Uniform vs. uneven lighting
Accommodation of multiple users’ preferences in study rooms

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Degree Project in Architectural Lighting Design
KTH Royal Institute of Technology
School of Architecture and the Built Environment – Lighting Design
Degree of Master of Science – Architectural Lighting Design
Course: AF270X | Second Cycle | 15.0 credits
May 2023

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Title of Thesis: Uniform vs. uneven lighting:
Accommodation of multiple users’ preferences in study rooms.
Tutor: Jörg Frank Seemann
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Acknowledgments

I would like to thank my tutor, Jörg Frank Seemann, for his help and guidance as well as his constant positive vibes during our tutorings. Our extensive and very interesting discussions were inspiring and motivating. I would also like to thank Federico Favero and Foteini Kyriakidou. Federico for his critical instructions and his insights on bibliography, and Foteini for all the effort and her supportive ideas throughout the master. Finally, I am grateful to my family for their valuable support and understanding during the preparation of the thesis, and to my friends and all the people who were by my side, contributing with their presence and their energy to my mental balance and the strengthening of my effort.
Abstract

Uniform lighting in public spaces like study rooms in libraries, is still a common practice. However, uniformly lit spaces are unable to simultaneously meet the needs of multiple users and can create dull environments.

The objective of this thesis is to analyze users' behavior under different lighting conditions in study rooms and investigate whether alternative lighting designs, which step away from uniformity, could be more beneficial than uniform lighting, from a human performance and well-being perspective.

A uniformly lit study room in the library of KTH was chosen as the main case study of this investigation and was thoroughly analyzed and evaluated through qualitative and quantitative research. Under the initial hypothesis that the lighting in this study room does not meet its users’ needs and fails to create an inspiring and comfortable environment, three additional study rooms in different Swedish libraries were comparatively analyzed through observations, interviews, and questionnaires, so as to better understand individual users’ needs and lighting preferences in study rooms.

The research revealed the existence of various types of users with different personal preferences regarding lighting in order to feel comfortable and alert. A new conceptual lighting proposal is presented for the study room in KTH library, following an uneven lighting approach that utilizes different lighting zones to accommodate individual needs and affect the sense of comfort, alertness, and ultimately, the well-being of multiple types of users.

keywords:
individual needs, light zones, contrast, visual comfort, lighting in libraries.
1. Introduction and background

“Lighting quality depends on an interaction between lighting, place and person” (Allan et al, 2019, p.115). Architecture can act as “the ‘blank canvas’ which can be made to reveal the complexity of natural light” (Lowings, 2021, p.176). Light can highlight architecture, promote its history and its aesthetic quality and elicit emotional responses. “Satisfaction and preference judgments include an emotional component: how the space makes the viewer feel” (Veitch, 2001, p.6). Some spaces are perceived as more inspiring than others. Light has a greatly important role in that. Different light typologies and distributions can lead to different perceptions of a space and emotional responses. For example, uniform light can make a space feel more detached and less tense than a space with non-uniform lighting. “Spaciousness can be enhanced with uniform lighting, while the experience of privacy can be reinforced with non-uniform and peripheral lighting” (Wänström et al, 2021, p.5). “Wall-oriented light and low-intensity table lamps can contribute to a spacious impression preferable for a pleasant character. Moreover, a bright ceiling increases the perceived height and gives a spacious impression” (Wänström et al, 2020, p.35 and 115).

Nowadays, it remains common to use artificial lighting that creates an even, uniform and sometimes characterless light effect in space. Standards promote this as well. This is probably a “relic” of the older types of lighting, like fluorescent lights, that had a typology and an illuminance output that supported uniform and bright lighting atmospheres. Despite that, an investigation of alternative lighting designs, which step away from uniformity, could be more beneficial, both from a human performance as well as energy savings perspective. According to Cuttle “the first illuminating engineering societies, formed in the early years of the last century, had no doubt that the purpose of illumination was to provide for visibility, later defined in terms of visual performance”. However, nowadays we are “surrounded by examples of recommended illuminance levels being far in excess of levels required to satisfy visual performance needs, while users are complaining of ‘cave effect’ and bland, gloomy workplaces” (Cuttle, 2013, p.22). Thus, the norms and recommendations for illuminance levels, as well as common practice, may be questioned since “in many cases they exceed what is necessary for effective visibility” (Hiller et al., 2023, p.610) leading to unnecessary energy consumption and environmental impacts. As Tiller et al. found in their research, “rooms with a nonuniform distribution of luminance were judged as requiring between 5 and 10% less working plane illuminance to achieve equivalent brightness than identical rooms with a uniform luminance distribution. This raises the possibility of modest energy savings through lighting design” (Tiller et al, 1995, p.100).

Uniform lighting refers to a lighting situation where the light is evenly distributed across the entire surface of an object or space, without any noticeable variations or shadows. This can be achieved through various lighting techniques, such as using diffused lighting sources or placing multiple light sources at strategic angles to eliminate shadows. In many settings such as workspaces, libraries, medical facilities, and schools, uniform lighting is generally considered to be better because it provides consistent illumination across the entire space, improving visibility, and promoting safety. Additionally, uniform lighting is often necessary in these settings to ensure accurate color representation, which is important for tasks like medical diagnosis and color-critical applications.
However, uniformly lit spaces can feel unnatural and static, leading to a little variation throughout an entire space where no scale of importance can be indicated. As Andersson mentions, "if a uniform, diffuse light is applied to a whole space it communicates that no part or surface is worth emphasizing or more important than any other. A space like this is usually experienced as boring and insignificant." (Andersson, 1988, p. 27). Additionally, Palasmaa writes that “homogenous bright light paralyses the imagination in the same way that homogenisation of space weakens the experience of being, and wipes away the sense of place. An efficient method of mental torture is the use of a constantly high level of illumination that leaves no space for mental withdrawal or privacy" (Pallasmaa, 2005, p 46 and 49).

Moreover, uniform lighting is not commonly found in nature (fig.1 and 2). On the other hand, non-uniform and varied lighting is very common in nature, since sunlight produces varying levels of illumination throughout the day and across different environments and creates multiple patterns and gradiances of color and intensities. It can be found in sunrise and sunset, mountain peaks and forests, where the sunlight filters through the trees and vegetation, producing patches of light and shade that create a dynamic and ever-changing lighting pattern. Humans are connected with nature and natural light and there is probably an archetype collective memory of the light effects it creates. For example, prospect - refuge theory holds that individuals wish to see but not to be seen (Wänström et al., 2021, p.5) in order to feel comfortable inside a space, and maybe this has to do with what empirical studies by the psychologist Stephen Kaplan have identified, pointing the “edge of the wood” as the place of innate human choice, as it feels to be the safest (Hildebrand, 1999, p.27).

In general “people prefer to see without being seen, by nature” (Barazawa et al., 2013, p.274) and spatial arrangements that “support seeing and hiding, while providing the opportunity for movement and exploration” are more preferred (Keszei et al, 2019, p.116).

Throughout history, electric lighting has been seen as a means of promoting happiness, knowledge, cleanliness, and health. The symbolism of light is often associated with truth, wisdom and progress, while darkness is often associated with ignorance, oppression, evil, or a lack of personal control (fig. 3). Moreover, the dimness that exists at the border between light and dark, as well as during dawn and
dusk, is particularly associated with imagination, intimacy, and the supernatural (Moezzi, 1996, p.124). All these symbolic meanings, combined with the physiological effects of lighting, make the interplay between light and dark a fascinating subject.

Contrast and dark zones play an important role in highlighting the unique characteristics of architectural spaces and support visibility (maybe even more than high illuminance levels) and orientation. “Contrast is [...] fundamental to the understanding of vision and visual quality” (Liljefors, 1999, p.7) and “deep shadows and darkness are essential, because they dim the sharpness of vision, make depth and distance ambiguous, and invite unconscious peripheral vision and tactile fantasy” (Pallasma, 2005, p.46). Moreover, as Wänström Lindh mentions, “the ability of the peripheral vision to view comprehensive scenes and indistinct field contrasts is facilitated through variable light. Therefore, an increased focus on light at vertical surfaces as well as larger brightness contrasts—and not uniformity—would be useful for our spatial experience and orientation ability” (Wänström Lindh, 2012, p.22).

Consequently, the fact that we still choose to have mostly uniform lighting environments in our contemporary office spaces or educational spaces, like libraries, seems to be problematic and opposite to the potential benefits of providing varied lighting options that support individual well-being and productivity as well as cost-effectiveness. The author has the intention to investigate whether alternative lighting designs, which step away from uniformity, could be more beneficial than uniform lighting, both from a human performance and well-being as well as energy savings perspective, with a vision of creating future spatial environments with lighting that supports comfort and well-being for multiple types of users.

An observation (we mostly light public spaces uniformly) contrast to a hypothesis (uniformly lit environments cannot support productivity, visual comfort and well-being appropriately) approach will be developed in order to find answers concerning how light zones, dark zones, shadows, contrast, color temperatures and light distributions can be used to highlight architecture, promote beauty and comfort and create inspiring atmospheres.

The author has been in close contact with educational spaces and study spaces in libraries because of her recent student identity. That is why library environments and study rooms are chosen as the main type of analyzed spaces in this investigation. Under the hypothesis that uniform lighting is not appropriate for creating a sustainable and comfortable lighting environment that facilitates various needs, a specific, uniformly lit, case study room inside the library of KTH, Stockholm, will be thoroughly analyzed and evaluated, and a new conceptual lighting design proposal will be presented, corresponding to the lighting preferences, visual comfort, and circadian rhythms of the space’s diverse user types.
1.1 Research question

Main question:
Is uniform or uneven lighting better for study rooms in libraries, in terms of well-being, concentration, alertness and comfort?

Secondary questions:
- What is adequate light? Why do we overlight interior spaces? Why do we avoid shadows, dark zones?
- What do users need to feel comfortable and alert?
- How can light be used to highlight architecture and historical importance while changing the perception of space and creating energy efficient and inspiring environments?

1.2 Sustainable statement

In order to promote sustainable practices, it is essential to prioritize both the well-being of users and energy efficiency. By integrating sustainable lighting systems that are energy-efficient and enhance the quality of life, we can create healthier educational spaces and reduce our impact on the environment.

There is not one specific, correct way to study. In order to design quality study environments, the consideration of the multiple needs and preferences of users is crucial. Prioritizing well-being of all the types of users in study rooms and their needs for varied lighting atmospheres, by using as much as natural light is possible and control lighting systems that follow the circadian rhythm and provide artificial lighting when and where is needed, can lead to a more sustainable future that better support physical and mental health (correlation with UN Sustainable Development Goals 3 and 4).

Finally, varied illumination in study rooms, libraries and public places in general, that is controlled to be used when it is needed and from whom is needed and is energy efficient, as well as eco-friendly and recyclable materials for fixtures and the careful setting of illuminance thresholds responsibility after correct evaluation of standards, directly correlate with UN SDG 7 and can lead to a more sustainable future.
2. Method and procedure

A familiar to the author study space in the ground floor of the northern gallery in KTH library (fig. 7) was instinctively chosen as a case study area for exploring the possible negative characteristics of uniform lighting atmospheres. The study space appeared uninteresting and dull based on observation and was proven to have fewer visitors in comparison with the rest of the northern gallery of the KTH library. In order to better evaluate the chosen case study area and accurately come to conclusions that would help the formation of a new lighting design proposal, more information was needed about lighting in libraries, and that is why 3 more study areas in 3 different Swedish libraries were visited and evaluated. These 3 additional study areas were the annex in Kungliga biblioteket and the southern wing of Stockholms Stadsbibliotek in Stockholm, as well as the study hall at the Centre for Economic Sciences, Ekonomikum, in Uppsala University. Through personal evaluation of the lighting conditions and through questionnaires answered by users of the 4 libraries, information was gathered about the needs of the users, as well as about the relationship of light distribution and light typology with the feelings of comfort, alertness and concentration. The research in the 4 libraries together with the analysis of relevant literature review, were expected to provide the needed data in order to make a new conceptual lighting proposal for the main case study area in the library of KTH, which was assumed, since the beginning of the research, to be disadvantageous in comparison with the rest of the analyzed libraries. The qualitative and quantitative research were also expected to validate this assumption.
Uniform vs. uneven lighting

VISION
Lighting that highlights architecture and historical value, while supporting well being by facilitating multiple users’ needs.

GENERAL OBSERVATION
Uniform lighting is commonly used in public spaces like libraries.

HYPOTHESIS
Uniform lighting can have negative effects on well-being, concentration and feeling of privacy.

QUESTION
Is uniform lighting the right approach for public study rooms? Can it satisfy the needs of every user?

METHODOLOGY

LITERATURE REVIEW
effects on concentration, visual comfort and energy consumption

ANALYSIS OF 4 LIBRARIES CASE STUDIES
(Kungliga biblioteket, Stadsbiblioteket, Uppsala Ekonomikum, KTH library)

UNIFORM LIGHTING

UNEVEN LIGHTING

TYPES OF USERS
(through questionnaires and interviews)

TYPES OF LIGHT DISTRIBUTION
(through space evaluation)

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ANALYSIS OF 4 LIBRARIES CASE STUDIES
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UNEVEN LIGHTING

TYPES OF USERS
(through questionnaires and interviews)

TYPES OF LIGHT DISTRIBUTION
(through space evaluation)

DESIGN INVESTIGATION / CONCEPTUAL PROPOSAL
for the study room in library of KTH

DISCUSSION

CONCLUSION

Fig. 8. Methodology flowchart
2.1 Areas of analysis

KTH Library (main case study area)

As mentioned before, the main area of analysis is a study space on the ground floor of the northern gallery in the KTH library. The KTH library was renovated by Ahrbom & Partners and opened for the students of KTH in 2002. In the past, the building was a machine laboratory, designed by Erik Lallerstedt in 1917, and was primarily used for practical research and engineering. The two angled wings of the building housed various laboratories and water gutters (fig.9). After its renovation, the building was united by a large connective ceiling above the main yard, which was previously an open space and now serves as the library’s main hall. Nowadays, the chosen case study area that is situated on the ground floor of the northern wing, is occupying a space were previously a water gutter was hosted. The study room can accommodate approximately 30 seated people and is adjacent to the emblematic main hall of the library, which receives ample daylight through skylights.
Annex in Kungliga biblioteket, southern wing of Stockholms Stadsbibliotek and Uppsala Ekonomikum (secondary case study areas)

The addition of an annex in the northern part of Kungliga biblioteket’s historical building was completed in 1997 in the former underground book warehouse, by Murman Arkitekter. The annex houses a big staircase and various study desks around it, and is covered by a glass structure - skylight that brings an abundance of daylight in the interior. (fig.14).

The southern wing of the historical building of Stockholms Stadsbibliotek is a double-height room with desks that can fit up until 10 users each and high windows that face the exterior and let direct sunlight as well as diffused daylight enter (fig.15).

Finally, the Ekonomikum study room in Uppsala (fig.16), is a contemporary study space that was created in 2019 by Sweco Architects on the lower floor of the Ekonomikum building at Uppsala University. The aim of the designers was to create a peaceful and dimmed space, with carefully placed light sources that would accommodate different needs and preferences of users and would contribute to a better concentration. Natural daylight slightly affects the study room through glass doors that connect it with an adjacent space that has brighter illumination and windows to the exterior.
2.2 Qualitative study and participants

Four different study rooms in four different Swedish libraries were visited and subjectively evaluated, first by the author and then by available users of the spaces. The evaluation involved observations, V/P theory, questionnaires, and small interviews. The author’s subjective evaluation included notes on available fixtures, light distributions, adjustability of the fixtures, connection with daylight, and general behavior of the users. Moreover, the main topics of the questions asked to the users in interviews were visual comfort, concentration, and general lighting preferences between bright - uniform and dimmed - uneven light scenarios.

The participants in the questionnaires regarding the lighting conditions in the libraries, were users of space that happened to be present at the moment and were randomly approached by the author. They voluntarily agreed to be engaged in a conversation and anonymously be part of the research. They were mostly students, aged between 18 and 35, who were positive to express their opinion about the lighting conditions in the area they were using to study, upon being asked. In Kungliga biblioteket, Stockholms stadsbibliotek and Uppsala Ekonomikum, 8 users of each study space answered a questionnaire (see Appendix, p.38) and evaluated the lighting conditions of the space through V/P Lighting theory and the 7 lighting factors (Liljefors, 1999). 5 males and 3 females in Kungliga biblioteket, 3 males and 5 females in Stockholms stadsbibliotek and 3 males and 5 females in Uppsala Ekonomikum. The evaluation took place on three different sunny dates in May at 2:00 PM each day. Additionally, 31 people, 16 males and 15 females (8 on the first date and 23 on the second date, after realizing that the space did not truly satisfy its users) answered a questionnaire and evaluated the lighting conditions of the study room on the ground floor of northern gallery in KTH library (through V/P Lighting theory), which is the study space that will be further analyzed in order to develop an improved lighting scenario, more compatible with the users’ needs that are currently not being met. Finally, 4 users of KTH library study room, 2 males and 2 females, were extensively interviewed about their subjective impressions concerning the study area (see Appendix, p.39).

2.3 Quantitative study

The quantitative study was conducted solely in the main case study area of the KTH library. Illuminance was measured on a formed grid in the space, with an illuminance meter placed at desk height levels (0.72m) during daytime (1:00 PM) to assess the overall uniformity. Illuminance levels were also measured in specific spots closer to the edges of the room where daylight enters from the main hall and the northern rooms. Additionally, luminance was checked on the desks, floor, and ceiling using the FusionOptix app and a luminance meter (see Appendix, p.38) during daytime (1:45 PM). Finally, CCT and flicker from existing fixtures were measured using a spectrometer.

2.4 Limitations

The three secondary case study areas in Kungliga biblioteket, Stockholms Stadsbibliotek, and Uppsala Ekonomikum were not analyzed in the same level of detail as the main case study area in the KTH library, resulting in an uneven comparison. Fewer users participated in the questionnaire and interviews and less formal analysis of the lighting conditions was conducted.
3. Results

Through observations, the four analyzed study rooms were categorized into four different types based on their connection with daylight (skylight type, embracing type, uniform and neutral type, introverted and concentric zoning type, see Table 1 - 2). The qualitative research conducted in these four types of spaces revealed that different lighting conditions, with varied connections to daylight, attract different types of users with different needs. Users appreciate the lighting conditions and light distribution individually in the study areas they choose to work in, and they can be classified into different types based on their preferences concerning a comfortable and inspiring environment that helps them concentrate and stay alert while studying. Evaluation of the case study rooms by their users indicates that they are mostly content with the lighting conditions. Natural daylight is highly appreciated by all.

Among the users, those using the study room in the KTH library were the most dissatisfied with the lighting. Based on the author’s observations, the lighting in this space can be described as a “pool of light” with diffused light hovering from the low ceiling planarly. The space is monotonous and uninspiring, which is a common comment from its users that feel that the space is small and oppressive due to the low ceiling. The area is commented as tight (like an enclosed box), dimmed, oldish and homogeneous (lacking diversity or smaller private areas/zones) and normally it is not the users’ most preferred choice compared to other rooms in the KTH library. However, it is frequently chosen as a seating area simply because it is rarely crowded.

The quantitative study in the KTH library’s study room showed that the desks have lower horizontal illuminance than what is recommended by Standards.

Finally, the conceptual design proposal presented for the study room in KTH library, which is the least pleasant and appreciated by its users among the four analyzed library areas, aims to incorporate multiple and adjustable lighting conditions in order to affect positively the users of space and create a varied and uneven light atmosphere that simultaneously accommodates the individual needs of multiple users in terms of concentration, alertness and comfort.

![Diagram showing the factors that affect the formation of a type of user in study rooms.](image-url)
### 3.1 Observation of case study areas and lighting conditions

Table 1. Types of study rooms depending on the different lighting conditions in each library - Part α: Kungliga Biblioteket and Stockholms Stadsbibliotek. Graphical analysis of the lighting conditions, subjective observations and evaluation. (bluer tones: daylight, yellowish tones: artificial lighting with no indication of CCT).

<table>
<thead>
<tr>
<th>Kungliga biblioteket</th>
<th>Stockholms Stadsbibliotek</th>
</tr>
</thead>
<tbody>
<tr>
<td>(northern annex with skylight)</td>
<td>(southern wing)</td>
</tr>
<tr>
<td><strong>the skylight type</strong></td>
<td><strong>the peripheral lighting and “embracing” type</strong></td>
</tr>
</tbody>
</table>

#### Subjective observations

**Kungliga biblioteket**
- Massive amount of cold light comes from above through the skylight and task lighting for users depending the needs.

**Positives:**
- Connection with natural environment.
- Connection with time of the day.
- Beautiful reflections from trees to walls.
- A lot of light and no view that could distract from reading.

**Negatives:**
- Too much light.
- Too much glare when facing the sun.

**Stockholms Stadsbibliotek**
- Light feels like coming from above and filling the space
- Peripheral lighting
- Diffused skylight
- Ambient central illumination
- Diffused skylight
- Task lighting

**Subjective observations**
- It is interesting how natural light contrasts with the warm artificial lighting.
- Feeling of privacy even though there are a lot of people.
- It feels like light comes from around and above. Hugged - embraced by light, maybe because of the peripheral lighting the windows that are high.
- Warm ambient illumination through pendants that produce uplighting and downlighting.

**Positives:**
- Light feels natural and cozy.
- Privacy and comfort.

**Negatives:**
- Sometimes direct sun can produce glare.
Table 2. Types of study rooms depending on the different lighting conditions in each library - Part b': study room on the ground floor of the northern gallery in KTH library and Uppsala Ekonomikum. Graphical analysis of the lighting conditions and subjective observations and evaluation. (bluer tones: daylight, yellowish tones: artificial lighting with no indication of CCT).

<table>
<thead>
<tr>
<th>KTH Library (northern gallery ground floor)</th>
<th>Uppsala Ekonomikum (lower floor - level 1 study room)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>the uniform and neutral type</strong></td>
<td><strong>the introverted and concentric zoning type</strong></td>
</tr>
<tr>
<td>light comes uniformly from the low ceiling</td>
<td>concentric zone lighting</td>
</tr>
<tr>
<td>feels like a “pool of light” above the heads</td>
<td><em>adjustable lighting</em></td>
</tr>
<tr>
<td>uniform and yellowish artificial lighting</td>
<td><em>zones of privacy</em></td>
</tr>
<tr>
<td>diffused skylight from high windows of edge rooms</td>
<td>central and brightest zone</td>
</tr>
<tr>
<td>natural light (both diffused and direct) from the main atrium</td>
<td>dimmed circulation area</td>
</tr>
</tbody>
</table>

**Subjective observations**

KTH Library
- Oldish environment.
- It feels like a pool of light, space floating in uniformity, low ceiling.
- Space with no character.
- In-between space.
- The daylight that enters from the atrium is not easily perceivable.

Positives:
- Next to areas with strong architectural character.
- Daylight enters from both sides (even though under the existing lighting conditions is not easily perceivable)

Negatives:
- Users feel it is a dimmed environment.
- No adjustable task lamps.
- Dullness and unexciting uniformity.

Uppsala Ekonomikum
- Zones of privacy: center (bonfire – the faces are visible). Next zone (desks and chairs looking at the center). Outside zone (desks looking at the wall and beds - cocoons extremely private).
- While entering the eyes need some time to adapt.
- What a silence! The atmosphere is super calm.
- Some greeneries have lights on it (connection with nature even though there is no view).
- It feels like a time machine – calming machine.
- Each zone is bright somehow, defined by light. The circulation is shadowed – contrasted.

Positives:
- Next to areas with strong architectural character.
- Daylight enters from both sides (even though under the existing lighting conditions is not easily perceivable)

Negatives:
- Users feel it is a dimmed environment.
- No adjustable task lamps.
- Dullness and unexciting uniformity.
3.2 Types of users and evaluation of case study areas

Table 3. Observed connection of the four different study rooms with daylight and how this affects the formation of different types of users with different needs concerning lighting.

<table>
<thead>
<tr>
<th>lighting type</th>
<th>users type</th>
</tr>
</thead>
<tbody>
<tr>
<td>the skylight type</td>
<td>prefer dynamic daylight to feel alert and concentrated</td>
</tr>
<tr>
<td></td>
<td>privacy is the least important factor</td>
</tr>
<tr>
<td></td>
<td>100% chose the bright, cold and uniform example of the questionnaire as preferable</td>
</tr>
<tr>
<td>the peripheral lighting and “embracing” type</td>
<td>prefer lighting atmosphere that feels natural.</td>
</tr>
<tr>
<td></td>
<td>not too bright, not too dimmed</td>
</tr>
<tr>
<td></td>
<td>62% chose the warm and contrast lighting example and 38% chose the bright and uniform example of the questionnaire as preferable</td>
</tr>
<tr>
<td>the uniform and neutral type</td>
<td>Half of the users need more cold light to feel concentrated and half find the dimmed lighting more cozy and easier to focus</td>
</tr>
<tr>
<td></td>
<td>42% chose the warm and contrast lighting example and 58% chose the bright and uniform example of the questionnaire as preferable</td>
</tr>
<tr>
<td>the introverted and concentric zoning type</td>
<td>users with multiple needs concerning the feeling of privacy</td>
</tr>
<tr>
<td></td>
<td>appreciation of calm and silent atmosphere with warm and adjustable lighting</td>
</tr>
<tr>
<td></td>
<td>100% chose the warm and contrast lighting example of the questionnaire as preferable</td>
</tr>
</tbody>
</table>

*It was observed that people that are using a specific study place are mostly compatible with the lighting conditions it offers (for example users of the annex in Kungliga biblioteket prefer dynamic daylight and bright and cool lighting while studying, in comparison with users of Uppsala Ekonomikum that prefer uneven illumination, warm and dimmed environment and possibilities of adjustability in lighting to feel comfortable to study).*
Table. Analysis of 6 different types of users with different preferences concerning lighting conditions, formed after personal observation and evaluation of the results of questionnaires answered. (Bluish tones: daylight, greenish tones: cold artificial light, orange tones: warm artificial light). Each type of user has different needs in order to feel comfortable, alert, concentrated and safe while studying. The types of users found in the four different case study-libraries are compatible with the lighting condition that the space in each library offers.

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**Hypothetically, would you mostly prefer to sit and study in an area with lighting conditions similar with the ones in the left image or the right image.** *(Think only about the lighting conditions and not the furniture or the design)*

**Left image: Uniform and bright light environment**

**Right image: Uneven and dimmed light environment**

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Fig. 18. Answered question by participants concerning their preference between uniform - bright - cold and varied - dimmed - warm lighting atmospheres in study environments (the images presented in the questionnaire show the two extremes). The answers in the four different case study-libraries are representing the type of users in each study space and their preferences. In Kungliga biblioteket and Uppsala Ekonomikum the answers are fully compatible with the lighting conditions that each study room offers.
Fig. 19. Diagrams that show the users’ opinion about the luminous atmospheric quality of each library’s study space. (green: positive comments, grey: negative comments). It is clear that the study space in KTH library is the least preferable and has the most negative description (“hospital vibes”, “gloomy”, “monotonous”, “suppressive” etc). There are some positive comments but they are less in amount than in the other libraries (taking into account that the participants in the questionnaire in KTH library were 31, compared to the rest of the libraries where the participants were 8 in each). On the contrary, Uppsala Ekonomikum has a lot of positive comments close to a pleasing and relaxing lighting atmosphere (“feels like mother’s womb”, “cozy”, “calming”). Kungliga biblioteket and Stockholms stadsbibliotek have mostly positive words to describe their lighting atmosphere, connected mostly with daylight, and a smaller amount of negative descriptions again connected mostly with daylight (“glare because of direct sunlight”). (diagram inspired by the article: Casciani, D. & Rossi, M. 2014. An applied research to assess the experience of the colour of urban lighting: a pilot study in Milano downtown. JAIC - Journal of the International Colour Association 2227-1309. 13. 14-26).
Fig. 20. The results of the subjective evaluation of the lighting conditions in the four case study spaces - libraries through V/P Theory and the 7 lighting factors (by users of space and by the author). In all the case study spaces the evaluation is closer to good (worst case scenario number 3 in the evaluation scale from good to bad), showing that the users are generally satisfied with the lighting conditions. Kungliga biblioteket’s and KTH library’s study rooms have the most numerous low evaluations while in Uppsala Ekonomikum’s study room, almost all of the evaluations are the maximum positive (number 1 in the evaluation scale from good to bad). The evaluation of the author is mostly different than the evaluation of the users. Specifically in Uppsala Ekonomikum’s study room, the evaluation of the author shows the greatest similarities with the evaluation of the users, between the four case study spaces - libraries.
3.3 Quantitative study in KTH library’s study room

Fig. 21. Section and plan showing the perceived uniform light distribution in the study room of the ground floor of northern gallery in KTH library during daytime. The room is uniformly lit with 30 fixtures of CCT: 3000K on the ceiling that produce uniform and diffused ambient illumination and 6 small wall glazers of CCT: 3000K in the arches of the open northern edge of the room (next to the northern corridor). The CCT gets cooler towards the west (in the adjacent room and bookcases) and north (corridor), where fixtures with 4000K are installed. The height of the room is maximum 3.20m which is rather low for a public space. A feeling of suppression and monotony was commented by some of the users of space.
illuminance uniformity (height 72cm - 28.04.23 - 13:15pm)  
\[ U_o = \frac{E_{\text{min}}}{E_{\text{average}}} \rightarrow U_o = 0.62 > 0.6 \] (complies with the standards of EN12464-1) 

Fig. 22. Plan with a measurement grid indicated, that shows the results of horizontal illuminance and illuminance uniformity in the study room of KTH library, at desk height (72cm), measured on the 28th of April at 13.15pm. The uniformity complies with the standards of EN12464-1 (p.48). However the horizontal illuminance on the desks is lower than the recommendations of standards of EN12464-1 (lower than 500 lux for reading areas in libraries). That corresponds with most of the users that evaluated the space as dimmed.

<table>
<thead>
<tr>
<th>Wattage of fixtures</th>
<th>Quantity of fixtures</th>
<th>Energy Consumed (W/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30W</td>
<td>30</td>
<td>900</td>
</tr>
<tr>
<td>15W</td>
<td>6</td>
<td>90</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>990</td>
</tr>
</tbody>
</table>

The area of the study room is 131.5 m²  
Thus LPD will be 990/131.5 = 7.50 W/m²  
### 3.4 Literature Review

Three articles relating to the topics of the effect of light distribution on comfort, concentration, calmness and energy efficiency, the comparison between adjustable and static lighting and their impact on human behaviour and mood, as well as the contribution of light distribution and contrast to the perception of space, were analyzed in order to be used as references for the conceptual design proposal that will be presented. Two of the articles focus on educational spaces and discuss experiments conducted with pupils in classrooms. Although their results pertain to younger individuals, they will be connected to the needs and preferences of adults regarding lighting conditions, which is the focus of this research.

<table>
<thead>
<tr>
<th>article</th>
<th>topic</th>
<th>findings through experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Mil, I. W. et al. 2018. Light at eye level is a means to create energy savings and space for learning, focus and concentration</td>
<td>effects of light distribution on comfort, concentration, calmness and energy efficiency in educational spaces</td>
<td>“Improved performance in math and reduced noise level by young pupils in classrooms can be a result, when working in light from pendants (non-uniform lighting) compared to evenly distributed light from the ceiling” (p.82). Non-uniform lighting like pendants, can lead to energy savings of up to 68%. Suspending pendants tend to attract pupils resulting in them being seated in closer proximity, rather than being scattered around the classroom. Non-uniform lighting leads to a variation in lighting conditions within the same learning space. Quote from student: “I think it is really nice that there is not so much light everywhere. Now I can choose where I like to sit”.</td>
</tr>
<tr>
<td>Wessolowski, N., et al. 2014. The effect of variable light on the fidgetiness and social behavior of pupils in school.</td>
<td>adjustable lighting compared to static lighting environments</td>
<td>“Variable light (VL), is an interior lighting approach that adapts to the particular needs of human beings, like circadian rhythms. Variable light can “directly reduce pupils’ restlessness” and “aggressive behaviors and disturbances during the lessons” (p.107) compared to everyday classrooms that currently have only a single, static lighting situation. Dimmed, warm-white light in the classroom can directly lead to a decrease in fidgetiness and an enhancement in social behavior among students.</td>
</tr>
<tr>
<td>Wänström Lindh, U. and Billger, M. 2021. Light Distribution and Perceived Spaciousness: Light Patterns in Scale Models.</td>
<td>light distribution, contrast and perception of space</td>
<td>“The play of contrasts between bright and dark areas in the space is essential for how the level of light is perceived” and “darkness can be an enlarging factor when the spatial boundaries become unclear and the distance more difficult to estimate, while bright walls can appear to be closer if the brightness sharply contrasts with the surrounding region” (p.10-13). Light can serve as a simple method to visually enlarge spaces. The optimization of light distribution within a given space is more important compared to the installation of more light. “Variations in light distribution affect the visual experience more than the amount of light” (p.1).</td>
</tr>
</tbody>
</table>
3.5 Conceptual design proposal for the KTH library's study room

All the aforementioned results, along with some comments from the library administration, were used to develop a conceptual lighting proposal for the KTH library’s study room. The proposal aims to accommodate the needs of multiple users and introduces light zones with different light distributions and adjustable lighting. The library administration’s brief provided information highlighting the need to renovate the aesthetics of the room, as it currently feels disconnected from its adjacent, more vibrant spaces and creates a sense of disorientation. Daylight or representations of its dynamism, were noted by the administration and the users to be missing.

New lighting proposal

- Light zones for different types of users → gradiance of privacy
- Adjustable lighting that corresponds to all needs and circadian rhythm
- Reflections that represent history and the natural element of water

Plan of the new conceptual proposal with different light zones that accommodate the needs of different types of users.

Fig. 24. Factors that affected the formation of the design proposal.

Fig. 25. Plan of the new conceptual proposal with different light zones that accommodate the needs of different types of users.
Zone 1.  
Artificial skylight. Cold light during daytime and controlled CCT to follow circadian rhythm. 

Compatible with needs of types of user a’ and c’ that need bright and cold light to concentrate. Zone with automatically controlled CCT (tunable white light from 5500K to 3000K) following the time of the day and circadian rhythm. Social area. “Light seems almost to act like a glue for all the people sitting around the table” (Alexander, 1977, p. 1161).

Zone 2.  
Zone affected by natural daylight. Individual task lighting. Warm downlighting during nighttime or if needed (automatic dimming control with daylight sensors). 

Compatible with needs of type of user b’, that feels comfortable when the light feels natural and is not too bright not too dimmed. Daylight can reach this zone and affect the natural feeling. Moreover it faces the main hall so it is compatible with the need of “feeling accompanied” while studying.

Zone 3.  
Private area between the arches. Task lighting (possibility of no artificial lighting). Slightly affected by daylight during the day. 

Compatible with needs of types of user d’, e’ and f’ that appreciate privacy, warm light and task lighting. These types also commented appreciation of natural light, of reflections of natural elements and of dimmed lighting. The zone is close to the corridor with water reflections, has some contact with daylight and when the task light is off it can be even more dimmed affected only by its adjacent light zones.

Fig. 26. Representation of the lighting conditions corresponding to users’ needs, in each light zone included in the conceptual design proposal - Part 1.
Zone 4.
Private and chill area with comfortable seats and moveable floor lamps (that can be turned on or off).

Compatible with needs of types of user e’ and f’ that need privacy, warm and dimmed light to feel comfortable and a cozy environment with adjustable lighting to study concentrated. CCT of 2700K. The floor lamps can be turned off-on or be moved depending the needs. Peripheral lighting on the back wall during nighttime. The experience of privacy can be reinforced with non-uniform and peripheral lighting” (Wänström et al, 2021, p.5).

Corridor
Reflections of water as representation of nature and of the history of space. During nighttime wall glazing recessed uplights between arches.

Compatible with needs of all types of users that appreciate nature. Representation of water will be a memory of the history of the space that used to be a water gutter. Projections and dynamic lighting help the mind to escape when needed. Repetitive uplighting of columns highlights the corridor and its architecture.

Peripheral lighting
Recessed uplighting and wall glazing effect.

Circulation
The circulation in between different light zones is dimmed.

“It is found that uplighting and wall-washing are more energy efficient than downlighting” (Cuttle, 2013, p.33).

“The function of the intermediate shadow-zones, which limits and defines the light-zones, is thus circulation” (Madsen, 2007, p.55).

Fig. 27. Representation of the lighting conditions corresponding to users’ needs, in each light zone included in the conceptual design proposal - Part 2.
The design proposal tries to incorporate the needs of all user types identified and creates divided light zones that collectively form an inspiring, comfortable, and human-centered environment that is compatible with users’ circadian rhythm and well-being, addresses their need for privacy or socialization, establishes a connection with daylight and the perception of time, and fosters a sense of orientation within the space.
4. Discussion

During the research, different types of users, with different lighting needs while studying, were identified in the four case study areas in libraries. Some of them preferred brightness for alertness, while others dim lighting for coziness and comfort that helps them concentrate, or even no light at all during the use of laptop. The results of the qualitative research showed that the lighting preferences of the users in the four different study rooms evaluated, were mostly compatible with the lighting atmosphere provided by each space, except for the KTH library’s study room. For example, the users in the annex of Kungliga biblioteket, that was evaluated by the author as the skylight type, full of daylight, expressed a preference for bright environments to enhance concentration, and they ranked privacy as the least important factor for choosing a study area. Moreover, all participants in the questionnaire selected the bright and uniform lighting scenario as preferable, from the two given photos. On the contrary, users of Uppsala Ekonomikum, which was evaluated by the author as the introverted type of space, commented that they prefer dimmed and warm environments, with possibilities of adjustable lighting and different light zones, they considered privacy and comfort as the most important factors for choosing their study area, and all of them chose the warm and varied lighting scenario (between the two given photos) as preferable. Although the questionnaire responses indicated that lighting conditions were not the primary factor influencing users’ choice of study space, these two extremes show an absolute compatibility between user type and space type and can lead to the interesting conclusion that users select, maybe unconsciously, a study area when it accommodates their needs, or they become accustomed to the lighting it provides after prolonged contact with the space. However, it is also important to educate the users that are not familiar with the positive or negative effects of illumination on their health and well-being (such as the impact of CCT on circadian rhythms).

The interesting case study of Uppsala Ekonomikum study room, was the one that was evaluated by its users mostly positively and that indicates an appreciation of the zoned lighting (that creates a “space” inside the actual space), and of the capability of choosing their own preferred micro-working environment, whether it’s a brighter or darker area, based on personal preferences at that specific moment. Light zones as described by Merete Madsen are “(spatial) groupings of the lighting variables (intensity, direction, distribution and colour)” (Madsen, 2007, p.51), that while interacting, they can affect significantly the perception of space and the emotional response of the user. Moreover, as it was found by the literature review, uneven and varied lighting leads to a variation in lighting conditions within the same space, which can consequently lead to an inspiring and versatile spatial environment with a variation of lighting choices that can accommodate different needs. However, Uppsala Ekonomikum was at the same time the most disconnected study room from daylight, which was a factor much appreciated by participants in the questionnaires in all the four study rooms. Although it is said that “the short term variations in natural daylight provide variety and interest to an interior in a way that continuous artificial lighting cannot” (Collins, 1976, p.84), Upssala Ekonomikum’s example shows that careful lighting design that provides a pluralistic light atmosphere and adjustable lighting that can be con-
commented that the space feels smaller than it is as well as suppressive and enclosed. This can be connected with the low ceiling and the numerous downlights that create a low, hovering, even light zone above users’ heads. At the same time, the lighting is evaluated as lower than expected on the working plane, and that was confirmed during the illuminance measurements that showed results lower than the recommended. Moreover, comments about the need for spatial diversity and connection with daylight from the main hall were made. Uneven lighting with various light zones can be a more efficient lighting method for the space, since it was found through the literature review, that it is able to create micro-spaces inside the space that can act as “intangible” dividers. Additionally, as it was mentioned in the introduction, contrast and darker areas in space make depth and distance ambiguous and activate unconscious peripheral vision. That is a way of making the study room seem enlarged as well as the available daylight from the sides of the space to be more obvious and pronounced. The conceptual design proposal tried to implement all these ideas in order to improve the study room’s environment, highlight its architecture and history, change the way it is perceived by users and fulfill their individual needs regarding comfort and concentration.

Concerning energy efficiency, controllable zoned lighting that is used when it’s needed together with task lighting, uplighting and wallwashing, can save energy comparing to the uniform downlighting of the study room in KTH library. The conceptual design proposal adhered to these principles to ensure the space aligns with the sustainable statement of the research and UN SDG 7. The area was found to be adequate to standards in terms of lighting power controlled by users, reduces the discontent due to lack of daylight, at least to an extent.

It is crucial, however, that contemporary public spaces like study rooms in libraries, are equipped with adjustable lighting not only in terms of individual use and manipulation by users, but also automated and controlled (advanced dimming control with daylight sensors and tunable white OLEDs) in order to be human-centric, follow the needs of users concerning circadian rhythm and emotional well-being and be energy efficient and sustainable. As Myriam Aries has written, “during the day, bright light (1000-2000lux) in a combination of daylight and electric lighting improves mood and motivation levels. Humans must receive sufficient light exposure to maintain an optimal mood” (Aries, 2005, p.19). Existing examples, like “the light room” in Uppsala University, provide artificial lighting that tries to replicate the daylight’s brightness and color temperature in order to reduce “winter fatigue” that lack of daylight during winter creates to humans, especially in Nordic countries. Although this is inspiring and innovative, more research should be done in order to find ways of incorporating these spaces of “artificial daylight” in study rooms, instead of providing them only in enclosed, separated rooms. It is interesting as well that artificial dynamic lighting could abstractly represent daylight and its visual effects, in order to reduce the results of its insufficiency and affect emotionally the users that could feel more connected to nature (ex: projections of shadows of trees or water), while creating inspiring interior environments.

The main case study area of the KTH library’s study room was found through the qualitative and quantitative research to be inadequate in satisfying its users, as it was initially foreseen. Most of the users
density however it was also found to have poor lighting that doesn’t fulfil the wishes of users and could be improved. As it is stated by Johanna Enger, standards (like EN 12464-1) are the only recognized tool for evaluating light quality. However, they still rely on a simplified understanding of how vision functions, which can lead to the installation of excessive lighting systems that can have negative impacts on both well-being and energy consumption (Enger, 2018). Careful reinterpretation of standards and zoned lighting with control systems and adjustability can be the means to create sustainable study room environments that satisfy their users.

Finally, as it was mentioned in the introduction, although uniformity is not commonly found in nature, it was established together with an effort of overlighting, as a regular way of illuminating offices and public spaces like schools and libraries, at least during the last 60 years. This can be probably linked with a historical tendency of western civilization to avoid darkness included in contrast and shadows, as it is a symbol of uncertainty and unsafety. And this could be a possible reason for the interesting fact that the choice of an accurate and decent word to represent the opposite of uniform lighting (except for non-uniform), is hard, since most of the words have a negative hue (ex: fragmentary, delimited, scattered). Maybe we still broadly create uniform and overlit environments because it’s an easy and quick method in terms of design and installation, or maybe because we are used to it. However, “when we only spend time in brightly and evenly lit environments, we stop playing with the full palette of perception” (Jane Slade, Anatomy of night).

4.1 Conclusion

From all the conducted research, uneven lighting seems more appropriate than uniform lighting for public study spaces that have the responsibility to satisfy multiple types of users and their individual needs concerning concentration, alertness and comfort. Since uniformity can accommodate the needs of only one category of users, it can be regarded as disadvantageous comparing to varied lighting atmospheres. However, uniform lighting can be efficiently supportive by being one of the chosen controlled light scenarios for study rooms, that could be used depending on the situation, as for example during the cleaning process or during specific events, like workshops.

The research showed that design of high-quality study environments, requires the awareness that there is no one single, valid and standardized lighting approach, since considering the diverse needs and preferences of users is essential. Prioritizing the well-being of all types of users in study rooms involves providing varied and uneven lighting atmospheres that facilitates both privacy and socializing, giving prominence to existing natural light, and implementing automated control lighting systems that align with the circadian rhythm and the daily passing of time. The conceptual proposal in this research took into account all of these insights and integrated them in the design in order to ameliorate the existing study room in KTH library, with a primary objective of creating spaces that support physical and mental health through lighting, while corresponding to UN Sustainable Development Goals and the vision of a more sustainable future.
Uniform vs. uneven lighting

References


Websites


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Figure 2: Downloaded from: https://wallpaperfrom.com/211324_white-mountain-range-fog-and-landscape-hd.html (accessed on 10/05/23)

Figure 3: Downloaded from: https://99percentinvisible.org/episode/under-the-moonlight/ (accessed on 10/05/23)

Figure 4: Downloaded from: https://www.pinterest.com/pin/hoseo-university-library--577445983450937013/ (accessed on 10/05/23)

Figure 5: Downloaded from: https://insights.regencylighting.com/lighting-retrofits-for-schools-and-universities (accessed on 10/05/23)

Figure 6-8: Personal archive (sketch, photographs, Illustrator)

Figure 9: Retrieved from the archive of Stockholms Stadsmuseum (archive: A 23/99, p.16)

Figure 10: Plan downloaded from: https://www.aop.se/projekt/kthb-huvudbiblioteket-pa-kth-campus/ (accessed on 10/05/23)

Figure 11-30: Personal archive (photographs, AutoCAD, Photoshop, Illustrator)

Figures in questionnaire: Downloaded from:
https://lumega.eu/blog/guide-proper-lighting-for-open-space-offices/
and
https://www.foodnet.se/article/view/827708/espresso_house_gor_sin_nordligaste_etablering (both accessed on 10/05/23)
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Table 1: Types of study rooms depending on the different lighting conditions in each library - Part a’: Kungliga Biblioteket and Stockholms Stadsbibliotek. Graphical analysis of the lighting conditions, subjective observations and evaluation. (AutoCAD, Photoshop, Illustrator)

Plan of Kungliga biblioteket: Downloaded from: https://www.kb.se/in-english/planning-a-visit/maps-of-the-premises.html (accessed on 10/05/23)


Table 2: Types of study rooms depending on the different lighting conditions in each library - Part b’: study room on the ground floor of the northern gallery in KTH library and Uppsala Ekonomikum. Graphical analysis of the lighting conditions and subjective observations and evaluation. (AutoCAD, Photoshop, Illustrator)

Table 3: Observed connection of the four different study rooms with daylight and how this affects the formation of different types of users with different needs concerning lighting. (AutoCAD, Photoshop, Illustrator)

Table 4: Analysis of 6 different types of users with different preferences concerning lighting conditions, that were formed after personal observation and evaluation of the results of questionnaires answered. (Photoshop, Illustrator)

Table 5: Indication of the main findings through experiments, in the three articles of the literature review. (Illustrator)

Table 6: Proposed lighting scenarios for the study room on the ground floor of the northern gallery in KTH library. (Illustrator)
Appendix

Do you come here to study oftenly?
It is the 1st time_/ Every week_/ Every month_/ No__

If you were free to choose, would you still choose this area to sit and study?
Yes_/ No_/ I don’t have an answer__

Is your preference related with the lighting conditions?
Yes_/ No_/ I don’t have an answer__

If yes, how is related? (tick what you think is important)
Because of the lighting conditions...
___ I can see well ___ I feel comfortable and safe ___ I see the view from the window
___ I am alert here ___ I can concentrate Other: ________________________________

What are the most important factors when using this space? (Rank from 1 to 5 with 1 being the higher priority)
Spaciousness___ Comfortness___ Privacy___ Concentration___ View___

Could you describe the atmosphere and the lighting conditions of this seating area  with 3 or more words? (ex: gloomy, pleasant, welcoming, inhospitable, calming etc.)
______________________________________________________________________________

Would you like anything to change / be added/ be removed in the lighting?
______________________________________________________________________________

What is your favourite aspect of the space?
______________________________________________________________________________

The least favourite?
______________________________________________________________________________

Any other comments concerning the lighting conditions of the area:
______________________________________________________________________________

Fig. 29. Questionnaire given to users of the study rooms in the four case study libraries in order to evaluate the lighting conditions and express their preferences.

Fig. 30. Luminance studies with the use of Fusion optix app, on the 28th of April at 14.00pm. From left to right: ceiling, view towards the main hall, desk and view of the hall room towards the north. A general uniformity of the mainly diffused lighting is observed. Moreover, the impact of materials on the visual field’s brightness distribution is revealed. The desks have more reflective material and the ceiling and floor has lower reflectivity.
Interviews in KTH study room

The interviews were conducted on the 10th of May 2023 (sunny day) in the afternoon.

Main questions:
“Can you describe the lighting conditions inside here?”
“What do you feel about the study room and the lighting? Did you choose this study room because of the lighting?”
“Do you like it? Do you think it makes the space look interesting?”
“Do you feel comfortable and alert inside here?”
“Would you like “nature” to be implemented inside the room somehow?”

Participant 1 | Male, 22 years old, KTH student
_”I come here sometimes to study because the place is commonly empty and it’s easy to find a seat” (since people don’t like this room so much).
_”It’s dark and you cannot easily concentrate in here. I mostly concentrate when it’s bright. Also the space feels not renovated and oldish and I think the illumination is bad.”
_”Although there are so many lamps in here it’s still dark, it’s strange no?”
_”The atmosphere is like a typical office, cold and not cozy at all.”
_”I sit here because I know that it’s brighter as daylight affects this seat.” (close to the main hall)

Participant 2 | Male, 33 years old, KTH student
_”The place is gloomy with really few natural light, a bit bad for productivity. Natural light is blocked by these rooms in the north!”

Participant 3 | Female, 24 years old, KTH student
_”It’s somehow cozy, the light is very diffused.”
_”I feel it’s too red in here. Maybe if there was greenery or bluish colors it would be better.”
_”It is such a small place.. I feel like I am in a box and I have a bit of claustrophobia. I cannot stay long. The problem is the low ceiling. The light comes right on my face. I wish I could push it to go higher and further from me!”

Participant 4 | Female, 26 years old, KTH student
_”It’s bit dimmed the place, but that is not a problem. I usually use the laptop and don’t need more light.”
_”I feel like it’s a cozy and dimmed place but when I want to be really productive and alert I go to sit in the main hall that has brighter light.”
_”The place is tight and maybe plants or something would be too much for here.”