

CRITERIA TO CONSIDER PRIOR TO A LIGHTING DESIGN OF A CLASSROOM: CLASSROOMS IN CONSTANTINE AS THE FIELD OF PARTICULAR INTEREST

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Abstract

This paper is an introductory section of a more detailed research work, which concern the elaboration of basic guidance for lighting design in local primary school classrooms. Its objective is to discuss the criteria a designer should consider before establishing a lighting design project. This is achieved through an investigation of the visual performance of the tasks undertaken. Where the visual task is critical, it is necessary to attribute more importance to the activities to take place instead of the enclosure itself, which means to the functional lighting.

Keywords: *Lighting design, classrooms, visual performance, tasks undertaken.*

Résumé

L'objectif de cet article est orienté vers l'étude des critères à prendre en considération avant d'entamer un projet d'Eclairage en général et l'éclairage des salles de classes en particulier. Ceci nécessite souvent une investigation de la performance visuelle des tâches à entreprendre. Quand la tâche visuelle est critique (délicate), la priorité est donné aux activités et non à l'espace, et alors l'éclairage doit être fonctionnel ou de quantité.

Mots clés: *Eclairage, salles de classe, performance visuelle, tâches entreprises.*

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All lighting design can scarcely be adopted as a recipe like in all enclosures or sometimes even in different spaces with similar functions. Lighting together with colour have the power to affect psycho-physiologically the human being and quite often in a negative way if not designed to meet to the requirements of the specific tasks to perform. Thus, prior to any lighting design, it is always necessary to review the range of tasks undertaken within the space of interest.

It is usually called functional or task lighting that lighting which allows to perform activities with no visual constraints. However, it is often seen that various tasks, with different and sometimes conflicting lighting requirements, are performed in a single space. Therefore it is always necessary to give further considerations to the major specific activities to take place rather than to the general space. In respect to that and with regards to educational premises, the ANSI/IES group [1,2] suggests running a survey.

The survey in question aims first to assess the range of visual tasks to be performed within a space, which in this case is a classroom. Then, its second objective is to classify data according to their degree of importance or prevalence. The survey is believed to be a practical tool that provides a clear picture of what are the tasks undertaken and visual performance within a classroom. Actually, the survey takes the form of a series of questions among which the four key ones are:

- 1- *What kind of tasks is involved?*
- 2- *What kind of occupants (age, scholastic level)?*

ملخص

إن الغرض من هذا المقال هو مناقشة المقاييس التي يجب أخذها بعين الاعتبار قبل تأسيس مشروع إضاءة. إن المطلوب عامة يحتوي على استخلاص أهم الجهد للرؤية (visuel) و عندما يتطلب العمل رؤية دقيقة يصبح ضروريا توفير إضاءة ذات خصائص عملية.

الكلمات المفتاحية: *إضاءة، غرف الأقسام، الجهد للرؤية العمل.*

3- Which of the tasks are prevailing in time over some others?

4- What is the optimum degree of accuracy required for visual performance of any given task?

Indeed, providing clear answers to the questions of the survey, would give sufficient information about the criteria to take into account prior to any lighting design project. Therefore, it was used as a basis for the development of this paper. Also, the enclosures of interest being classrooms, relevant information about scholastic tasks undertaken in such spaces and inherent visual performance are reviewed. Yet, the specific characteristics of classrooms and education in Constantine are constantly recalled together with the relevant work conditions and the particular actions or measures undertaken.

TASKS UNDERTAKEN WITHIN CLASSROOMS

In general, the tasks to be performed within regular classrooms and lecture theatres consist mainly of assimilation and presentation of information. In general, most lighting research bodies [1-3] agree that around 2/3 of the tasks are visual and 1/3 are orals. The visual tasks of a pupil within a classroom are very diversified, they range from reading or writing at his desk (table) level, reading from a chalkboard, watching a teacher (or another pupil) for perhaps quite extended periods, to watching eventually T.V, slides and film projections.

However, it is believed that this quantification cannot be blindly retaken and would more or less vary with each educational system. For instance the Algerian syllabus includes regular reciting of lessons, significant copying from chalkboard and not that much art-craft activities. More precisely, visual tasks involve reading or writing at desk level, reading from a chalkboard or watching a teacher for a more or less extended period of time. Other activities such as watching slides or television, and film projections are not even occasionally encountered in our local primary school levels. Yet, to establish *accurate ratios* for each activity, a thorough survey would be well necessary.

TYPE OF OCCUPANTS IN A PRIMARY SCHOOL AND THEIR VISUAL REQUIREMENTS

"Age is widely accepted as an important variable in the relationship between illumination and visual performance, yet little account is taken of it in existing codes of lighting practice" [4]. The main difference between an adult and a child visualising a target is that throughout his visual experience the adult will (consciously or subconsciously) involve his memory to recall and restructure what he sees, whereas a young child is in most cases seeing a character or a shape for the first time.

A child visual ability develops gradually with the years to reach an optimum at an average age of twenty [5]. Then it starts to slow down perhaps because of previous visual experience and the continuous chain of communication between the sight and the optical memory. Therefore accurate vision is required to identify, register and learn and this would not be possible if the inherent lighting is

inadequate.

The occupants of the local primary school classrooms, are usually children between 6/7 and 11/12 years of age and considered as normally sighted. They would often need to change from looking almost straight down (on the desk) to looking along and above the horizontal. This implies from a physiological point of view, frequent changes in accommodation and when necessary several times in a very short time period.

Note that children accommodation is weak at birth and develops within the five first year of a child life to become fully effective at the age of 5. At this age the accommodation 'amplitude' is of an average of 14 dioptres (12 to 16), which relates to a point set at around 70 mm from the eye [5]. "Young people with normal vision can focus an object at any distance from infinity to about 150 mm from the front of the eye"[6]. Such a statement provides further evidence of how important it is to consider age groups separately when it comes to analyse with some accuracy peoples' visual requirements (a child aged 6 years would have visual requirements certainly different from those of a 15 year old teenager).

In addition, the sitting arrangement in a classroom would create an imbalance in the efforts to accommodate among children. For instance, in the environment of study where pupils are seated in rows [11], a child seating at the back of the room would be at around 9m away from the chalkboard. Therefore he would perform some visual tasks (such as copying or reading from a chalkboard) with more efforts that a child seated at around 3m from the visual target.

Also, within a same classrooms the variety of tasks goes together with continuous change in vision performance. Oral activities and other manual works would not require precision for visual performance as would do reading and writing. Actually the optimum degree of accuracy for visual performance would certainly be for the coupled tasks, reading from the chalkboard and writing on a textbook, when taking place at the same time. Accommodation to perform near and distant vision, would be involved and the constraint would get greater the far the child is seated away from the chalkboard.

Remark

The fact that "lighting is generated for normally sighted pupils" is believed worth rising. Actually, there would have been no problem if the child visual defect consists of impairments that can be possibly corrected by wearing glasses (such as Myopia, Hypermethropia or Astigmatism). On the other hand, in the case where the child is suffering defects such as Ambliopia no alteration to the initial lighting design is provided although it is recommended that an increase in illumination by 50 to 100% is necessary for the impaired child to perform normal vision.

It should be reported that some visual defects are due a failure of the child to learn to see because of the lack of training experience [6]. Fortunately nowadays many of these defects can be detected within the very first years (before three) and to palliate to such visual impairment spectacles are usually worn and whenever necessary

surgery is undergone.

According to Constantine Health Department (DHSS), in general average of around 3% of school children are recorded as seriously suffering from visual impairments each year. This is a low figure if you compare it with the French records which present some figures like 1 over 5 children do have general visual defects [5]. But it is not awkward because it was confirmed (by the concerned local authorities) that unless a child is seriously handicapped by his visual impairment, he is not reported as so. This only means that regardless of their vision characteristics, all children would attend classrooms under standard lighting conditions.

TASKS PREVAILING IN TIME OVER SOME OTHERS

The tasks prevailing in time over current teaching sessions would depend to some extent upon the syllabus and the teaching methods. At the present time in Algeria, there is no mystery that the schooling programs are overloaded. In primary schools, reading on books, writing on textbooks and reading from chalkboard coupled with writing on desks are activities daily performed (morning and afternoon) by pupils. Saying that these activities form around 2/3 of the total tasks, is believed a quite accurate estimation. The remaining activities are believed visually less stringent, like reciting lessons, listening to the teacher or painting.

VISUAL PERFORMANCE OF TASKS

To achieve some accuracy in tasks performance, there should be considered other criteria inherent to good vision requirements. For the ability to see the finest detail while performing tasks, visual acuity is required. A child visual acuity increases with age (Fig. 1). At birth the visual acuity is really weak, then it increases almost proportionally up to the age between 6 to 7 [5]. Then its development starts to slower down till the age of 18, and becomes steady after that.

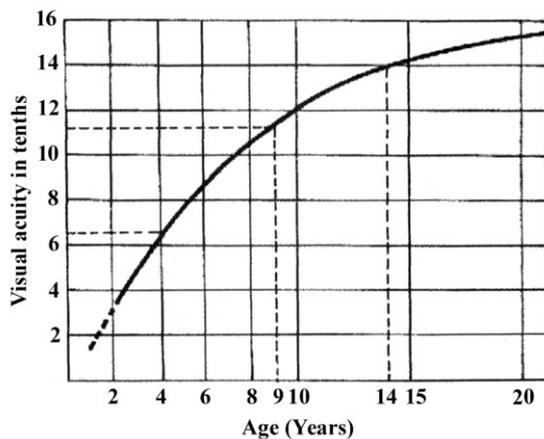


Figure 1: A child visual acuity increases with age. (Source: AFE 1987, [5])

Visual acuity is particularly important to perform the tasks of reading or writing at a desk only, or likewise

reading from the chalkboard only. Nevertheless it might be improved with an increase of the illumination level (Fig. 2).

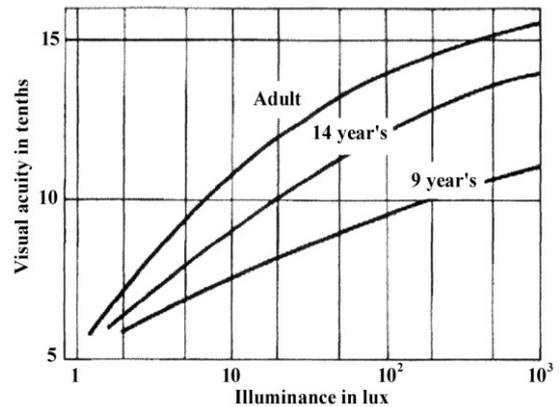


Figure 2: Visual acuity improves with an increase of illumination level (Source: AFE 1987, [5]).

The automatic involvement of the far and near vision, in visual performance of school tasks, are affected by the size of the characters to decipher (small or large characters), the luminance of the visualised surface (matte or glossy), and the contrast of colour and luminance of the details to visualise.

Both contrast and critical size play a vital role in the fulfilment of the tasks to undertake within a school room. A good understanding of the meaning of these two factors for scholastic activities is necessary. For no reason they should be considered as only helping hints but should be taken as rules and part of general recommendations to enable good school work conditions.

Contrast

Contrast is one important characteristic which allows a good visibility of task details or objects and which means contrast with the background luminance, size of details, and time of viewing.

Each critical detail of a seeing task must have a different luminance or a different colour from the visible surrounding background. Sensitivity to contrast increases whenever background luminance increases (Fig. 3).

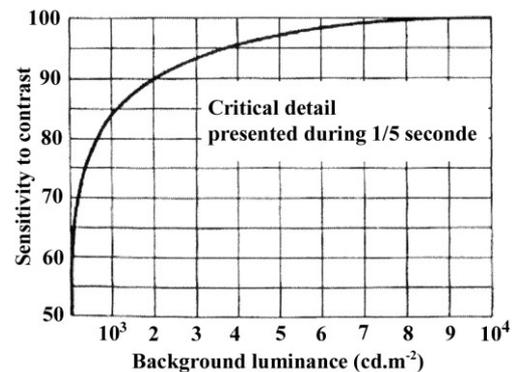


Figure 3: Sensitivity to contrast increases proportionally to background illuminance (Source: AFE 1987, [5]).

The greatest is the luminance contrast of tasks with regards to the background and the greatest is the visibility performance, and the same process remains valid for

contrast of colours. For instance with high contrast, black characters on white paper, the visibility is adequate at low illuminance level. Whereas with poor contrast the visibility of characters requires higher level of illuminance. In the IES Lighting Handbook [7], it is recommended to include felt tipped pens instead of ball point pens as these often have glossy ink. It is also advised to use low glossy ink to facilitate the readability of details and matte paper with high degree of opaqueness for text books and workbooks.

For an easy reading from a chalkboard it is suggested to provide a good combination of high quality white chalk with regularly restored chalkboards surfaces and to provide supplemental vertical illumination for the chalkboard (as lighting for horizontal tasks provide less than one half the same illuminance on a vertical surface). More, teachers ought to use large size characters whenever writing on the chalkboard.

Critical size

As writing and reading are the major tasks within a classroom (almost 2\3 of pupils time), the size of printing and writing cannot be presented without due thoughts.

The ANSI/IES group [1,8], discussed printed material size types as follows:

- The use of **6.point** should be considered as the minimum extreme allowable for a person normally sighted. Also it can be used for short reading only and in no case for continuous visual attention.
- The **8.point** type may be regarded as a size just acceptable for good readability.
- The **10.point** type is seen as the most reasonable point size for prolonged or continuous reading. It is even established as the minimum acceptable type size for text books and that is probably the reason of its increasing use. However, young children will definitely require larger type size with adequate spacing between the lines. In fact the early learning books should be printed in as large characters as possible to ensure the ease to learn and recall for the untrained eye and brain.
- Last but not least, is the **12.point** size which is recommended for continuous reading over a long period of time in order to avoid visual stress and eye fatigue.

As the size types recommended here above is related to a previous old word processor, it is supposed that with the actual word processor (word 97), the equivalent counterpart type sizes (adequate for children reading) would be:

- 8.point instead of 6.point which gives "The ear is mute, the mouth is deaf, but the eye can both hear and speak".
- 10.point instead of 8.point which is the type size of this current work.
- 12.point instead of 10.point which gives "The ear is mute, the mouth is deaf, but the eye can both hear and speak".
- 14.point instead of 12.point which gives "The ear is mute, the mouth is deaf, but the eye can both hear and speak".

Assimilation time

The eye assimilates details one at a time. The real process consists of focusing on one detail, assimilating it and then move to the next one. Under conditions of poor visibility (small size of details, poor luminance or colour contrast) the accuracy and speed of visual assimilation decrease and school work is negatively affected. Accuracy may be more important for some tasks than for others. For instance in reading a word, even if one omits to read all the letters he may still get the correct meaning, whilst in reading figures a 3 mistaken to an 8 or a 2 to a 5 can bring about serious problems.

Assimilation of details is very depended upon the visibility conditions, hence, good contrast, type size in accordance with the child learning grade, and adequate illumination, play an active role in the achievement of good assimilation.

VISUAL PERFORMANCE AND THE MAJOR ROLE OF PERCEPTION

The role of perception in tasks performance

Because vision process includes not only the elementary physiological functioning but also the ability to analyse information by the brain, the entire process gives birth then to what is so called perception. This can be widely described as a process of constructing the simplest hypothesis to explain the sensory data [9]. It can be also simply defined as the ability to translate the physical stimuli of the retinal input information into identifiable object (Fig.4). To this effect, previous experience brings meaning to the visual patterns and modifies the human system reaction, which explains the major role of perception in the process of pure visual performance.

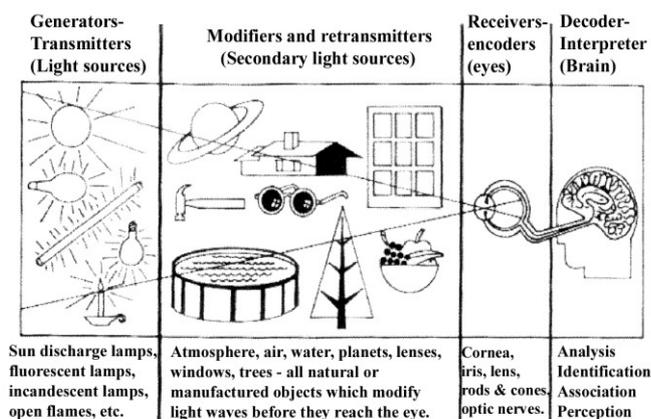


Figure 4: From the physical stimulus (light) to the perceived image (Source: IESNA, 1993, [2]).

Additionally, the visual picture of the world is formed by complicated patterns of light, shade, colour and contours [9] which justifies the specification of aspects while approaching the perception process. The most important aspects of perception are certainly; perception of three-dimensional forms and perception of colour. For the user sake and particularly for children at school, researchers and designers must develop circumstances most appropriate to the visual target.

A very young child has an overall perception of its surrounding almost unselectively. Later discrimination becomes more and more elaborated. The perception becomes then analytical, precise and aimful (centralised) and goes together with an effort of memorisation. From the age of seven and throughout teenagish years a human sees well but because of the lack of experience he does not perceive enough.

Children and the perception of forms and colours

The perception of shapes is a very important process for the child intellectual development and plays a vital role in the mental development of his personality. Therefore it is for the designers and educators to create conditions to increase this ability of perceiving shapes in the most constructive manner.

From birth, a child perception of colours develops gradually. Note that a three years old child should be able to recognise and differentiate the colours unless his ability to see colours is deficient (colour-blind). The sensitivity to Blue comes last [5] affecting consequently the function of the iris, which gets reduced.

Colour is considered as one of the most effective way to arouse different impressions [10], in addition because children react spontaneously to bright cheerful colours, it is the duty of the designer to provide children with environments where colour is a language with multiple messages; arousing, stimulating, soothing and so on.

DISCUSSION

Within classrooms, the tasks undertaken should be performed with a minimum of physiological effort and some psychological relaxation. Whilst lighting designers have to deal with the quantity and quality of light to provide good environment conditions for maximum visual comfort, educators have the duty to increase this efficiency throughout the means provided for school pupils. The major means involved directly in improving the visibility are good contrast, and the right working implements such as good quality white paper and dark colour writing pen. It is also necessary to bear in mind the correct size of details of writing on chalkboards and books printouts.

Common measures undertaken in Constantine schools

In the local schools, it is current to see a rather limited number of measures undertaken in order to provide good visibility. Among these measures, there is a particular emphasis upon contrast and size for writing on textbooks and printing on books.

More practically explained, it is imposed to the pupils the high quality white paper (e.g. Alif label) and blue ink fountain pen for writing. With regards to the reading books the characters are printed in black on white paper (sometimes off-white) with the size varying according to the academic level. The chalkboard is dark green and the teachers are trained to write clearly and in large characters. However this last implement it is not often restored as it is recommended and this quite often minimises the contrast

especially by the end of the academic year.

Visual performance and disability glare due to sunlight in local classrooms

The poor control of sunlight, is provocative of a further problem which is visual adaptation. Though the adaptation is automatic, it is not instantaneous and therefore it should be advised to protect children from sudden exposures to significant luminance variation. There the eye would be under continuous stress trying to adapt especially when natural light varies from bright to suddenly dull in winter, or when direct sunlight radiation striking the children are provoking disability glare.

CONCLUSION

Tasks undertaking and even learning may be affected by inefficient visual performance. In schools good lighting is required for better, easy and rapid tasks performance. Although the lighting design should first meet to the requirements of those normally sighted pupils, also it should show flexibility to satisfy sometimes the needs of those pupils with vision defects.

Because light and lighting remain the masterpieces by which visual performance is allowed, they are subject to analysis in a number of other papers.

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