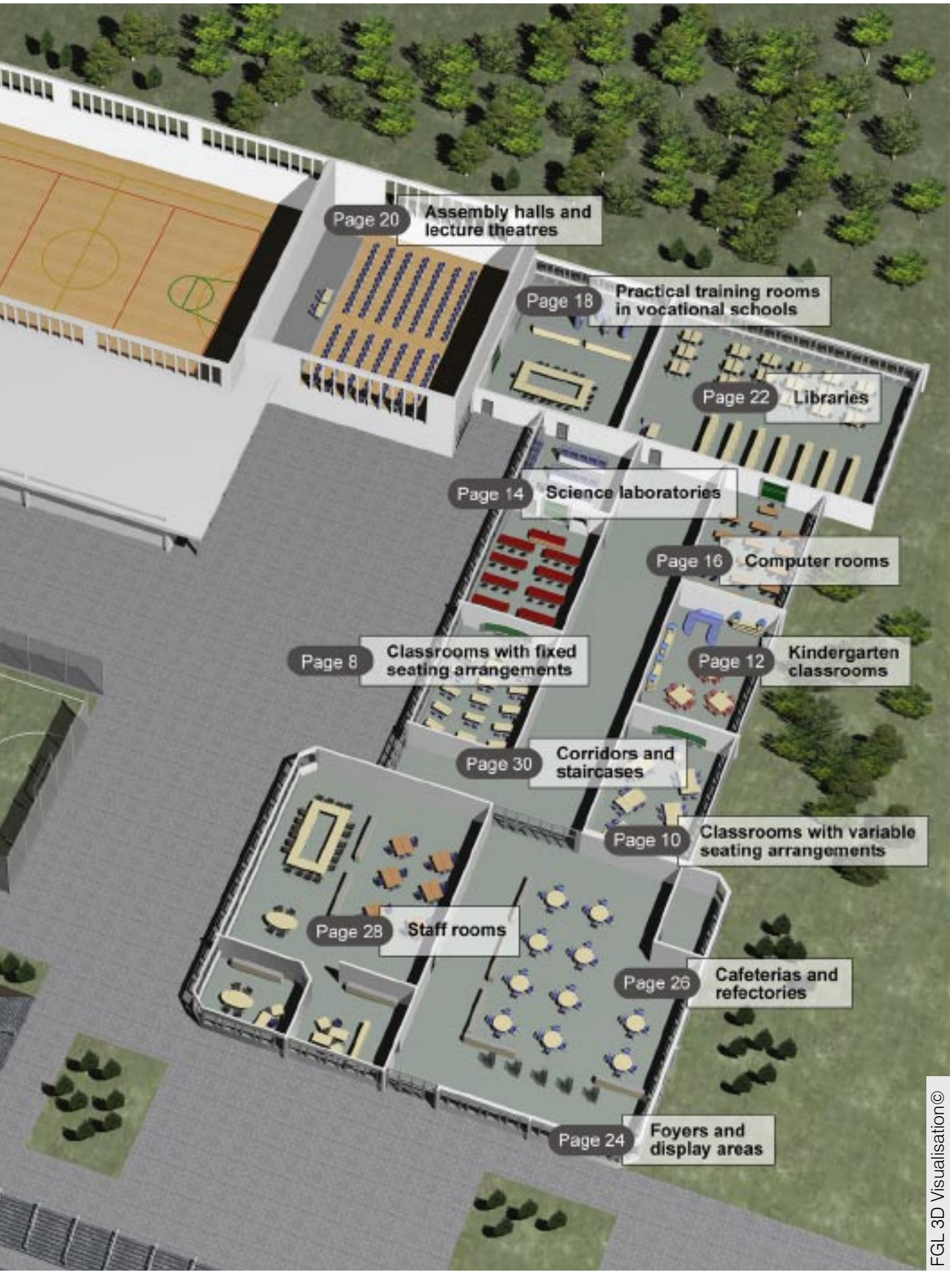
For any room in a new or refurbished building, the aim should be to find the best way of harnessing natural daylight and the requisite artificial lighting. Here, however, the importance of artificial lighting is often underestimated, although it plays a major role in most classrooms. In winter especially, the available daylight is generally not adequate. For media work with projectors, windows need to be darkened. And for scientific experiments, a special lighting situation is frequently necessary.

However, planning artificial lighting involves more than just ensuring adequate brightness in a room. A differentiated lighting design incorporating various separately controlled luminaire systems permits the creation of lighting scenes tailored to requirements. With dimmable room lighting, separate wallwashers at the front of the room and additional luminaires at the entrance and perimeter, it is also possible to stage multimedia presentations, lectures and exhibitions with lighting fine-tuned for suitability and safety.

Today, economical operation of lighting systems is assured by energy-efficient lamps and operating gear, high-grade luminaires with high light output ratios as well as lighting control systems which automatically adjust the brightness of lamps to suit the daylight component available and deactivate lighting when a room is not used. Modernising lighting systems when premises are refurbished can reduce the annual lighting costs of old school buildings or other educational establishments by more than 60%.

But lighting design must always focus primarily on human beings, the activities they perform in the room in question and the visual tasks they need to address. What kind of lighting is needed? How much light is right? And what kind of lighting system is required to provide it? Lessons conducted from the front of the class call for different lighting than group work, presentation area lighting has to cater to different needs than play area lighting, and reading and writing have different lighting requirements than tasks performed at computers or machines.

On the following pages, we look at the types of room most commonly encountered in schools and educational establishments and present model solutions for them and photographs showing theory put into practice. These are not a substitute, however, for individual lighting planning.



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Classrooms with fixed seating arrangements

In classrooms with fixed seating arrangements, the principal viewing direction is towards the blackboard. The desks here are positioned perpendicular to the window wall. Room lighting is generally provided by louvered luminaires arranged parallel to the windows. The deeper the classroom is, the more rows of luminaires are required. With room depths up to eight metres, three rows of luminaires normally suffice; in deeper rooms, four or more rows should be planned.

Depending on the ceiling system, linear or square louvered luminaires are recommended. With higher ceilings, pendant luminaires with an indirect lighting component are also an option. These additionally illuminate the ceiling, giving the room a more open, spacious appearance.

On an overcast day or in winter, the incident daylight from a window wall is normally not enough to provide adequate illumination for the desks in deeper parts of the room. The rows of luminaires should therefore be separately switched and dimmable. The lighting can then be adjusted for uniform brightness throughout the room.

Modern luminaires with daylight sensors perform this task and regulate the distribution of light automatically. Where very little daylight is available, all the luminaire rows are activated and set at brightness levels which rise with room depth. As soon as the daylight increases, the luminaires are uniformly dimmed down.

The blackboard needs to be clearly visible from every desk. Shadows and reflections on the board make it hard to read what is on it and cause visual fatigue. The result: loss of concentration and motivation. Wallwashers with asymmetrical beams provide the right lighting at the front of the room, delivering high vertical illuminance and avoiding disturbing shadows and reflections.

When positioning wallwashers, care must be taken to ensure adequate planar illumination so that the board can be raised and any extensions opened without any part of the board being outside the illuminated area. Flipcharts or maps positioned alongside the board should also be uniformly illuminated by the wallwashers. For overhead projector, beamer or TV presentations, the wallwashers should be separately switched and dimmable to enable the illuminance to be adjusted to suit the occasion.

Accent lighting can significantly improve the visual ambience of a classroom. Supplementary wallwashers or spots for illuminating notice boards highlight displays in the room and create a more differentiated lighting landscape. Additional downlights at the room entrance provide more light for hazard zones and can be linked to the emergency lighting.

To help avoid unnecessary, uneconomical lighting, lighting systems can be fitted with presence control systems. When a room is vacated, e.g. at breaktimes or at the start of a free period, the lighting is automatically deactivated and reactivated only when the next person enters the room. Such systems can considerably reduce electricity bills for lighting.


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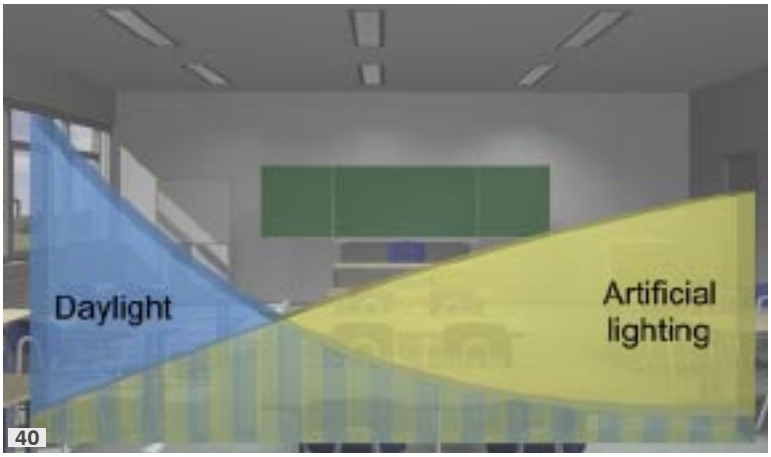

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Wallwashers provide uniform, shadow-free illumination for vertical surfaces such as blackboards. They also avoid reflected glare and ensure good legibility at every desk in the classroom *(Fig. 36)*.

Daylight decreases with room depth. Separately switched and dimmable rows of luminaires make for uniform brightness throughout the room. Luminaires with daylight sensors automatically control or regulate light output *(Fig. 40)*.

Lighting tips

- Separately switched rows of luminaires can be activated or deactivated according to the amount of daylight available.
- Wallwashers for blackboard lighting heighten visual comfort.
- Presence control systems save energy by automatically deactivating lighting when a room is vacated.

Classrooms with variable seating arrangements

Classrooms are often used by different classes. In many cases, they are occupied by school groups in the mornings, by project groups in the afternoon and used for parents' evenings or adult education courses in the evening. As a result, desks and chairs are repeatedly rearranged to meet the different requirements. U-shaped arrangements of desks give way to desks pushed together for group work, which then give way in turn, perhaps, to a classical arrangement of rows. There is no principal viewing direction in the room and no defined presentation zone.

Daylight and artificial lighting need to be harnessed to cater for this flexible room use. Particularly important here is daylight control. Where desks are assembled in U-shaped arrangements or put together to form group desks, many of the group face the window. On a sunny day, the luminance - the impression of brightness - for anyone looking out of the window may be tens of thousands of candelas, whereas the luminance for eyes turned into the room is considerably lower.

Constant changes of contrast place a great strain on our eyes and lead to fatigue and loss of concentration. So for balanced brightness distribution, louver blinds or vertical blinds are needed to control daylight incidence according to the position of the sun. Modern lighting control systems with daylight sensors automatically adjust the angle of the blinds and adapt the artificial lighting component accordingly. Classes no longer need to be interrupted while someone closes or opens blinds or regulates the room lighting.

Just as with fixed seating arrangements, artificial lighting for variable constellations of desks needs to be designed to minimise glare. Lamps should not be directly visible from anywhere in the room. Luminaires with direct/indirect lighting components and appropriate shielding are particularly suitable here. They permit free arrangements of furnishings and largely avoid direct glare and reflected glare on glossy materials.

For communication-intensive teamwork or the discussion that takes place on parents' evenings, direct/indirect luminaires have the additional advantage of providing very uniform illumination throughout the room. Modelling is more balanced and the lighting is softer and more agreeable. Faces, in particular, are cast in a more natural and more attractive light. Lamps of warm light colour add to the visual ambience required for the room.

Even in classrooms with variable seating arrangements, the normal presentation area in front of the blackboard still requires special attention. Separately switched and dimmable wallwashers provide correct, i.e. reflection-free high-angled lighting for the board. For flexible presentation lighting of the kind required for presenting group projects, room lighting should be provided by separately switched and dimmable groups of luminaires. Media presentations with projectors can thus be seen clearly in all parts of the room.


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With lighting control systems, lighting and louver blinds can be tailored to room use - for media presentations as well.

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Lighting tips

- Where desk arrangements are variable, care must be taken to ensure glare-free vision in the direction of the windows and in the room.
- Light-control blinds should be provided so that windows can be darkened.
- The lighting should be designed to cater separately for different presentation areas.

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Kindergarten classrooms

At no time in our lives do we have the capacity for learning that we have in early childhood. In many cases, early promotion of learning plays a crucial role in shaping our willingness to learn in later years. Where kindergartens and day care centres arouse children's curiosity and convey to them the thrill of acquiring skills and making discoveries for themselves, they lay the foundations for successful life-long learning.

Among the fundamental things children learn at kindergartens and day care centres are spatial perception and recognition of colours, objects and people. The right lighting plays a crucial role here.

To develop 3D vision, we need light and shade. In a uniformly bright room in which objects cast no shadows and there are no surfaces lighter or darker than others, we are able to gauge neither size nor distance.

Harmonious brightness distribution in a room makes for subtle grading in lighter and darker parts of the room and differentiated modelling of all objects. In a room where brightness is harmoniously distributed, we can move around securely and confidently because we have no problem seeing and registering our surroundings in 3D.

Recognising colours and surfaces, textures and materials is one of the most important visual challenges of everyday life. Once we have developed the requisite skill, we can generally tell instantly whether an object is hard or soft, heavy or light. Identification of colours and surfaces is particularly important here.

Colours are created by light bouncing off surfaces. What we perceive as the colour of an object is actually the light of a certain wavelength which is not absorbed by the object's surface. So, for seeing and identifying colours and objects correctly, good lighting and good colour rendering by lamps are crucial.

In kindergartens and day care centres, the emphasis is on activities which are both educational and fun. Running around, forming groups and handling small objects are activities for which good room lighting is important. Often, however, groups engage in different activities at the same time. While one is actively honing skills, another might be taking a short break. Differentiated lighting for different play and rest zones - made possible by zonal dimming control - facilitates this.

Children need to be able to play - even on cold and rainy days when the playground is covered in snow or under water. For playing indoors, the lighting needs to be adequately bright. Where rooms are not bright enough, the risk of accidents increases and the children's motivation declines. The higher the level of lighting for play, the more likely children are to become actively involved, feel a sense of wellbeing and be willing to learn.

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Separately dimmable lighting makes it easy to divide a room into rest zones and activity zones. *(Fig. 48).* The results of good planning: the whole room is agreeably bright and harmoniously lit, even shiny toys cause no reflected glare and colours are naturally rendered *(Fig. 49).*

Here, attempting to do justice to an original design of room, the lighting designer has failed: the angled downlights in the pyramidal ceiling dazzle anyone entering the room and cause reflected glare on books. The back of the room is far too dark and colours look dull *(Fig. 50).*

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Lighting tips

- Harmonious brightness distribution makes for better 3D perception.
- Lamps with good colour rendering properties make for natural colouring.
- Bright rooms promote willingness to learn, activity and motivation.

Experiments with explosive hydrogen and light-refracting prisms make a lasting impression on every student. Physics, chemistry and biology lay the foundations for understanding the world of modern technology and a knowledge of atoms, elements and neutrons paves the way for many an academic future and career. So effective and enthusiastic learning here is all the more important.

Large experiments set up on the teacher‘s desk and smaller ones on the desks of students form an intrinsic part of scientific instruction. So an adequate level of lighting throughout the room is essential to ensure that even small objects are clearly perceived. The 500 lux stipulated in the relevant lighting standard is a minimum requirement. The more demanding the visual task, the higher the illuminance needs to be.

For safe handling of chemicals and technical equipment in class, harsh shadows on the desk top and reflections on glass and metal should be avoided. Luminaires with indirect lighting components provide higher vertical illuminance, making for more harmonious light distribution, softer-edged shadows and less reflected glare.

In all the sciences, correct recognition of colours is vitally important. Chemicals which differ only minimally in colour, the slightest discolorations in petri dishes and the colour coding of cables and connectors need to be clearly perceived. All lamps should therefore have good colour rendering properties. Fluorescent lamps with a colour rendering index of 90 and neutral-white light colour are recommended. Luminaire enclosures, e.g. Plexiglass panels, must not affect colour rendering - high-grade protective glass enclosures remain colour-neutral for years.

Pictures and films make complex matters clearer. To ensure that multimedia presentations involving TV sets or projectors are clearly discernible, the lighting needs to be dimmable. It is also recommended that different parts of the lighting system should be separately regulated. This enables, for example, the lighting at the front of the room to be dimmed during a presentation while the lighting for students‘ desks remains bright enough for taking notes.

Presentation area and blackboard require uniform, reflection-free lighting. Wallwashers or spots with asymmetrical beams provide glare- and reflection-free lighting with high vertical illuminance for the blackboard and the demonstration desk.

To ensure that all experiments are conducted in safety, safety precautions must also be considered for lighting. When room lighting is dimmed, steps and exits need to remain illuminated, e.g. lit by stair lights and an emergency light over the door. Experiments with fire and inflammable materials or gases should be conducted only at specially designated places. In experiment rooms and in the vicinity of the teacher‘s desk, it is advisable to install explosion-protected luminaires (degree of protection IP 66). Luminaires with conventional ballasts “flicker“ at 50 Hz. Where rapidly rotating objects are present, stroboscopic effects can occur if the speed of rotation is identical to the luminaire frequency. The rotating objects then appear to stand still. Luminaires with electronic ballasts prevent this effect.


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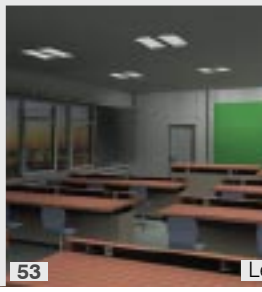
52 Experiment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Media presentation


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The technical installations of a science laboratory, e.g. power points or gas outlets, can also be integrated into the lighting. With direct/indirect pendant luminaires, desks can be freely arranged to accommodate large or small groups *(Fig. 59)*.

Bright lighting makes small objects easier to see; lamps with good colour rendering properties ensure accurate identification of colours *(Fig. 56)*.
Where television sets are used, the lighting for the front of the room should be dimmed *(Fig. 57)*.


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Lighting control systems facilitate changes in lighting *(Figs. 51 - 54)*. At the push of a button, the correct lighting is provided for experiments *(52)*, lectures *(53)* and TV- or projector-based media presentations *(54)*.

Lighting tips

- Bright room lighting facilitates the handling of small objects.
- Room and presentation lighting should be separately dimmable for experiments.
- Colours need to be perceived correctly. Lamps with good colour rendering properties are recommended.


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Computer rooms

In a world in which our work and knowledge is defined by computers, learning how to handle such media is crucial for success in today's knowledge society. Schools, in particular, have a duty to lay foundations for productive and constructive information acquisition as well as effective and efficient life-long learning.

As the PISA studies have shown, however, German schools achieve only mediocre results in classes designed to promote computer literacy.[1)] German students are keenly interested in using computers but, at the same time, they rate their ability to do so very low. This is largely due to the way schools are equipped: the average school in all the OECD countries has a computer for every 13 students; in Germany the seat at each screen is shared by 22 students. As regards the frequency of computer use in schools (several times a week or almost daily), German students appear at the bottom of the table with an 18% time allotment. The OECD average is 38%; in Hungary, Denmark and the United Kingdom it is more than 57%. German schools urgently need to catch up.

Planning a computer room entails paying attention to a number of ergonomic principles. Students need properly equipped rooms if they are to enjoy the learning experience and learn without having to combat fatigue. The desk top should be large enough to accommodate not just the monitor but also papers and work materials. Chairs need to be height-adjustable to enable large and small students alike to adopt a healthy posture.

As for lighting level, care must be taken to ensure a balanced ratio between the brightness of the screen, the desktop and the surroundings. Marked differences in brightness between the student's own work zone and the presentation area cause visual fatigue. Where a great deal of daylight falls on desks, windows need to be sun-screened. Separate lighting systems designed for individual dimming enable brightness levels to be tailored to different visual tasks. For students working at computers and receiving instructions by beamer at the same time, for example, the lighting at the front of the room can be dimmed to make the projected images more clearly visible.

Working at a screen calls for glare-free lighting. To avoid reflections, all desks should be positioned perpendicular to the window wall. Daylight then comes from the side and reflections on the screen are avoided. Luminaires should be mounted parallel to the windows. High-grade specular louver luminaires with special louver elements ensure glare-free lighting. Luminaires with direct/indirect beams offer greater visual comfort. A bright ceiling makes for more evenly balanced luminance, imbuing the room with a more natural and motivating atmosphere. Additional desk luminaires enable the lighting to be individually adjusted to suit the work situation.

1) Knowledge and Skills for Life, OECD, pp. 135ff.


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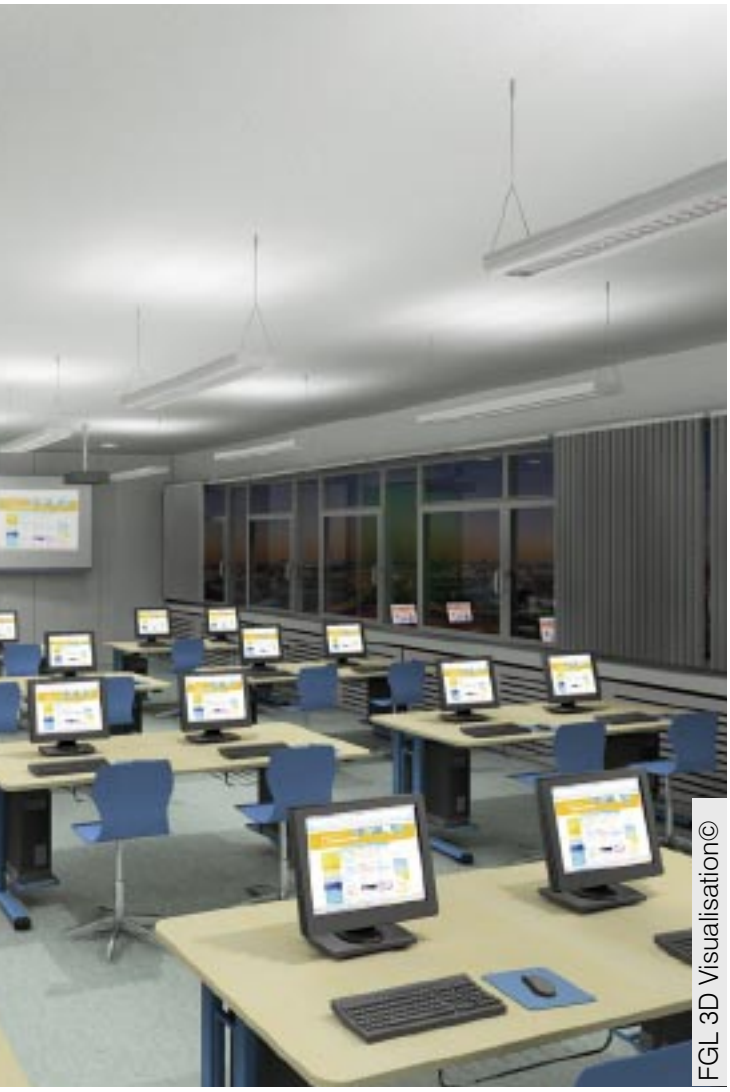
At computer workstations, luminaires need to be well shielded to prevent reflections being cast onto screens and ensure that colours are rendered accurately and screen brightness is maintained. *(Fig. 61).*

More information is contained in booklet 4 of this series, "Good Lighting for Offices and Office Buildings".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Lighting tips

- Lighting over desks and in the presentation area needs to be separately dimmable.
- Daylight incidence through windows needs to be limited by blinds or shades.
- Luminaires with good glare suppression minimise reflections and direct glare.


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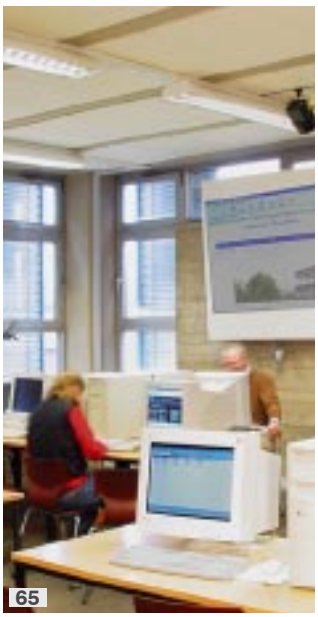
Lighting management systems permit control and regulation of individual groups of luminaires. Room lighting thus remains adequately bright while the presentation area lighting is dimmed *(Fig. 64)*.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Practical training rooms in vocational schools

More than 2.5 million people in Germany receive vocational training, most of them in preparation for traditional occupations in industry, commerce and the skilled trades. Along with courses providing commercial qualifications, the training options leading to qualifications as a motor mechanic, electrician, painter and decorator or doctor's receptionist are still very popular.

Much of the training for these occupations - the theoretical part at least - takes place in "ordinary" classrooms. These have been described on previous pages. Rooms where practical training is provided, e.g. at machines, are governed in industrial training facilities by the guidelines applicable to work premises and the relevant sections of DIN EN 12464-1.

Regardless of the nature of the activity performed, glare-free viewing of work materials and surroundings needs to be guaranteed in every practical training room. Colours must also be identified correctly, so only lamps with good or very good colour rendering properties should be used. Harmonious brightness distribution with balanced modelling and high vertical illuminance on work benches facilitates the handling of materials and equipment. Where dangerous tools such as knives are used - e.g. for woodworking or in butcheries - avoidance of hard-edged shadows is particularly important.

Rapidly rotating machines present a high safety risk. A/c-operated discharge lamps can "flicker" at the same frequency as rotating parts, causing stroboscopic effects which make spinning wheels or saw blades appear to stand still. Around such machines, special workplace luminaires need to be used and any discharge lamps should be operated by electronic ballasts. For illuminating smaller areas, LED luminaires can be used.

Where activities involve working with wood, minerals or metal, dust and suspended microscopic particles are distributed in the room and can settle inside luminaires, where they reduce light output. So in rooms where dust is generated, only dust-protected luminaires should be installed. And in very dusty interiors, such as joinery shops, all luminaires used should be additionally protected against combustion and inflammation. The surfaces of these luminaires are designed to minimise dust deposits and limit the luminaire surface temperature to prevent fire hazards.

In most classrooms, at least 500 lux illuminance is recommended. However, this is not enough for activities which involve demanding visual tasks. Where operations are performed on electronic components, for example, in printing rooms or in colour-matching and surface analysis rooms, DIN EN 12464-1 recommends a minimum of 1000 lux.

Boards and charts on walls may need to be additionally illuminated by wallwashers to ensure that they can be seen from every part of the room without being obscured by reflections.


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More information is contained in booklet 5 of this series, "Good Lighting for Trade and Industry".

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EB-operated luminaires avoid stroboscopic effects at rapidly rotating machines such as looms or lathes *(Fig. 69)*.
In rooms where experiments are conducted with fire and combustible substances, explosion-protected luminaires should be used *(Fig. 71)*.

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Direct/indirect luminaires provide particularly glare-free lighting with high vertical illuminance.
Task lighting provides more light for the workplace and permits individual adjustment *(Fig. 70)*.

Lighting tips

- Harmonious brightness distribution makes handling equipment and materials safer.
- Special luminaires guard against stroboscopic effects and inflammation.
- For demanding visual tasks, illuminance should be at least 1000 lux.

Assembly halls and lecture theatres

For students and teachers, the assembly hall is an important place for information and communication. It is where the school presents itself as host. So what lighting needs to do here is ensure good visibility and a sense of wellbeing, furnish tools for presentation and prestige, and provide functional illumination and lighting for atmosphere.

Assembly halls are used for a wide variety of events. During the day they are rehearsal rooms and a place where the whole school comes together, in the evening they are venues for theatre performances and concerts, debates and parties. And each type of event calls for its own dedicated lighting to create the right visual conditions and atmosphere.

So lighting management systems are particularly useful in assembly halls. At the push of a button, they enable pre-defined lighting scenes to be created for every occasion. Entrance areas, seating areas and stage can thus be bathed in the right quantity of light delivered in the right kind of beams.

This calls for a differentiated lighting design. At major events, tickets are sold, coats are hung up and drinks are dispensed at the entrance. Here, warm light colours make for a sense of wellbeing and lamps with good colour rendering properties ensure that admission tickets, coats, drinks and food are clearly discernible and identifiable. During the event, entrance area lighting should be dimmed to a minimum. Downlights and surface-mounted wall luminaires with halogen lamps are normally a good choice here.

The seating area must also be brightly lit before the event - so it is easy for people to get their bearings in the room and find their seats - and darkened once the event gets underway. A glare-free view of the stage from every seat must always be guaranteed. For general room lighting, louvered luminaires or high-intensity downlights are the preferred option. During the event, surface-mounted wall luminaires at the perimeter of the room allow the audience to retain a sense of the room's dimensions without affecting their view of the stage.

The front part of the room accommodates the presentation area and stage. Depending on requirements, a complex lighting system can be created here with numerous remote-controlled spots permitting changes in beam angle, beam spread and light colour. But even where a simple lighting system is selected, care must be taken to ensure good vertical illuminance and glare-free vision in the room so that people on the stage are seen clearly and can themselves see the audience. At concerts, sheet music needs to be legible with no interference from direct or reflected glare and the musicians should be able to see one another clearly. Dimmable, separately switched luminaires and spots facilitate adjustment of brightness, light distribution and lighting atmosphere

Stairs and steps must always be adequately lit. Recessed floor luminaires or LED light strip set into risers as well as illuminated signs at exits and lavatories are important for guidance and emergencies.

In lecture theatres, as in all other classrooms, the presentation area and the entire surface of the blackboard need to be illuminated without anyone being dazzled by direct or reflected glare. Wallwashers, asymmetrical downlights or pendant luminaires provide the right lighting solution here.


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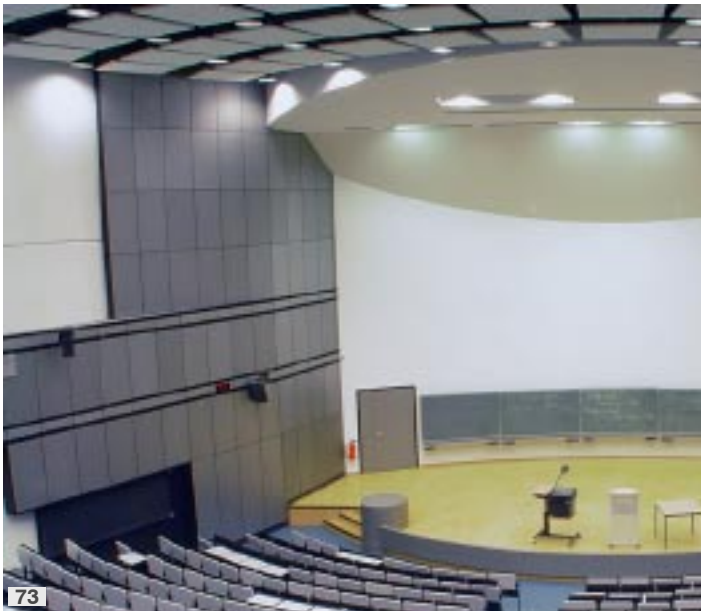
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More information is contained in booklet 9 of this series, "Prestige Lighting".


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For lectures, controls for all major room functions need to be located near the lectern. A lighting management system enables lighting to be activated, deactivated and regulated and permits remote control of room-darkening facilities and projectors without interrupting the speaker.

The presentation area and the blackboard need to be brighter than the rest of the room. The horizontal and vertical illuminance of the presentation area should be at least 1.5 times the mean illuminance of the room. So if room illuminance is 500 lux, the minimum lighting level at the front should be 750 lux.

Lighting tips

- Where different luminaire systems are installed, it is easier to cater for changes in room use.
- Where high vertical illuminance is provided on the stage, speakers see better and look better.
- For safety, all stairs and exits need to remain illuminated during events.

Even though reading habits have changed considerably since the advent of electronic media, books are still an indispensable tool for learning. In schools especially, libraries perform an important function in encouraging enjoyment of reading. The physical surroundings and the atmosphere of a library play a major contributory role here.

The reading area should be an agreeable place to work, a place where readers feels comfortable. Large windows for adequate daylight are a prerequisite for this. Blinds not only provide a protective screen against direct sunlight; on a cloudy day, they can also direct additional daylight into the room. When planning artificial lighting, the first rule here is to ensure glare- and reflection-free conditions for library users studying papers, reading books or periodicals or simply looking round the room.

With direct/indirect lighting, the so-called "cave effect" is avoided by ensuring an agreeably bright ceiling, and even reading matter printed on glossy paper remains clearly legible. Separately switched desktop lighting permits individual adjustment of workplace illuminance and makes for better conditions for writing.

For documentary searches, computers have almost totally superseded traditional card catalogues. So areas with VDU workstations are found in most libraries and need to be ergonomically designed and lit. Desks should be large enough to accommodate books and papers. As for lighting level, care should be taken to ensure a harmonious distribution of brightness, i.e. balanced ratios between illuminance at the VDU, on the desktop and in the background. It is imperative that direct and reflected glare should be avoided.

So that the required literature can be found, shelving units should be illuminated over their whole area. Special wallwashers designed for high vertical illuminance provide the kind of lighting that is required. When choosing lamps, attention must be paid to good colour rendering properties. We often look for books which we recognise by the colour and design of the spine.

All the aisles in the room and between the rows of shelves should be lit to ensure an agreeable brightness and enable users to get their bearings in the room quickly at any time. Escape routes and exits must always be clearly identifiable. Illuminated or back-lit signs at shelving units and doors are conspicuous and effective at helping users find their way.

Separate consultation zones are useful for catering for study teams or tutorial groups wishing to work in the library. Good sound insulation is needed to permit conversation without disturbing library users who are reading. Mobile standard luminaires designed for direct/indirect lighting make for an agreeably bright ceiling and can be repositioned with desks to meet the needs of different sized groups.


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Shelf unit lighting with asymmetrical wallwashers heightens vertical illuminance. Book titles and colours are thus more readily identifiable.


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Reading points need to be particularly bright. Natural lighting provides adequate basic brightness during the day; an additional reading light on the desk or table makes for greater comfort.


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Nowadays, library searches are conducted on computers; card catalogues have all but disappeared. So lighting needs to be suitable for VDU use. VDU workplace luminaires designed for good glare suppression and direct/indirect lighting with electronic ballasts and high-grade louvers permit hours of searching without sore eyes.


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Lighting tips

- Supplementary lighting at bookshelves heightens vertical illuminance.
- At reading points, lighting needs to be glare-suppressed and reflection-free.
- Computer workstations need to be ergonomically designed. Reflections on screens should be avoided.

Foyers and display areas

The entrance to a school or educational establishment is where first introductions are made. It is where students, teachers and visitors form their first impression of the building and the atmosphere - and where they decide, day after day, whether they feel welcome or not. So as well as serving the purely practical function of guiding people into the building and directing them where they want to go, a well-designed foyer also plays a representative role: it conveys the character of the establishment.

As for the actual entrance area, it performs a very important lighting function. Inside the building, brightness levels are more or less the same; windows and artificial lighting keep illuminance in the foyer within tight limits. Outside, however, illuminance is subject to wide fluctuations - from bright summer afternoons to dark winter mornings. So our eyes have to adapt - and it is up to the lighting at the entrance to make that adaptation possible within a short transition zone. Depending on the intensity of daylight, entrance lighting needs to be bright (summer‘s day) or subdued (winter‘s morning). Lots of windows, an adequately dimensioned lighting system and a daylight control system make these requirements easier to meet.

Foyers are often very busy places. At the start of the school day, during breaks and when lessons end, many people circulate here in what is a relatively small area. So to avoid accidents, the foyer needs to be adequately bright. The more light that illuminates the foyer and its walls, the better the visibility in the room and the easier it is for people to get their bearings. Steps at the entrance or stairs leading to other levels are a hazard zone and need to be brightly lit. Wallwashers in narrowing parts of the room and additional accentuating luminaires at the top or bottom of staircases help improve perception of potential hazards.

Foyers are an exciting design challenge for architects; many feature dramatic contours and ceilings. Foyer lighting should underline the design statement the architect intended to make. Where ceilings are high, high-intensity spots fitted with high-pressure lamps are recommended. As pendant luminaires for direct/indirect lighting, they emphasize the height of the room.
When choosing lamps, care should be taken to ensure good colour rendering and colour stability. Stucco ceilings, pillars or galleries can be strikingly emphasized by accentuating light. This can be provided by a wide selection of luminaires, ranging from recessed floor luminaires to decorative spots.

Most foyers are also used for exhibitions. The results of recent projects and art classes‘ latest works are put on display here. Exhibition area lighting on walls or mobile partitions needs to meet two requirements: first, it needs to ensure adequate brightness and uniform vertical illuminance; secondly, the luminaires must be flexible enough to illuminate changing exhibits properly.
Narrow-beam luminaires are better for very small exhibits, wide-beam models for large-format pictures.

Spots on power track can be selected, positioned and angled to meet individual requirements. Some spots also offer the possibility of varying the way light is distributed. Lamps must be selected to ensure good to very good colour rendering.


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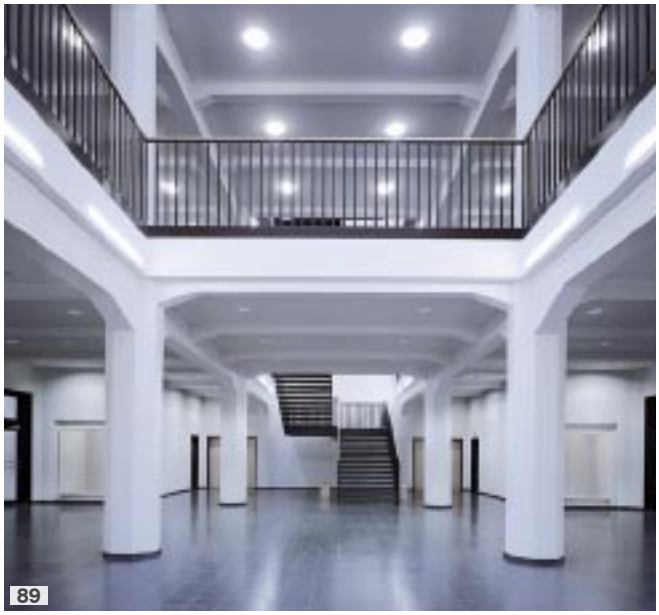

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Vertical surfaces such as that of a notice board need to be made brighter by appropriate additional luminaires. Uniform illuminance from top to bottom and adequately bright, reflection-free lighting with good colour rendering properties makes all notices easier to read.

Lighting tips

- At entrances, our eyes need to adapt to the difference in brightness between indoors and outdoors.
- Bright lighting for a foyer as well as for staircases and steps makes for added safety.
- Display area lighting needs to be flexible so that all artworks are cast in an equally good light.

Cafeterias and refectories

A person who is rested is better able to learn. School cafeterias and university refectories are more than just catering units: equally important are the chances they offer for rest and recuperation, communication and information - and the dining table often serves as an impromptu desk. Attractive architecture with matching colour scheme and materials, inviting modern furnishings and dynamic, motivating lighting provide ideal conditions for an actively regenerative break.

In kindergartens and schools especially, breaktime and catering facilities are becoming increasingly important because this is where all-day education is on the increase. So in new or refurbished buildings, plenty of space should be earmarked for rest zones and efficient catering facilities.

Small room units separated from one another by sideboards or partitions, make for a dynamically divided interior. With areas for large and small group tables, bistro tables and seating groups, a variety of atmospheres can thus be created.

Differentiated lighting with diverse lighting systems helps structure the room and provides the right light to create the atmosphere required. At group tables, pendant luminaires for direct/indirect lighting reduce shading on faces, make for a motivating bright ceiling and avoid reflected glare on glossy materials. Smaller pendant luminaires over bistro tables or table luminaires for seating groups make for a cosier lighting mood.

At places where people meet, faces need to be readily identifiable and illuminated without reflected glare. Direct glare from general-diffuse lamps or disturbing reflections on shiny tabletops need to be avoided. The light colour of lamps should be within the warm or daylight temperature range and should render the colours of food and drinks accurately. Decorative spots with halogen lamps for illuminating pillars or pictures enliven the interior and set interesting accents.

For better orientation, all presentation areas for food and drinks - including serving counters and snack stands - should be brighter than the rest of the room. When selecting lamps, care should be taken to ensure low heat gain and good colour rendering so that food and drinks look appetising. Depending on the nature of the food, preference should be given to particular light colours and luminaires for narrow or wide angle lighting. Help with the choice of luminaires and lamps can be obtained from experienced lighting designers.

Areas where food is prepared and served are workplaces. Here, lighting needs to be bright with good glare suppression and good colour rendering properties so that food and drinks are seen correctly. There must be no reflections on cashpoint displays and the keyboard or number pad needs to be adequately bright. In kitchens, luminaires also need to be protected against water vapour (luminaires for damp interiors, degree of protection IP 54); near cookers, they must additionally be protected against chemical attack.


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More information is contained in booklet 11 of this series, “Good Lighting for Hotels and Restaurants“.

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Lighting tips

- Lamps of warm light colour and with good colour rendering properties make a cafeteria more homely and make food look more appetising.
- Different lighting systems structure the room and separate different zones.
- Serving counters need to be brightly lit and reflection-free.

Staff rooms

From secretary's office to staff room, meeting room to office of the head or principal, work rooms form the hub of every educational establishment. They are contact points for students and teachers, forums for the exchange of information and centres for communication.

Staff rooms are increasingly turning into a kind of open plan office, used more and more for the preparation of lessons, marking homework and planning teaching units. The infrastructure of a staff room needs to be attuned to these tasks. An adequate number of suitably sized workplaces with connection points for computers or laptops make a staff room a fully fledged workroom for teachers.

Reading and writing, working at computers and consultation with colleagues are the main activities performed in a staff room. So the lighting needs to cater for the visual tasks such activities present. Room lighting designed for good glare suppression ensures that work materials and screens are not obscured by reflected glare. Also, large rooms acquire a more stimulating atmosphere where the ceiling is illuminated by direct/indirect luminaires. Separately switched workplace luminaires enhance the visual performance and visual comfort of staff members reading or writing. This is particularly important for older colleagues; 60-year-olds need more than twice as much light as 20-year-olds to ensure the same visual performance.

Lighting can help denote and define different zones in a staff room. As well as individual workplaces, staff rooms incorporate shared service areas and separate meeting zones. Optical partitioning of these service areas - where copiers and reference books are located - can be achieved with downlights. For bookshelves, wallwasher downlights should be used to provide extra vertical illumination for the spines of books and files.

In meeting zones, which either form part of the staff room or are accommodated in separate rooms, direct/indirect lighting - e.g. with pendant or standard luminaires - is recommended because it casts faces in a particularly natural light and ensures that work materials are easily legible. For beamer or overhead projector presentations, the lighting for the front part of the room should be on a separate switching circuit and dimmable. The presentation area lighting should also be asymmetrical to ensure harmonious, glare-free illumination for speakers and presentation aids.

In the secretary's office, two essential tasks need to be performed: administration of all school activities and communication with students and staff. For the administrative work, anti-glare room lighting should be selected to facilitate work at computer screens and with shiny work materials. For reception areas, direct/indirect lighting is recommended. This ensures an agreeably bright ceiling and natural, daylight-like brightness distribution.

Timetables and all important notices are posted on the notice board. To ensure they are clearly visible and easily legible, the lighting should be adequately bright and designed to illuminate the entire area of the board. Wallwashers provide the vertical illuminance needed to illuminate the surface evenly from top to bottom. Where notice boards are behind glass, the glass used should have a high-grade non-reflecting surface.


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More information is contained in booklet 4 of this series, "Good Lighting for Offices and Office Buildings".


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Lighting tips

- Staff rooms are workplaces and need to be designed as such. The lighting at computer workstations has to illuminate without glare.
- In large rooms and for meetings, direct/indirect luminaires provide natural, motivating lighting.


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Lots of light and bright colours create a convivial and motivating atmosphere in a staff room. Indirect lighting emphasises the high ceiling, making the room seem airier *(Figs. 101 and 102).* Anti-glare luminaires and adjustable blinds make for good lighting at computer workstations *(Fig. 104).*

Corridors and staircases

Our first steps inside a building take us to corridors or staircases leading to our destination. Corridors and staircases are the connectors between rooms and levels that make it possible for us to access the various zones of a building. Quick and easy orientation - signalling which corridor or staircase leads where - enables us to understand the layout of a building and find our way around it. Lighting can play a major role here as an orientation aid. Clear guiding light draws us in the right direction and illuminated or back-lit signs provide information.

But in many cases, not enough attention is paid to illuminance. Corridors and staircases appear intimidating if they are too dark. To avoid this so-called "tunnel effect", care should be taken to ensure uniform or finely graded brightness. In corridors with a bright ceiling and bright walls, we feel more comfortable and more secure. The creation of dark corners should be avoided and dark floor or stair coverings call for higher illuminance.

On stairs, it is particularly important to ensure glare-free lighting for treads. Safety is enhanced by modern LED light strips integrated into risers or recessed wall luminaires illuminating treads. Lamps must be shielded from view for anyone looking up or down.

In many schools and educational establishments, corridors are also places where students spend breaks between periods and thus make ideal display and presentation areas if they are appealingly designed and furnished with appropriately conspicuous lighting. A carefully crafted art exhibition in a dark corner grabs no one's attention.

Spots on power track provide simple, effective and flexible lighting for changing exhibits. They should be positioned and angled so that a visitor's view of the exhibits is impeded by neither shadows nor glare. Where exhibits are presented in glazed frames or glass showcases, the light should be designed to fall from the side of the observer to prevent the occurrence of disturbing reflections.

During lessons, i.e. for much of the day, corridors, stairwells and sanitary facilities are often deserted - yet the lighting is left on, normally just for convenience. A lighting control system with integrated presence sensors is very useful here; it is convenient and reliable and it saves energy. Sensors switch lighting off when a room or corridor is vacated and reactivate it when the next person enters. Energy-efficient use is thus made of artificial lighting and all areas in use are brightly and reliably lit.

Sanitary facilities acquire a more cheerful air where lamps of a warm light colour are used. Halogen lamps or compact fluorescent lamps of warm-white light colour provide an agreeable visual ambience and good colour rendering. For washbasins and mirrors, lighting should be diffuse to avoid harsh shadows on faces. A mixture of direct and indirect lighting, e.g. with downlights as room lighting and additional light sources beside mirrors, casts faces in a natural light. Switches and luminaires need to be protected against splashwater and compliant with the relevant standards.


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In bright stairwells and corridors, we feel safer and the risk of injury is reduced. Corridors and staircases are generally also escape routes and need to be identified as such and illuminated in compliance with the relevant standards.


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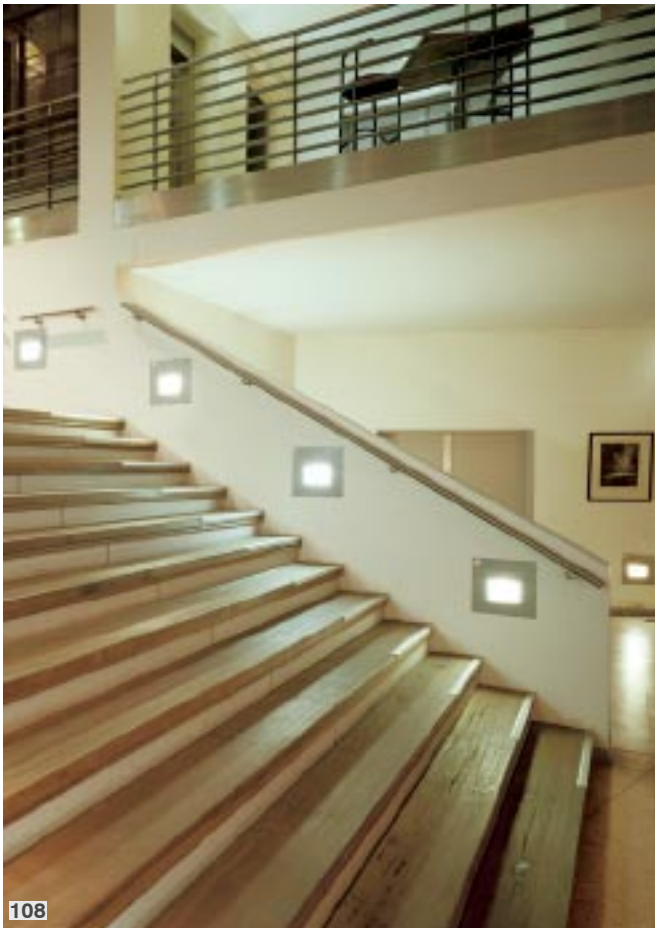
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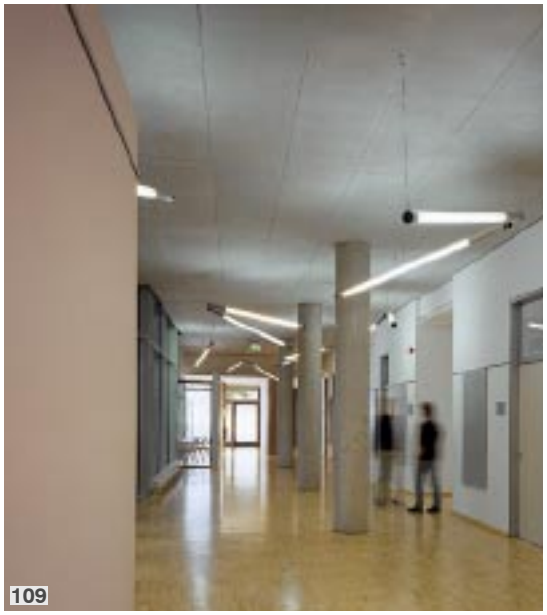
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Lighting tips

- Bright ceilings and walls make corridors look bigger and more appealing.
- Staircases should be provided with glare-free lighting to avoid accidents.
- Soft light from above or from the side can make steps or stairs easier to identify. Harsh long shadows should be avoided.

Outdoor areas and parking facilities

Schools and educational establishments are surrounded by large outdoor areas: courtyards and parking facilities for cars, motorcycles and bicycles as well as access roads, lawns and gardens. These are areas used by large numbers of people at the same time. Before school starts and after it ends, roads and parking areas are extremely busy; during breaks, students use outdoor areas for sports and games.

The lighting provided for outdoor areas needs to be adequately bright, above all to minimise the risk of accidents. On access roads and parking lots, lighting must not cause glare and needs to illuminate all areas used by vehicles so that motorists and cyclists can easily find their way and promptly identify obstacles and other road users.

Differentiated, well-designed outdoor lighting also facilitates orientation. Access roads and parking bays can be clearly marked by post-top luminaires or light stacks; bollard luminaires or discreet recessed ground luminaires can be used to separate parking facilities for motor vehicles from those reserved for cycles and to mark adjoining footpaths.
Students and teachers - as well as visitors attending concerts or other events in the evening - thus feel safer and more at ease.

Good exterior lighting with decorative luminaires also underlines the stylistic statement made by the building's architect and adds to the appeal of the complex as a whole. Column and bollard luminaires, ground and wall luminaires thus ensure a positive visual impact even after dark. To keep "unwelcome visitors" at bay, parking facilities and building façades should always be assured an adequate basic brightness. Even better are motion sensors which activate the lighting as soon as a person approaches. Security against theft and burglary is thus enhanced even at night and during vacation time.

In most schools, the school yard is used at all times of the year and in any weather as a place for recreational activities, sports and games. Good lighting helps youngsters at play recognise obstacles or flying balls more readily and thus heightens their safety. Partially covered yards can be lit safely, well and attractively by downlights; for open yards, post-top and bollard luminaires offer solutions. All luminaires need to be designed for outdoor use and protected against moisture. Impact-resistant models are particularly robust and stand up well to the stresses and strains of school life. Energy-saving compact fluorescent lamps or high-intensity high-pressure discharge lamps have a proven track record as light sources here.

Like indoor staircases, staircases in outdoor areas need to be specially lit to make them safer. Harmonious illumination with a balanced ratio of light and shade makes stairs stand out in 3D and easy to identify.
Long hard-edged shadows on treads must be avoided at all costs.


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More information is contained in booklet 3 of this series, "Good Lighting for Safety on Roads, Paths and Squares".

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Bright lighting for bicycle parks facilitates safe manoeuvring and keeps "unwelcome visitors" at bay *(Fig. 114)*. Paths connecting parking facilities with buildings can be marked and reliably lit by economical, long-life recessed ground LED luminaires *(Fig. 115)*.

Lighting tips

- Access roads and parking facilities require bright, uniform lighting.
- An illuminated façade makes for visual impact and enhances security against vandalism and burglary.
- Yards used during break-time are also playgrounds. Good lighting helps minimise accidents.

Sports halls and sports grounds are put to a wide variety of uses. They cater on a regular basis for most ball sports - from handball and volleyball to soccer - the full spectrum of field and track athletics as well as gymnastics and dancing. In the afternoons and evenings, when school sport is over, the facilities are used by local sports clubs; at weekends, they become venues for tournaments and competitions or major school events. School sports halls and sports grounds need to meet a host of requirements.

And the lighting needs be suitable for them all. So the first step when planning sports hall lighting should be to define the sports for which the facility will be used. The lighting should then be designed for the sport that presents the most demanding visual task. For most ball sports, DIN EN 12193 stipulates 200 lux horizontal illuminance as a minimum requirement. For faster ball sports involving small balls, such as badminton or table tennis, the value should be at least 300 lux and vertical illuminance even higher. For competitions and competition training in sports halls, the German standards authority recommends 500 to 750 lux for most sports.

When selecting luminaires, two crucial criteria need to be borne in mind: type of mounting and standard of glare suppression. Depending on the type of ceiling available, recessed, surface-mounted or pendant luminaires are an option. For high-ceilinged halls, pendant luminaires are normally more practical. As there is no principal viewing direction in a sports hall, luminaires need to be well shielded against glare in all directions. High-grade louvers in luminaires can significantly improve the visual performance of players and are sturdy enough to withstand the impact of stray balls. All luminaires should be of impact-resistant design.

The preferred light sources are fluorescent lamps or high-pressure discharge lamps. More important than the type of lamp, however, are good colour rendering properties and neutral-white lamp colour to avoid any confusion between players wearing similar coloured strip. A lighting management system is a practical, energy-saving solution for most sports halls. In multi-purpose halls, the lighting in individual hall sections can be dimmed at the push of a button. Where flexible lighting is required, e.g. for school events, luminaires should be wired in groups for control and regulation.

Most sports grounds are illuminated by floods mounted on four or six columns. The columns should be positioned at the corners or on the longer sides of the rectangular pitch. The higher the lights are mounted, the better the glare limitation. To avoid hard-edged shadows, floods or spots should be angled so that every point on the pitch is illuminated by at least two of them. Also, care must be taken to ensure that spectators are not dazzled.

Correct lighting for sports halls and sports grounds requires careful planning. Where facilities are used for competitions or events which are televised, lighting needs to meet particularly high standard and regulatory requirements. More planning guidance on this subject is found in booklet 8 of this series, “Good Lighting for Sports and Leisure facilities“.


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More information is contained in booklet 8 of this series, “Good Lighting for Sports and Leisure Facilites“.


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In changing rooms, lighting should be as uniform as possible to avoid harsh shadows. High vertical illuminance makes it easier to see inside lockers and lamps with good colour rendering properties ensure the colours of clothes are accurately rendered *(Fig. 120)*.
A presence control system in changing and sanitary rooms, which deactivates lighting when rooms are vacated and reactivates it when the next person enters, saves energy, extends lamp life and heightens security *(Fig. 121)*.

Lighting tips
- Lighting needs to cater to the sport that presents the most demanding visual tasks.
- Where neutral-white lamps with good colour rendering properties are used, colours are identified correctly.

Refurbishment - Economy

Emergency lighting - Safety

When an old school building is refurbished, its modernisation would not be complete without the renewal of its lighting systems. More efficient lamps and luminaires as well as added visual comfort are cogent arguments in favour of new lighting. But planners should also bear in mind that new types of luminaire have been developed which are particularly suitable for use in schools: stronger materials offer better protection against damage; luminaires with asymmetrical beams make for uniform glare-free blackboard lighting and better shielded luminaires permit more flexible arrangements of group desks.

An obsolete lighting system costs money. The efficiency of all lighting components - lamps, luminaires and operating gear - steadily declines. Soiling and ageing of materials reduces the light output ratio of an old lighting system by half in the course of its life. Investment in modern, efficient lighting significantly reduces annual operating costs and the extra acquisition costs are recouped in the space of a few years.

New lamp and luminaire technologies permit more economical operation and a better quality of lighting. Newly developed light sources such as T5 fluorescent lamps, compact fluorescent lamps and LEDs make for better luminous efficacy. Electronic ballasts reduce power losses, provide flicker-free lighting and improve the starting performance of lamps. And new materials and designs for reflectors improve luminaire light output ratios and glare ratings.

Even greater savings can be achieved by the use of modern lighting management systems. Sensor-regulated lighting which automatically adjusts artificial lighting according to the amount of daylight available, or presence control systems which deactivate lighting after a room is vacated reduce power costs and lengthen lamp life. Lighting management systems can be installed in rooms or groups of rooms that are already wired.

Special blinds which direct additional daylight into the room can reduce the amount of artificial lighting required. As well as saving energy, this makes for lighting which is found to be more natural, more dynamic and more stimulating; students and staff feel better and are more motivated.

Also important in a refurbishment project are aesthetic considerations. State-of-the-art luminaires are available today in designs to suit any architectural style. Often, the latest technology can even be integrated in existing luminaires. With lamps and operating gear becoming progressively smaller, more powerful and more efficient, it is possible to achieve bright, reliable, energy-efficient lighting even in historical buildings without making visible alterations.

Safety is not an optional item in a school's or any other educational establishment's budget. A modern emergency and security lighting system needs to be installed in all rooms and corridors. Even small smouldering fires can rapidly fill rooms with smoke, creating a situation where sure guidance and fast identification of exits and escape routes is critical.

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Lighting can save lives

In buildings which are open to the public, emergency lighting is required by law. Its importance is discovered only when an emergency occurs. Without emergency lighting, it is impossible for people to vacate smoke-filled rooms and corridors safely and find their way outside. Good emergency lighting is clearly visible and indicates the shortest route out of danger.

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More information is contained in booklet 10 "Notbeleuchtung Sicherheitsbeleuchtung" (available in German only) and booklet 12 "Lighting Quality with Electronics" of this series.

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Modern lighting re-imbues renovated buildings with new splendour. Modern luminaires can harmonise superbly with historical architectural designs *(Fig. 124)* or state-of-the-art technology can be integrated into existing light fittings *(Fig. 127)*. LED elements, for example, replace obsolete stair lighting without affecting the historical design statement *(Fig. 128)*. LEDs save energy, provide more light and offer considerably more operational reliability than incandescent lamps.

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Lighting management means operating a lighting system efficiently and economically, regulating and monitoring lamps and luminaires for optimum performance, offering the greatest possible lighting comfort and permitting stimulating room lighting that is right for the situation. These are all functions which are useful and important, particularly for schools and other educational establishments.

Especially in rooms where room use constantly changes, lighting management systems are a practical and convenient solution. With them, classrooms in which head-on instruction, group work, small exhibitions and music lessons take place in daily succession can thus be correctly lit at the push of a button. In assembly halls, too, where gatherings and concerts, rehearsals and performances are staged, lighting management systems create the right lighting scene for the occasion.

Many classrooms stand empty for the occasional free period during the day. At such times, the lighting often stays on. Intelligent control systems with integrated presence sensors automatically deactivate lighting when a room is vacated and reactivate it when the next person steps through the doorway. Corridors, too, are rarely used during lessons. Here, lighting can be dimmed to a minimum for most of the time. In both cases, simple lighting control systems provide a convenient way of saving a lot of the energy that is wasted in classrooms and corridors.

In autumn, winter and spring, daylight alone is often not enough to provide acceptable classroom lighting. In the mornings and evenings - in winter even by early afternoon - the level of incident light is too low to work by, and clouds reduce even more what little daylight there is. So in many classrooms - either for convenience or because not enough daylight enters the room - the lighting is switched on and left on all day.

Lighting control systems with daylight sensors which automatically adjust the brightness of artificial lighting according to the natural daylight that is available as well as special blinds which direct daylight into the room thus also offer scope for saving energy in schools and other educational establishments.

Aside from the energy-saving aspect, however, lighting management systems also create new opportunities for dynamic, motivating lighting. We know today that a uniform lighting level leads to fatigue and loss of concentration. So with a lighting control system which combines daylight and artificial lighting, the stimulating impact of changes in natural lighting can be simulated.

The lighting in individual rooms or small building units, such as sports halls, can be simply and conveniently regulated by DALI components. DALI (Digital Addressable Lighting Interface) is an internationally standardised system for switching and dimming lighting and monitoring connected components for availability.

The DALI working group (AG-DALI) of the Frankfurt/Main-based German Electrical and Electronic Manufacturers' Association (ZVEI) comprises leading European and US manufacturers of electronic ballasts and lighting control and regulation systems.


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In assembly halls and lecture theatres, blinds, lighting and projectors should be operable from the lectern. This enables the projector to be started, the sunshades to be lowered and the luminaires to be dimmed at the beginning of a presentation without causing disturbance through interruptions (Fig. 129). Afterwards, the room lighting can be fully or partially restored for the ensuing discussion. (Fig. 130). Most lighting management systems allow several lighting scenes to be programmed with ease for occasions such as lectures, presentations and discussions.

More information is contained in booklet 12 of this series, "Lighting Quality with Electronics".

Lighting control is a useful device for many classrooms. With separately switched and dimmable lighting system components, the right lighting for any situation can be generated at the push of a button.

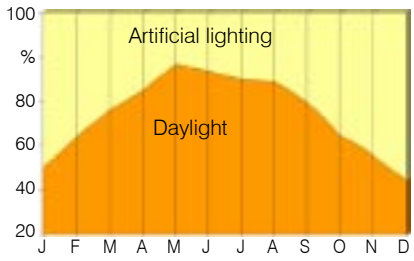
1 Lesson
For normal lessons, all lighting components are equally bright. *(Fig. 131).*

2 Lecture
For lectures, the light over the desks is dimmed; the front of the room and the blackboard remain bright *(Fig. 132).*

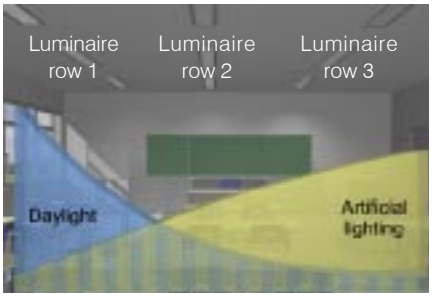
3 Experiment
During an experiment, the screened experiment room and demonstration area are illuminated. The light over the desks is dimmed but still bright enough for taking notes. *(Fig. 133).*

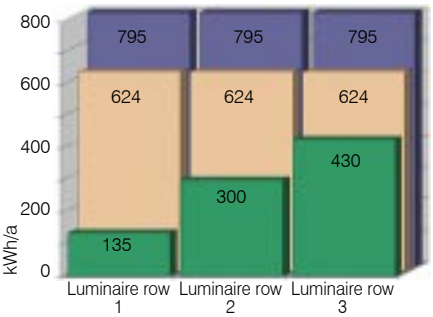
4 Media presentation
For TV or beamer presentations, the lighting is dimmed throughout the room. Reflections on screens are thus avoided, colours and contrasts are preserved and screen images can be seen from every desk *(Fig. 134).*

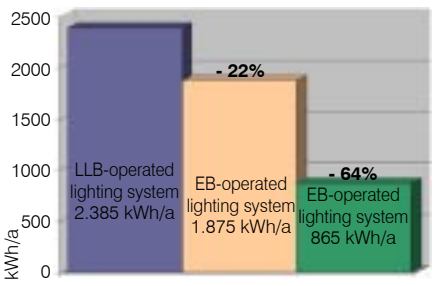
In many classrooms, lighting is switched on for much of the day. With a standard lighting system, this is the only way to ensure that desks which are not right beside a window are adequately lit at all times. In the summer months in Central Europe, however, there is enough daylight available to save nearly 80% of the power consumed by classroom lighting systems (100% = 500 lux).



The prerequisite for this is a daylight-dependent lighting system, which automatically ensures a constant level of brightness throughout the room. On a bright sunny day, only the third row of luminaires near the wall is activated. When the sky is overcast the other luminaire rows are switched on, ensuring that at least 500 lux is provided at all desks at all times.







LLB-operated lighting system
In a normal classroom, a non-regulated lighting system with lamps operated by conventional ballasts (CBs) or low-loss ballasts (LLBs) consumes 2,385 kWh a year. Each of the three luminaire rows consumes a constant 795 kWh/a.

EB-operated lighting system
In the same room, a modern lighting system providing the same illuminance (500 lux) with lamps operated by electronic ballasts (EBs) consumes only 1,872 kWh/a - i.e. 22% less electricity. Each of the three luminaire rows consumes a constant 625 kWh/a.

Lighting system with dimmable EBs and daylight
A lighting system with dimmable EBs and a daylight-dependent regulation system consumes only 865 kWh/a, i.e. 64% less than a LLB-operated lighting system. The 500 lux illuminance throughout the room is automatically regulated. Luminaire row 1 is near the window wall and can generally stay dimmed because of the greater daylight component. 2/3 of the power costs are saved by EB operation and daylight regulation.

Lamps

No.	Lamp type	Power rating W	Luminous flux lm (Watt)	Luminous efficacy lm/W (Lumen)	Light colour (Lumen/Watt)
Linear three-band fluorescent lamps					
1	T5; Ø 16 mm[1] with high luminous efficacy	14 - 35	1250 - 3650[2]	89 - 104	ww,nw,dw
2	T5; Ø 16 mm[1] with high luminous flux	24 - 80	1850 - 7000[2]	77 - 88	ww,nw,dw
3	T8; Ø 26 mm	18 - 58	1350 - 5200	75 - 90[3]	ww,nw,dw
Compact fluorescent lamps					
4	2-, 4- and 6-tube lamp	5 - 57	250 - 4300	50 - 75	ww,nw
5	2-tube lamp	18 - 80	1200 - 6000	67 - 75	ww,nw,dw
6	4-tube lamp	18 - 36	1100 - 2800	61 - 78	ww,nw
Energy-saving lamps					
7	miniature	7	220	31	ww,nw
8	incandescent-shape	5 - 23	150 - 1350	30 - 59	ww
9	standard shape	5 - 23	240 - 1500	48 - 65	ww
High voltage halogen lamps (230V)					
10	pin-based lamps	25 - 250	260 - 4300	10 - 17	ww
11	with reflector	40 - 100			ww
12	with base at both ends	60 - 2000	840 - 4400	14 - 22	ww
Low voltage halogen lamps (12V)					
13	pin-based lamps	5 - 100	60 - 2300	12 - 23	ww
14	with reflector	20 - 50			ww
Metal halide lamps					
15	with base at one end	35 - 150	3300 - 14000	85 - 95	ww,nw
16	with base at both ends	70 - 400	6500 - 36000	77 - 92	ww,nw
High-pressure sodium vapour lamps					
17	tubular	35 - 1000	1800 - 130000	51 - 130	ww
Light-emitting diodes					
18	LED	0,7 - 1,5	18 - 27	13 - 23	

Light colour: ww = warm white, nw = neutral white, dw = daylight white
1) for EB operation only 2) luminous flux at 35°C 3) luminous efficacy increases to 81 - 100 lm/W with EB operation

More information is contained in booklet 1 of this series, “Lighting with Artificial Light“.

Colour rendering index	Base
80 < 90	G5
80 < 90	G5
80 < 90	G13
80 < 90	G23, G24, 2G7, GX24
80 < 90	2G11
80 < 90	2G10
80 < 90	GX53
80 < 90	E14, E27
80 < 90	E14, E27
≥ 90	E14, E27, G9
≥ 90	E14, E27, GZ10, GU10
≥ 90	R7x
≥ 90	G4, GY6,35
≥ 90	GU5,3
80 < 90, ≥ 90	G12, G8,5, E27, E40
80 < 90, ≥ 90	RX7s, Fc2
20 < 40	E27, E40

Good lighting depends on the right choice of lamps. This page shows the most important types of lamp and their specifications for applications in schools and educational establishments.

1,2,3
Three-band fluorescent lamps

Three-band fluorescent lamps have a high luminous efficacy, good colour rendering properties and a long service life.
Operated by electronic ballasts (EBs), they achieve an even higher luminous efficacy and longer service life. 16 mm diameter T5 lamps are designed for EB operation only. Dimming control of all three-band fluorescent luminaires is possible with appropriate ballasts.

4,5,6
Compact fluorescent lamps

Compact fluorescent lamps have the same characteristics as three-band fluorescent lamps. Here, too, luminous efficacy is improved and service life lengthened by EB operation and lamps can be dimmed by appropriate ballasts.

7,8,9
Energy-saving lamps

Energy-saving lamps have an integrated ballast and either a screw base (E14 or E27) or a bayonet base (GX53). Energy-saving lamps consume up to 80% less power and have a considerably longer life than incandescent lamps.

10,11,12
High voltage halogen lamps (230V)

High voltage halogen lamps produce an agreeable white light with very good colour rendering. They are designed for direct line operation, have a longer life than incandescent lamps and generate more light from the same power. Dimming control presents no problems.

13,14
Low voltage halogen lamps (12V)

Low voltage halogen lamps produce an agreeable white light with very good colour rendering. To operate them, a transformer is needed to reduce the voltage to 12V. They can be dimmed with appropriate transformers.

15,16
Metal halide lamps

These lamps are noted for their high luminous efficacy and very good colour rendering properties. Modern metal halide lamps feature a ceramic burner that delivers light of a constant colour throughout its service life. Ballasts are needed to operate these lamps. EBs lengthen lamp life and make for greater lighting comfort.

17
High-pressure sodium vapour lamps

Very high luminous efficacy and a long service life make high-pressure sodium vapour lamps a very economical solution for outdoor lighting. Appropriate ballasts and starters are required to operate them.

18
Light-emitting diodes

LEDs are available in numerous shapes and colours. Owing to their minimal dimensions and long service life, they find applications today mainly in decorative luminaires and security lighting. They possess high impact-resistance and emit neither UV nor IR radiation.

Various types of luminaire are used in schools and educational establishments. Type and size of room, architecture and room use - these are all factors which have to be considered by the lighting designer.

Lighting should be planned jointly by client, architect and lighting designer. As well as the technical characteristics briefly described below, the design of the luminaires and their incorporation in lighting management systems are important matters for consideration. Central control of the luminaires makes for greater convenience for the user and reduces power consumption.

Lighting characteristics

The way light is radiated by a luminaire is indicated by intensity distribution curves (IDCs). These define the spatial distribution of illuminance and are an important criterion for the assessment of glare. For room lighting, direct or direct/indirect luminaires are a popular choice.

Direct luminaires are often very economical, while the light cast by direct/indirect luminaires is found by most people to be agreeable and motivating. Purely indirect luminaires are used as wallwashers or ceiling floodlights to provide accentuating light for architectural details.

Another lighting and power management criterion for luminaires is light output ratio. The higher the ratio, the greater the efficiency and economy with which the luminaire harnesses the luminous flux of its lamps.

The third important quality feature of a luminaire is glare limitation. The better the lamp shielding, the higher the quality of lighting. Attention particularly needs to be paid to this feature where computer workstations are present.

Electrical characteristics

The electrical characteristics of a luminaire depend, in part, on the kind of electrical components it features for safe, fault-free lamp operation. With discharge lamps such as fluorescent lamps, for example, the connected load of a luminaire system - and thus the rate at which it consumes electricity - can be reduced by the use of electronic ballasts (EBs). EBs also make for gentler lamp starts and thus extend the service life of lamps. Furthermore, they discontinue starting attempts if a lamp is defective.
To meet lighting safety requirements, luminaires and integrated electronic ballasts need to comply with IEC 598 regulations and display the ENEC symbol.

Design characteristics

Aside from preference for a particular type of light or luminaire, options may be narrowed by the architecture of the room and, in particular, the nature of the ceiling. Most types of luminaire are available in recessed, surface-mounted or pendant designs.

Assembly is another factor to consider, so is regular maintenance, e.g. lamp replacement. Quality luminaires come with well-designed assembly aids or practical details permitting e.g. toolless maintenance.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Recessed louvered luminaires
as linear luminaires *(as illustrated)*
or square luminaires


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Direct/indirect pendant luminaire
with optical control panels


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Recessed wallwashers
with asymmetrical beam


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Wall luminaires
as surface-mounted luminaire *(left)*
or recessed luminaire *(right)*

Direct/indirect recessed luminaires
as square luminaires *(as illustrated)*
or linear luminaires

Surface-mounted louvered luminaires
as linear luminaires *(as illustrated)*
or square luminaires

Downlights
with symmetrical beam *(left)*
or asymmetrical beam *(right)*

Direct/indirect standard luminaire
with desktop luminaire

Spot
for power track *(left)* or
as recessed luminaire *(right)*

Safety lighting luminaire
for illuminated signs and
emergency lighting

Bollard luminaire *((left)*
Recessed ground luminaire *(right)*

Post-top luminaire *(left)*
Light stack *((right)*

The quality of lighting in schools and educational establishments depends on numerous criteria, some of which are discussed on pages 4 and 5 of this booklet. But lighting design also needs to comply with new laws and standards. On the standards front, a major change occurred with the creation of the European standard on indoor workplace lighting and its adoption as German standard DIN EN 12464-1.
This standard supersedes much of DIN 5035-2 “Artificial lighting of interiors - Guideline values for indoor and outdoor workplaces“. However, it also contains recommendations and requirements for educational establishments which were formerly defined in Germany in the standard DIN 5035-4 “Artificial lighting of interiors - Special recommendations for lighting in educational establishments“.
DIN 5035-4 continues to apply to general educational establishments such as primary schools and grammar schools as well as universities.
References to standards below are basically confined to DIN EN 12464-1, with which many people are not yet familiar. The contents, concepts and methods set out in DIN 5035-4 have applied since 1983 and are taken as known. DIN 5035-4 is expected to be revised in line with DIN EN 12464-1.

Illuminance in the visual task zone
Illuminance and illuminance distribution impact significantly on the speed, reliability and ease with which we register and perform a visual task. Page 46 of this booklet shows a list of recommended illuminance values for numerous types of room in schools and educational establishments. The values are taken from DIN EN 12464-1 and apply to the visual task zone. Where the size and/or location of the visual task zone is not known, it must be taken to encompass any area where the visual task may occur. The values apply to normal visual conditions and should be increased where the degree of difficulty of the visual task is above-average or those performing it have below-average eyesight.

Illuminance service value and service factor
Illuminance Em is a service value, i.e. mean illuminance must not fall below the value stated, regardless of the age and condition of the lighting system. So a new system needs to be designed for a higher illuminance value. How fast and how much illuminance decreases depends on the ageing characteristics of the lamp, the type of ballast used, the luminaire, the environment and the servicing schedule. The lighting designer needs to record assumptions for service factor and servicing schedule at the planning stage. Where no information is available, the ZVEI, for example, recommends a reference value of 0.67 for clean rooms in which lighting is serviced every three years.

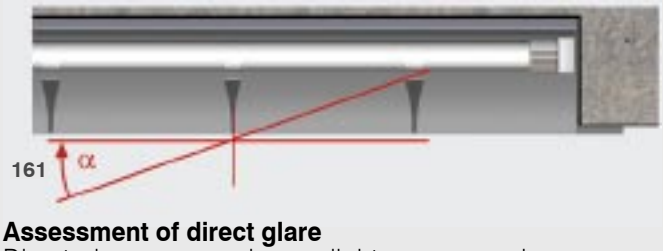
Illuminance in the immediate surroundings
Illuminance in the immediate surroundings depends on the illuminance in the visual task zone and should make for balanced luminance distribution in the field of vision. Marked localised differences in illuminance levels can overtax our eyes and cause discomfort. Illuminance in the immediate surroundings can be lower than that in the task zone itself but must not be lower than the following values:

Illuminance in the visual task zone (lux)	Illuminance in the immediate surroundings (lux)
≥ 750	500
500	300
300	200
≤ 200	$\bar{E}$ Task
uniformity: : ≥ 0,7	uniformity: : ≥ 0,5

Glare
A distinction is made between two types of glare. With physiological glare, visual performance is impaired. With psychological glare, visual performance is disturbed. Errors and accidents may result. Glare must therefore be limited.

Shielding against glare
To avoid glare caused by bright light sources, lamps should be shielded and windows provided with blinds or shades for darkening. For the lamp luminance values below, the relevant minimum shielding angles need to be observed.

Lamp luminance cd / m²	Minimum shielding angle α
20,000 bis < 50,000	15°
50,000 bis < 500,000	20°
≥ 500,000	30°



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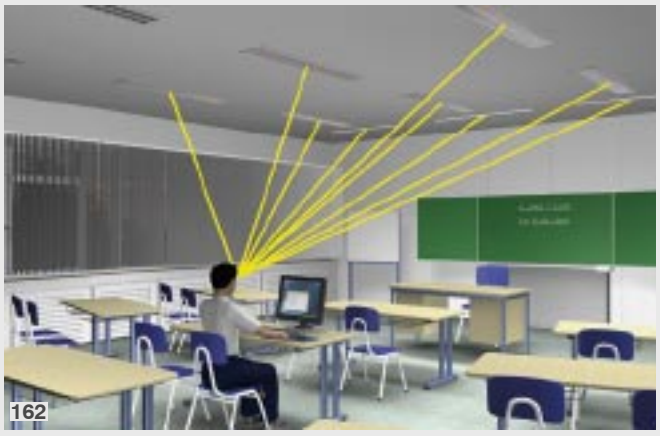
Assessment of direct glare
Direct glare occurs where a light source, such as a general-diffuse lamp, is in our line of sight. The new standard DIN EN 12464-1 introduces the standardised UGR method (unified glare rating) for the assessment of (psychological) glare.
The UGR method takes account of all the luminaires in a lighting system which add to the sensation of brightness as well as the brightness of walls and ceilings; it produces a UGR index (Fig. 162). The UGR limits (UGRl) which must not be exceeded for most kinds of rooms in schools and educational establishments are found in the table on page 46.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VDU workplace lighting

Lighting for VDU workplaces needs to be suitable for all the tasks that may be presented there, e.g. reading from the screen, reading printed text, writing on paper, operating the keyboard.

Work at a monitor or sometimes even at a keyboard can be affected by physiological or psychological glare due to reflections. The lighting designer needs to select luminaires and define luminaire arrangements which ensure that disturbing reflections are avoided.

Veiling reflections and reflected glare

Reflected glare occurs as a result of disturbing reflections of light sources on shiny or reflective surfaces, such as a VDU screen or glossy paper. Reflections on screens *(Fig. 163)* and glossy documents *(Fig. 165)* make for disturbed vision and impair legibility.


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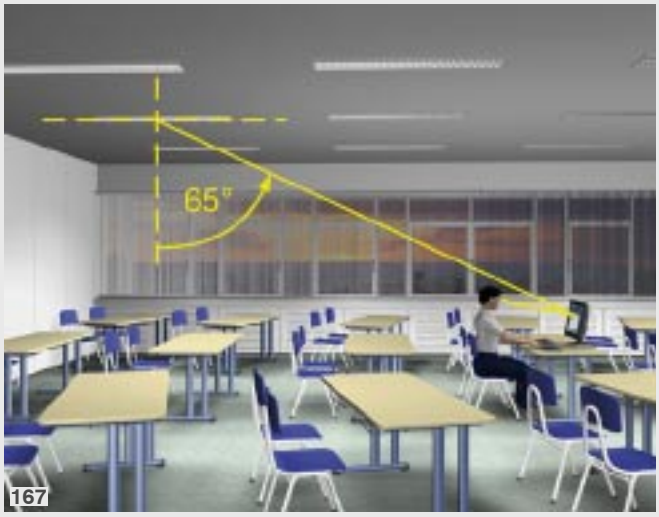
Luminance limits for direct luminaires

The luminance of luminaires which could be reflected on screens at normal lines of sight needs to be limited all around the luminaire above a threshold angle of radiation of 65°.
The table shows the mean luminaire luminance limits for workplaces with screens which are vertical or tilted at angles up to 15° *(Fig. 167)*.

VDUs	mean luminance of luminaires and surfaces which reflect on screens
Positive display VDUs	≤ 1000 cd/m²
Negative display VDUs with high-grade anti-reflective system Evidence of test certificate required	
Negative display VDUs with lower-grade anti-reflective system	≤ 200 cd/m²

Classification of VDUs on the basis of anti-reflective systems and the type of display mostly present on the screen. The cd/m² values indicate the maximum permissible mean luminance of luminaires which could be reflected on the screen (in accordance with DIN EN 12464).



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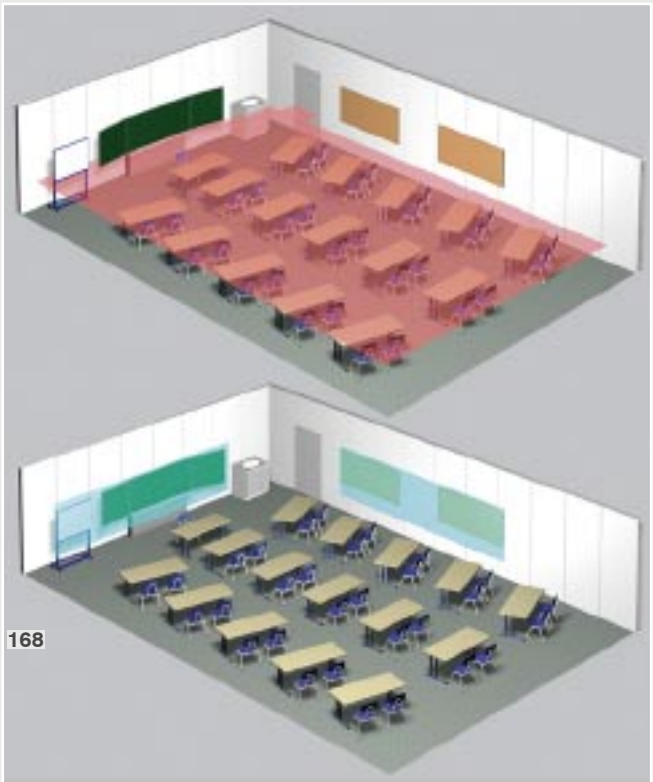
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Application example

Where the size of the zones in which visual tasks are performed is not known, the entire room (less a perimeter zone of 0.5 m) should be treated as a task zone (red area) at a height of 30 mm above the relevant work surface. The entrance area, the area in front of the blackboard and the area fronting partitions are part of this horizontal zone *(Fig. 168, top)* Vertical visual task zones include, for example, blackboard surfaces, notice boards, cupboards and shelves. In the case of blackboards, the height of the assessment area depends on how high the board can be raised. The width of the assessment area is governed by the width of the boards when extended. The illuminance required is that recommended on page 46, with a uniformity of 0.6 *(Fig. 168, bottom).*

Lighting requirements of DIN EN 12464-1

6.1 Kindergartens, nursery schools (pre-school establishments)					
Ref. No.	Type of room, purpose or activity	$\bar{E}_m$	UGR_L	R_a	Remarks
6.1.1	Play room	300	19	80	
6.1.2	Nursery	300	19	80	
6.1.3	Handicraft room	300	19	80	

6.2 Educational premises					
Ref. No.	Type of room, purpose or activity	$\bar{E}_m$	UGR_L	R_a	Remarks
6.2.1	Classrooms, tutorial rooms	300	19	80	Lighting should be controllable
6.2.2	Classrooms for evening classes and adult education	500	19	80	Lighting should be controllable
6.2.3	Lecture hall	500	19	80	Lighting should be controllable
6.2.4	Black board	500	19	80	Prevent specular reflections
6.2.5	Demonstration table	500	19	80	In lecture halls 750 lx
6.2.6	Art rooms	500	19	80	
6.2.7	Art rooms in art schools	750	19	90	$T_{CP} \geq 5000$ K
6.2.8	Technical drawing rooms	750	16	80	
6.2.9	Practical rooms and laboratories	500	19	80	
6.2.10	Handicraft rooms	500	19	80	
6.2.11	Training workshops	500	19	80	
6.2.12	Music practice rooms	300	19	80	
6.2.13	Computer practice rooms (menu driven)	300	19	80	DSE-work: see clause 4.11
6.2.14	Language laboratories	300	19	80	
6.2.15	Preparation rooms and workshops	500	22	80	
6.2.16	Entrance halls	200	22	80	
6.2.17	Circulation areas, corridors	100	25	80	
6.2.18	Stairs	150	25	80	
6.2.19	Student common rooms and assembly halls	200	22	80	
6.2.20	Teachers rooms	300	19	80	
6.2.21	Library: bookshelves	200	19	80	
6.2.22	Library: reading areas	500	19	80	
6.2.23	Stock rooms for teaching materials	100	25	80	
6.2.24	Sports halls, gymnasiums, swimming pools	300	22	80	See EN 12193
6.2.25	School canteens	200	22	80	
6.2.26	Kitchen	500	22	80	

3 Offices					
Ref. No.	Type of room, purpose or activity	$\bar{E}_m$	UGR_L	R_a	Remarks
3.1	Filing, copying, etc.	300	19	80	
3.2	Writing, typing, reading, data processing	500	19	80	DSE-work: see clause 4.11
3.3	Technical drawing	750	16	80	
3.4	CAD work stations	500	19	80	DSE-work: see clause 4.11
3.5	Conference and meeting rooms	500	19	80	Lighting should be controllable
3.6	Reception desk	300	22	80	
3.7	Archive	200	25	80	

The tables above are taken from DIN EN 12464-1, which also sets out the minimum values for many other types of room, e.g. rooms equipped for industrial and craft activities in vocational schools.

Abbreviations used in the tables:
$\bar{E}_m$ = Illuminance service value
UGR_L = UGR limit according to the standardised glare limitation system
R_a = colour rendering index

Literature, acknowledgements for photographs and order forms

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LiTG

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Publication # „Das UGR-Verfahren zur Bewertung der Direktblendung der künstlichen Beleuchtung in Innenräumen" (in Vorbereitung) (The UGR method of assessing direct glare caused by artificial lighting in interiors) (in preparation)

www.litg.de

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Standards

DIN EN 12464-1 Light and lighting - Lighting of work places Part 1: Indoor work places

DIN 5035 Artificial lighting
Some of the contents of Parts 1, 2, 3 and 4 of DIN 5035 are superseded by DIN EN 12464, Part 5 has been replaced by DIN EN 1838.

DIN EN 1838 Emergency lighting

DIN EN ISO 9241-6 Ergonomic requirements for office work with visual display terminals (VDTs). Part 6: Guidance on the work environment

E DIN 5035-7 Lighting for rooms with VDU work stations or VDU-assisted workplaces

DIN EN 12193 Light and lighting - Sports lighting

DIN EN 12665 Light and lighting - Basic concepts and criteria for defining lighting requirements

DIN 4543-1 Office work place, Part 1 Space for the arrangement and use of office furniture ; safety requirements, testing

DIN 5035-6 Measurement and evaluation

DIN 5035-8 Special requirements for the lighting of single work-places in offices and similar rooms

DIN 5044 Permanent traffic lighting

ASR 7/3 Workplace guideline on „Lighting"

AMEV Hinweise für die Innenraumbeleuchtung mit künstlichem Licht in öffentlichen Gebäuden (Beleuchtung 2000) (Notes on interior artificial lighting in public buildings (Lighting 2000))

AG DALI manual "Digital Addressable Lighting Interface - An activity of the Electric Luminaires Product Division of the ZVEI) published by Zentralverband Elektrotechnik- und Elektronikindustrie (ZVEI) e.V./AG DALI, Frankfurt am Main 2002

www.dali-ag.org, www.zvei.org

ZVEI, Stresemannallee 19, 60596 Frankfurt am Main, Germany

CELMA Guide for the Application of Directive 2000/55/EC on Energy Efficiency Requirements for Ballasts for Fluorescent Lighting, Hrsg.: CELMA Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union, Brüssel 2003 (deutschsprachige Ausgabe über den ZVEI)

www.celma.org

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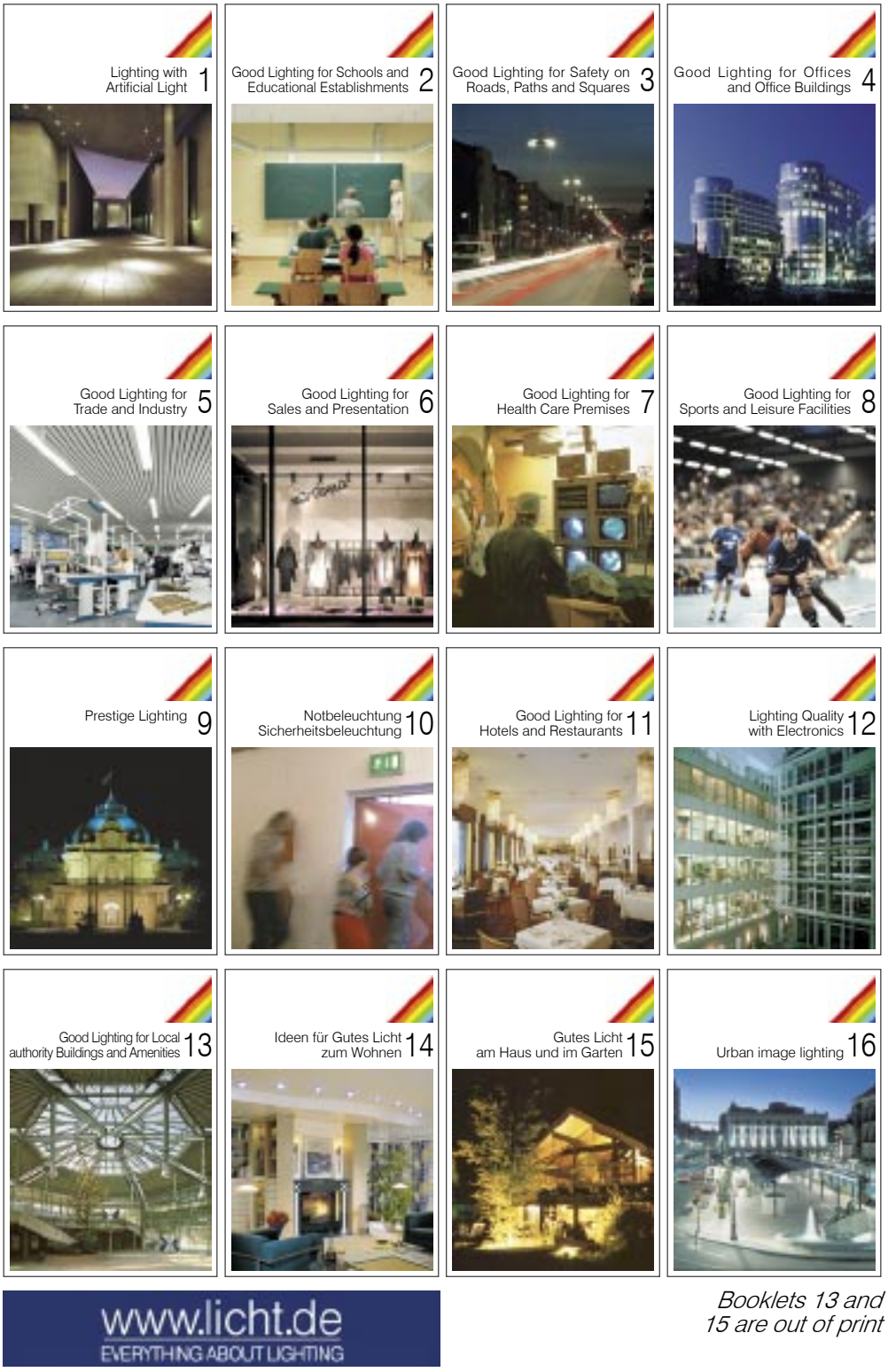

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