CHAPTER XVIII

SIGNIFICANCE OF LIGHTING AND COLOUR DESIGN IN EDUCATIONAL STRUCTURES

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1. INTRODUCTION

Playing an important role in perceiving dimensional characteristics of a space and also in visual comfort, lighting is an important parameter allowing a learning and teaching process in an educational structure to take place in a more productive and vigorous process. A correct lighting provides a productive educational environment also for students and teachers. Due to education continuing all day in classrooms, there must be adequate and evenly distributed natural lighting in spaces and this is an important matter in terms of energy consumption. When inadequate, natural lighting should be augmented with correctly designed artificial lighting. Lighting closed spaces with daylight has physiological and psychological effects on humans. If spaces do not receive sufficient amount of daylight, negative effects such as lack of energy, increased need for sleep, difficulty in visual perception, inefficiency, lack of motivation, difficulty in learning, frequent illness and headaches are experienced.

Spaces of various functions and dimensions that are used in the same and different time intervals in educational buildings such as classrooms, computer rooms, circulation areas, administrative offices, activity workshops (painting, ceramics, etc.), laboratories and libraries have different lighting requirements. Having desirable visual comfort conditions in such spaces is important for higher learning performance, increased productivity and protection of eye health. In an education process, the contribution of visual perception to learning is more

than the contribution of the other sense organs. Therefore, a correct lighting can be achieved by a purposeful illumination. In other words, fulfilment of visual comfort conditions based on the function of the activity taking place in the interiors of an educational structure can be achieved by satisfying the necessary conditions for the quantity and quality of lighting.

Writing and reading activities taking place in classrooms are the most important factor that needs to be considered during the planning of lighting. While writing activity is directly associated with the illumination level of the horizontal plane from a close distance, reading and understanding the figures and words on a blackboard is directly associated with the vertical illumination level. In both cases, the eye must adapt to a transition from a horizontal plane to a vertical plane (Kazanasmaz, 2015, p.78). Lighting should support this adaptation and prevent luminosity distributions that would cause glares. Figure 1 shows horizontal and vertical plane surfaces in a common classroom.

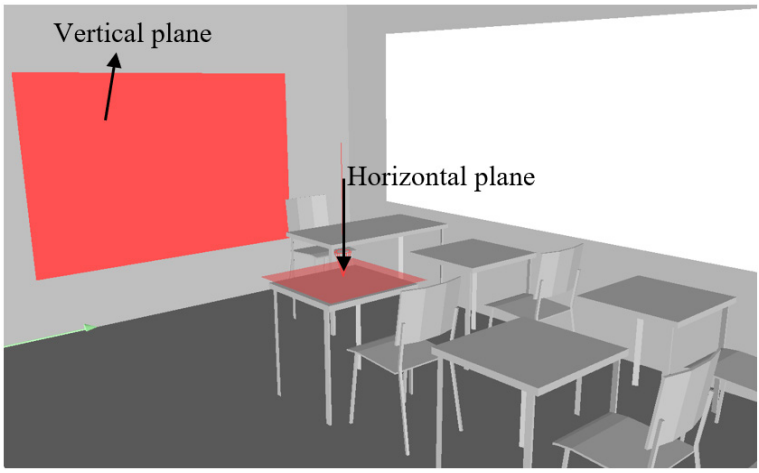


Figure 1: Representation of the Horizontal and Vertical Plane in the Volume.

In an educational structure, a high-quality design is achieved by an efficient use of daylight. Studies have shown that students are more successful in both examinations and individual matters in classrooms that utilize daylight than in those that do not utilize daylight adequately (Yener Köknel et al.,2009, p.107).

Another major parameter affecting the learning process in educational structures is the colours used on interior surfaces. According to scientific studies, colours are known to have impact on mental development, creativity,

productivity, and learning. Since formal education is carried out in a classroom, that is in a certain closed space, designing an interior space in consideration of colour, material and size of the space can have positive effects on individuals. If colours are used properly, both students and teachers will be more productive. Meticulously designed classrooms may improve sense of aesthetics, love for the school, and achievement in students.

2. LIGHTING DESIGN IN EDUCATIONAL STRUCTURES

The International Commission on Illumination defines lighting as "applying light to enable the environment and objects to be seen properly".

Lighting is divided into two; natural and artificial (daylight and lamp light).

Natural lighting is a combination of sunlight and sky light in various proportions. It changes continuously depending on seasons, climates and hours of the day. The major characteristic that differentiates daylight from artificial light is its changeable and nonmonotonic nature. While the density of, and colours appearing from, daylight offer abundant variations even during the day, we see an unlimited assortment of light in the location when we take into account the seasonal differences in a year. With these characteristics, daylight displays a vibrant and dynamic nature. This feature suits human nature very well.

Artificial lighting is a type of illumination that is made by consuming energy in situations where daylight illumination is insufficient. It was invented because humans needed to see and work every hour of the day and everywhere. Artificial lighting is enabled by lamps. Light from lamps is obtained to be used everywhere desired, to the extent desired, in the nature desired, and whenever desired. Contrary to natural light, artificial light is created intentionally in a structure. It should be aimed that the designs made to increase the quality of education and space in schools comply with standards and regulations.

2.1. Natural Lighting Design in Educational Structures

The purpose of a natural lighting design in educational structures is to create a suitable visual environment for the users of the space, to increase learning performance and productivity, and to achieve a minimum use of artificial energy. Daylight enters closed spaces through various openings such as windows, glass walls, glass doors, and dormers (Figure 2).

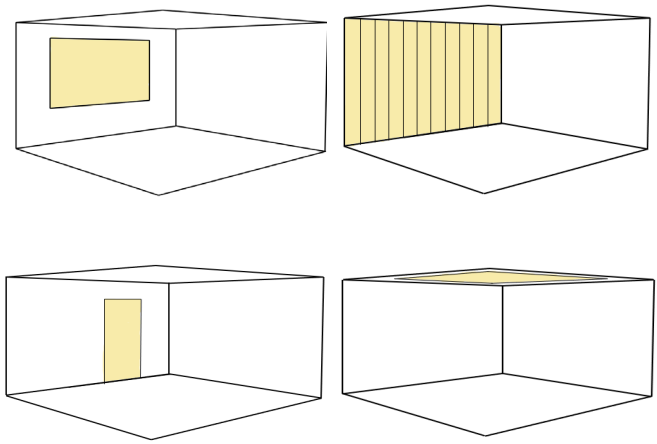


Figure 2: Daylight Enters Enclosed Spaces Through Various Openings.

The amount and distribution of the illumination from daylight in interior spaces depend on many factors. These factors can be listed as the geographical location and the climatic conditions associated with it, the architectural design of the structure such as niches and projections, the geometric shape, measures and interior surface colours of the space, the number of windows and walls in the space, the number of windows on the walls and their positions, the dimensions, shape and direction of windows, the types of their glass and frames, and man-made and natural obstacles. In addition to these factors, the dimensions, shapes and colours of internal architectural elements and their positions in the space may also play a role in the amount and distribution of natural light. Since daylight shows differences depending on a number of variances, the performance of illumination also differs depending on these factors.

Various standards have been published for the factors affecting the luminance of daylight and the methods of calculating illumination from natural light.

Ever-changing nature of daylight, more clearly, the illumination from natural light being changeable every day of the year and throughout the day and this change showing differences also depending on the geographical conditions, makes it necessary to make some concessions in calculating luminancy.

The parameters affecting the performance of natural illumination include daylight factor, daylight distribution, daylight autonomy, transparency rate, and other daylight parameters.

Daylight Factor (D)

CIE defines daylight factor as "the factor showing the ratio of that part of the illuminance at a point on a given plane which is received directly or indirectly from a sky of assumed or known luminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky". In simplified daylight calculation methods, daylight factor is calculated by taking CIE (International Commission on Illumination) standard for an overcast sky as defined by CIE as reference and daylight utilization is assessed according to this factor (Uç, 2022, p.2).

The daylight factor varies from country to country. Spaces where it is less than 2% are generally considered as not illuminated sufficiently. In this case, the space needs to be supported by artificial light. Spaces for which the daylight factor is calculated to be between 2% and 5% are spaces where natural lighting is sufficient (IESNA, 2011).

Daylight Distribution (U_0)

Luminance distribution ($U_{0;}$ E_{min}/ E_{mean}) is defined as the ratio of the lowest illumination level on a surface (E_{min}) to the mean illumination level (E_{mean}) (BS EN 12464-1, 2011). For this reason, an evenly distributed illumination needs to be created in spaces where the same types of functions are carried out such as classrooms, laboratories and gymnasiums. If the luminance distribution is lower than the desired value, there will be lighting differences in the space. The standards recommend a daylight distribution regularity between 0.3 and 0.4.

Daylight Autonomy (DA)

Daylight autonomy refers to the percentage of the time in which targeted daylight illumination level is achieved (or exceeded) on a point taken as reference to the time of using a space throughout a year (IES, 2013).

Transparency Rate

There are various definitions for transparency rate in the literature. One of these is the ratio of a window area to the gross wall area. This ratio corresponds to the ratio of an approximate glass area to the wall area measured from inside the space. A second transparency rate definition is the ratio of a window area to the floor area. A third definition is the ratio of the sum of net glass areas of the windows on the entire walls to the total area of interior surfaces (Uç, 2022, p.58). The standards recommend a window area / wall area ratio not

less than 20%. The window area / floor area ratio is recommended to be not less than 7%.

Daylight factor, daylight distribution, daylight autonomy, and transparency rate values that affect natural illumination performance are shown in Table 1.

Table 1: Natural Lighting Conditions Recommended for Educational Buildings (EN 12464-1, 2011; IESNA,2011)

Classrooms	**Daylight Distribution**	**Daylight Factor**	**Transparency Rate**	**Daylight Autonomy**
Classroom	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Laboratories	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Computer rooms	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Technical drawing classes	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Music classes	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Painting workshops	≥ 0,3	≥ % 2	≥%20 - ≥%50	≥ %50
Library	≥ 0,3	≥ min. % 2	≥ %20	≥ %30
Auditorium	≥ 0,2	≥ %1	≥ %10	

In a natural lighting design, windows should be situated in a way to utilize daylight at a maximum level. External obstacles that would hinder daylight entering the space should be avoided. The reflection factor of internal surfaces should be appropriately selected. A furnishing - window relationship should be established taking luminance distribution into consideration. To avoid a silhouette effect and glare, windows should be situated behind the students. The light should be allowed into the space mostly from the left side to prevent shades on desks. To perceive objects in their real (original) colours in educational structures where the activity of seeing is very important, daylight should be utilized at a maximum level in such spaces.

Utilizing daylight in places illuminated by daylight should also involve avoidance of glare that may be caused by daylight and discomfort that may be caused by high luminosity contrasts. In cases where glare is highly unfavourable, measures should be taken by using sun protection gears such as roller shutters and blinds.

2.2. Artificial Lighting Design in Educational Structures

Although educational structures are mostly used during the day, they should be supported by correctly designed artificial illumination when daylight remains insufficient. There are various layout proposals for spaces in educational structures such as classrooms, workshops and laboratories and lighting should be designed accordingly (Figure 3).

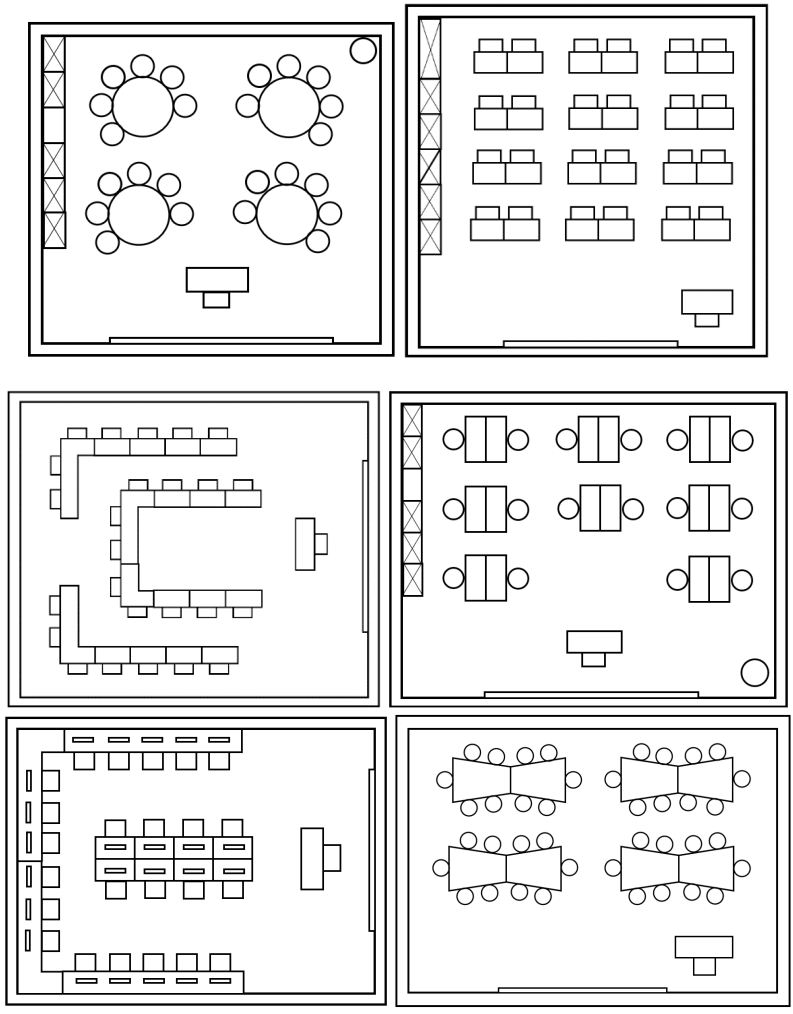


Figure 3: Different layout suggestion for classrooms

To avoid glares, lighting appliances should not be placed parallel to the direction of the eyebeam.

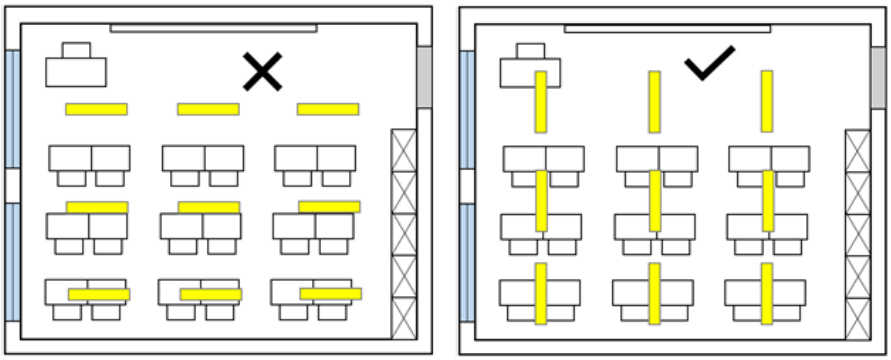


Figure 4: The position of the lighting device in the volume

The minimum values required for the parameters affecting the performance of artificial illumination, level of illumination, glare, proper luminance distribution and colour reflectance are given in Table 2.

Illuminance (E)

Luminous flux received by a small part surrounding a point on a surface divided by the area of that tiny surface part is called the 'Illuminance (E; lm/m^2)' (IES, 2013). Its unit is lux (lx). The need for illuminance has different values depending on user characteristics and the work being carried out.

Glare (UGR)

Glare is the unpleasant sensation produced by bright areas within the visual field, such as lit surfaces, parts of the luminaires, windows and/or roof lights. Glare shall be limited to avoid errors, fatigue and accidents. Glare can be experienced either as discomfort glare or as disability glare. (BS EN 12464-1, 2011)

Dazzling sensation depends on the luminance distribution within the visual field, and for this reason, is associated with the position of the person in the place and his/her eyebeam. Glare may be caused by either direct or indirect light.

Direct dazzling occurs when looking at the source of light directly, and as a result of this, eye health is harmed.

Indirect dazzling occurs as a result of a reflection of light from a reflective surface and the work being done is affected negatively (BS EN 12464-1, 2011).

Luminance Distribution (U_0)

When examining luminance distribution in closed spaces, two different luminance distributions are considered, general lighting and local lighting. Evenly-spread general lighting should be used in areas where the same functions are being carried out in a classroom (sections where students sit, etc.). Local lighting is more beneficial in sections such as in front of the blackboard and the stage of a conference hall where the instructor stands, to attract students' attention to these sections.

Most standards providing information on lighting do not specify a numeric value for an even distribution of illumination. However, values between 0.60 and 0.80 are generally recommended for an even luminance distribution on a horizontal working plane in educational structure units (Çelik & Ünver, 2017, p.6).

Colour Rendering (R_a)

This refers to the ability of a light source to render colours accurately. The most widely adopted method of indicating colour rendering performance of lamps is the CIE colour rendering index (C.R.I.) (CIBSE, 2009). To provide an objective indication of the colour rendering properties of a light source the general colour rendering index Ra is used. The maximum value of Ra is 100.

The higher the color rendering index, the closer the surface illuminated by the light source appears to be to its original color. The color rendering of daylight is accepted as 100%, other artificial light sources may contain different values. Numerical values and determinations of color rendering values are given in Table 2 (CIBSE, 2009).

Table 2: Color Rendering Index (CIBSE, 2009)

Colour Rendering Group	**C.I.E. Colour Rendering Index (Ra)**
1 (Very good)	
1A	Ra>90
1B	80<Ra<90
2 (Good)	
2A	70<Ra<80
2B	60<Ra<70
3 (Middle)	40<Ra<60
4 (Bad)	20<Ra<40

Lamps from group 1A have a colour rendering index greater than 90 and would be used where accurate colour rendering is required. Lamps from group 1B are widely used for interiors where colour is important but not critical. Lamps from group 3 will not render colours accurately but on the other hand do not produce a marked distortion of colours either. Lamps from group 4 are likely to produce a marked distortion of some colours (Figure 5).



Figure 5: Appearance of objects depending on different color rendering index (Url-1).

In Table 3, the illuminance level, distribution of illuminance, glare and color rendering values that affect artificial lighting performance are given.

Table 3. Natural Lighting Conditions Recommended for Educational Buildings (CIBSE, 2009; IES, 2013; BS EN 12464-1, 2011)

Classrooms	**Illuminance (lx)**	**Luminance Distribution (U_o)**	**Glare (UGR)**	**Colour Rendering (R_a)**
Classroom	500	0,60	19	80
Evening lessons	500	0,60		
Laboratories	500	0,80		
Whiteboards	500	0,70		
Computer rooms	300	0,60		
Technical drawing rooms	750	0,70		
Teachers rooms	300	0,60		
Library	500	0,60		
Conference hall	500	0,60		
Art rooms	750	0,70		90
Circulation areas	100	0,40	25	80
Sports halls	300	0,60	22	80

To fully satisfy the conditions for a perfect artificial illumination pattern as well as for visual comfort, values such as the colour of a lamp light, the direction of light, shade features, and light reflectance factors of interior surfaces need to be specified. Light sources with a spectrum similar to that of the daylight in terms of light colour (3300-5000 K, warm) should be used in classrooms.

As a lighting style, direct, semi-direct or diffuse lighting should be preferred. If a direct lighting style is chosen, direct light coming to the eye should be prevented and the appliances should not be placed parallel to the eyebeam. Additionally, lighting appliances should be placed according to the furnishing layout. A lighting source with low energy consumption should be selected.

It will generally be appropriate to create a diffuse light area in classrooms to achieve an illumination without shades or with soft and light shades (Aydın, Sözen, 2016, p.52). Sharp shades that will prevent three-dimensional vision should be avoided.

The reflectance factors of interior surfaces and furnishings in classrooms are as follows: 0.20-0.50 on floors, 0.40-0.60 on walls, 0.60-0.70 on windows and walls with luminance, 0.70-0.90 on the ceiling, at least 0.20 on the blackboard, and 0.30-0.50 on the desks. If these values are obtained, an ideal lighting can be achieved **(**IES, 2013; BS EN 12464-1, 2011).

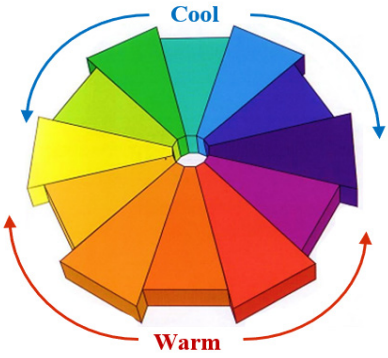
3. THE CONCEPT OF COLOR

Defined as the sensation forming in our minds after light is reflected from all objects around us and reaches our eyes, colour is a physical occurrence. Colour comes into existence in the presence of light. Light is a physical phenomenon that accommodates all the colours in a colour spectrum (Becer, 2008, p.142).

The impact of colours on humans has long been known and humans expressed their experiences and feelings by reflecting them on colours. Although feelings such as sadness, joy and excitement are in the nature of humans, the culture to which one belongs sets the stage for reflecting these feelings in different ways. For this reason, colours have been used in different cultures to have different meanings (Çalışkan & Kılıç, 2014, p.69). The effects of colours are not only limited to communities but can reach universal dimensions. Therefore, knowing the impressions of colours is highly important in directing humans and achieving social unity (Özer, 2012, p.272). When used properly, colours express many things as in their cultural and practical functions and send various messages to the individual.

The effect of colours on human psychology and physiology has been scientifically verified. Colours have perceptual (psychological, illusionary, aesthetic), functional and symbolic effects on humans. For this reason, colour is used for various purposes in the design of locations such as separating functions, emphasizing the scale, finding directions, security, making spaces more prominent and emphasized, creating focal points, attracting attention to style and material, etc. (Read, et al.,1999, p.420).

Depending on their psychological behaviours on humans, colours are divided into cold and warm colours. Warm colours with high wavelengths are yellow, red and orange, and cold colours with low wavelengths are blue, purple and green (Uçar, 2019, p.37), (Figure 6).



Figüre 6: Cool and Warm Colors

Since warm colours are perceived more readily, they are said to be more visible in visual terms, and thus, we feel them closer to us; similarly, cold colours create a feeling of distancing (Becer, 2008, p.143). (Figüre 7).

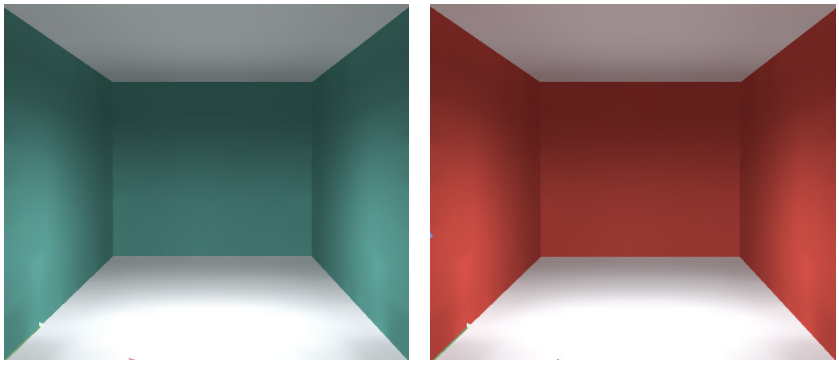


Figure 7: Spatial Effect of Warm or Cool Colors

Apart from their symbolic meanings, colours are also used functionally to give the desired impression to educational spaces. For example, by using a warm colour with a familiarizing effect on the short side of a wide and long hallway and a cold colour with a distancing effect on its long side, the space can be made to be perceived shorter and wider.

Warm colours are known to cheer up people, increase their physical power, energy and dynamism, and accelerate their metabolism. However, excessive use of warm colours also has negative effects such as too much excitement, tiredness, violence, aggression and difficulty in concentration. Cold colours are known to have relaxing, refreshing, reassuring and calming effects on individuals. Besides warm and cold colours, light and dark colours can be used to create a difference in spatial perception. For example, dark tones of green may give negative feelings such as fear, sadness and anxiety.

Colours have perceptual, functional and symbolic effects on humans. For this reason, creating a focal point, making any desired element in the space prominent, and attracting attention to the form affect the ratio and scale, impair symmetry, give aesthetic value, and are used to reinforce various meanings and purposes in separation of functions from each other, etc.

3.1. Effect of Colour Choice in Classrooms on Education

Since formal education is carried out in a classroom, that is in a certain closed space, designing an interior space in consideration of colour, material and size of the space can have positive effects on the users of that space. According to scientific studies, colours have psychological and physiological effects on students and teachers in an educational process, and contribute to their productivity, creativity, cognitive development, and learning. In this context, since the time it takes to perceive and respond is critical in an education and learning process, educational sections need to have adequate lighting, comfort and colour harmony.

Baker (1986: 80) stressed in their study the importance of interior space environmental factors consisting of ambient factors (temperature, sound, odour, etc.), design factors (plan, colour, material, furnishing layout, etc.), and social factors (age, gender, education, etc.) in confining spaces and making them meaningful with respect to their functions. Proper and correct use of environmental factors may have positive effects on the quality of the location, perceptive-behavioural performance of users, the time of staying in the space, spatial orientation, and direction-finding performance of users.

Trent (1995: 36) emphasizes that the function of a location and the age group of the children who will use that location should be taken into consideration when deciding on the colours that will be used in educational structures and classrooms. They point out that because particularly the children in lower grades are very active, classrooms and school environment should be arranged in line with this characteristic and that using warm and bright colours on surfaces and furnishings will create a positive effect.

In educational structures, the spaces where educational and teaching activities take place most are classrooms. Therefore, students spend most of their time in classrooms during the time they are in school. In this context, when making a colour design, colours that are friendly and relaxing and that promote motivation and creativity should be used. Colours used in educational structures may show their effect also physiologically. For example, there are field studies showing that bright colours used in school buildings trigger hyperactivity (Koyuncu & Arabacıoğlu, 2019, p.73).

Colour Design in Preschool Education:

Meticulous design of classrooms is an important matter to be considered in terms of improving sense of aesthetics, love for their school, and increasing achievement in students. Studies have shown that differences can be made in spatial perception by using warm or cold colours, and light or dark tones. For this reason, use of cold colours (blue-green) alone in classrooms affects activities negatively and impairs motivation. In preschool education, in order to avoid affecting children's interest in the lesson negatively in terms of time, it is beneficial to use warm and vivid colours (red-orange in light tones), which arouse excitement, happiness and energy, in classrooms. A balanced combination of warm and cold colours is important also in activity workshops in this age group where learning colours is important (Figure 8).



Figure 8: Suggestion for the Use of Color in Pre-School Education Spaces (Url-2)



Figure 9: Suggestion for the Use of Color in Pre-School Education Spaces (Url-3).

Colour Design in Primary and Secondary Education:

Since the children at this age lose their attention quickly, they are in more need of an increase in their attention and concentration. To meet the physical conditions supporting child development in primary schools, scientific data need to be used in colour selection. In a classroom environment, increasing students' attention and concentration is needed more than increasing their energy. To this end, blue-green-straw yellow (beige) colours in light tones on surfaces in the classrooms are suitable for this age group (Figure 10).





Figure 10: Suggestion for Using Color in Primary and Secondary Schools (Url-4, Url -5).

Colour Design in High Schools:

Once they enter adolescence, children make a transition from warm colours to cold colours. Although warm colours increasing their excitement, energy and adrenalin are still part of their lives in this age period, children in this age group are expected to have more attention, focus and harder work in their

lessons, rather than being energetic. The psychological relaxation, resting and creativity enhancement as well as freedom and peace effects created by straw yellow (beige) and light tones of blue and green will lead to calm and increased productivity in learning in this age group (Figüre 11).



Figure 11: Classroom Color Design in High Schools (Url-6).

Since students keep their attention on the same point for a long time in classrooms, the surface of the wall on which the blackboard stands should be painted with a colour different from the other surfaces, preferably with a medium-dark colour (with a reflectance factor between 0.30 and 0.35).

One of the most important components affecting colour selection in interior design is the material used on the surfaces. The type, texture, surface reflectance factor (light-dark), and light reflectance rate of the selected material, that is, its brightness or opacity, make a difference in perceiving the colour. It is mentioned as an example of this that "if a bright satin and a high-pile velvet are woven with the same silk, satin will have a bright and light effect and velvet a deep and warm effect". A different material despite being in the same colour and a different texture despite being of the same material will cause the colour of that object to be perceived in a different way (Rasmussen, 1994, p.86).

Since formal education is carried out in a classroom, that is in a certain closed space, designing an interior space in consideration of colour, material and size of the space can have positive effects on individuals.

4. CONCLUSION

In conclusion, from the earliest ages of humanity, colours have been perceived differently and used to have different meanings in every culture. While colours had similar meanings in some cultures, they had entirely opposite meanings in others. Nevertheless, colours seem to have assumed symbolic meanings in cultures in the historical process and they were used as a guide for the preferences of people in their lives. Alongside their cultural dimensions,

given the universal meanings they have and their psychological and physiological impacts on individuals, colours also have directional and unifying functions.

If colours are used properly in classrooms, the aesthetic senses of students and the productivity of both students and teachers will improve. Although colours are first considered as a design parameter focusing on visual quality, they also leave physiological and psychological effects improving morale comfort in spaces. Studies have shown that effective use of colours in educational processes improves students' motivation and attention.

Due to parameters such as perfect vision conditions, colour differentiation, and correct colour learning, a properly designed lighting system should be employed in educational structures. The values specified in standards should be taken as the basis for a general illumination level in the spaces in educational structures. To avoid glare, lighting appliances should be placed parallel to the eyebeam of students. To concentrate students' focus on the teacher and blackboard, local illumination specific to this section should be designed. It is recommended to illuminate the area where the teacher stands with a warm coloured light with an average luminance between 600 and 750 lx. Educational structures should be illuminated with a light having a proper spectrum. Having plenty of daylight in these spaces is one of the best solutions, but since daylight will remain insufficient in overcast atmosphere conditions, lamps with a spectrum similar to that of daylight should be chosen.

For targeted achievement and increased productivity in education, visual perception should be flawless and spaces should be designed according to pre-established criteria.

REFERENCE

Aydın, Ş. & Sözen, M. (2016). Dersliklerde görsel konfor ve iç yüzeylerin etkisi, *Megaron,* 11(1), 49-62.

Baker, J. (1986). The role of the environment in marketing services: The consumer perspective, In J. Czepiel, C. Congram, & J. Shanahan (Eds.), *The services challenge: Integrating for competitive advantage* (p. 79-84). Chicago: American Marketing Association.

Becer, E. (2008). İletişim ve grafik tasarımı (6. baskı). Ankara: Dost Kitapevi.

BS EN 12464-1, (2011) Light and lighting - Lighting of work places - Part 1: Indoor work places. Birleşik Krallık

Chartered Institution of Building Services Engineers, (1999). Daylighting and window design - Lighting guide (CIBSE Standart No. LG10: 1999)

Çalışkan, N. & Kılıç, E. (2014). Farklı kültürlerde ve eğitimsel süreçte renklerin dili, *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, 15(3), 69-85.

Çelik, K. & Ünver, R. (2017). Aydınlatmanın eğitim yapıları tasarım kılavuzlarındaki yeri, https://www.emo.org.tr/ekler/9febf4375a6155f_ek.pdf

Illuminating Engineering Society. (2013). Recommended practice for daylighting buildings (IES Standard No. RP-5-13)

Illuminating Engineering Society of North America (IESNA), (2011). Lighting Handbook. 11th edition, New York.

Kazanasmaz, T. (2015, April). Okullarda iç çevre konfor bileşeni olarak aydınlatma, *12. Ulusal tesisat mühendisliği kongresi*, Turkey.

Koyuncu, B. & Arabacıoğlu, B., A. (2019). İlkokul öğrencilerine iç tasarım becerileri kazandırmak: öğrenmeye değer öğretim tasarımı, *Cumhuriyet International Journal of Education,* 8(1), 70-94.

https://doi.org/10.30703/cije.452268

Kutlu, R., Köknel Yener, A.& Şener, F. (2009). İlköğretim dersliklerinin görsel konfor açısından incelenmesi ve değerlendirilmesi, İTÜ Dergisi/a Mimarlık, Planlama, Tasarım, 8(1), 105-116.

Özer, D. (2012). Toplumsal düzenin oluşmasında renk ve iletişim, *Sosyal Bilimler Araştırmaları Dergisi*, 3(6), 268-281.

Rasmussen, S. E. (1994). *Yaşanan Mimari* (1. baskı). (Ö. Erduran, Çev.). İstanbul: Remzi Kitabevi.

Read, M.A., Sugawara, A.I. & Brandth J.A. (1999). Impact of Space and Color in the Physical Environment on Preschool Children's Cooperative Behavior, *Environment and Behavior,* 31(3), 413-428.

https://doi.org/10.1177/00139169921972173

Trent, L. (1995). The ABC's of Color. *American School and University,* 67(11), 34-37.

Uç, B. (2022). *Konutların doğal aydınlatmasında pencere açıklığının tasarım ölçütü olarak değerlendirilmesine yönelik bir yaklaşım,* Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Uçar, T. F. (2019). *Görsel iletişim ve grafik tasarım* (10. baskı). İstanbul: İnkılap Yayınevi.

Url - 1, https://www.thelightsolution.co.uk/library/colour-rendering/

Url - 2, https://educationsnapshots.com/projects/6619/sainte-anne-academy/

Url - 3, https://design-milk.com/an-imaginative-kindergarten-that-will-make-your-kids-love-school/

Url - 4, https://indigodergisi.com/2017/05/filli-boya-okullarda-renk-etkisi-projesi/

Url - 5, https://www.legat.com/how-interior-designers-use-color-theory-to-impact-learning/

Url - 6, https://www.educationcorner.com/classroom-design-layout.html