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ABSTRACT:

This report explores the potential of applying theatrical lighting approach for lighting of urban spaces with a focus on benches unused during the night-time.

The thesis investigates the differences in lighting design practice applied in urban spaces and theatres and how the two can be merged to enhance the existing atmosphere of urban spaces, so they are used for longer periods of time. The literature study introduces the growing issue of non-places that affects new neighbourhoods, the criteria for choices of the sitting place and possible social interaction between the bench user and the pedestrians. Afterwards, in the pre-analysis section, examples of existing benches are gathered into a set of typologies that assess different forms that lighting can take in an urban space.

In the case studies, the report scrutinizes three benches placed in new neighbourhoods of Copenhagen to find out that lighting issues that exist on similar benches are caused by the illuminance level that is higher on the audience than on the actors, the lighting fixtures that are placed too high and overall bad light distribution. The solution for the space is presented in the design proposal which applies a theatrical approach to reposition the lighting fixtures and adjust the distribution of light in the space. The report finishes with a test that underlines how the light intensity level affects the perception of the space and therefore influences its usage.

The thesis aims to underline how the theatrical approach towards lighting design can enhance the existing lighting of urban spaces to encourage city inhabitants to use the benches more during the night-time.

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Theatrical lighting approach for urban benches and audience-actor interaction.

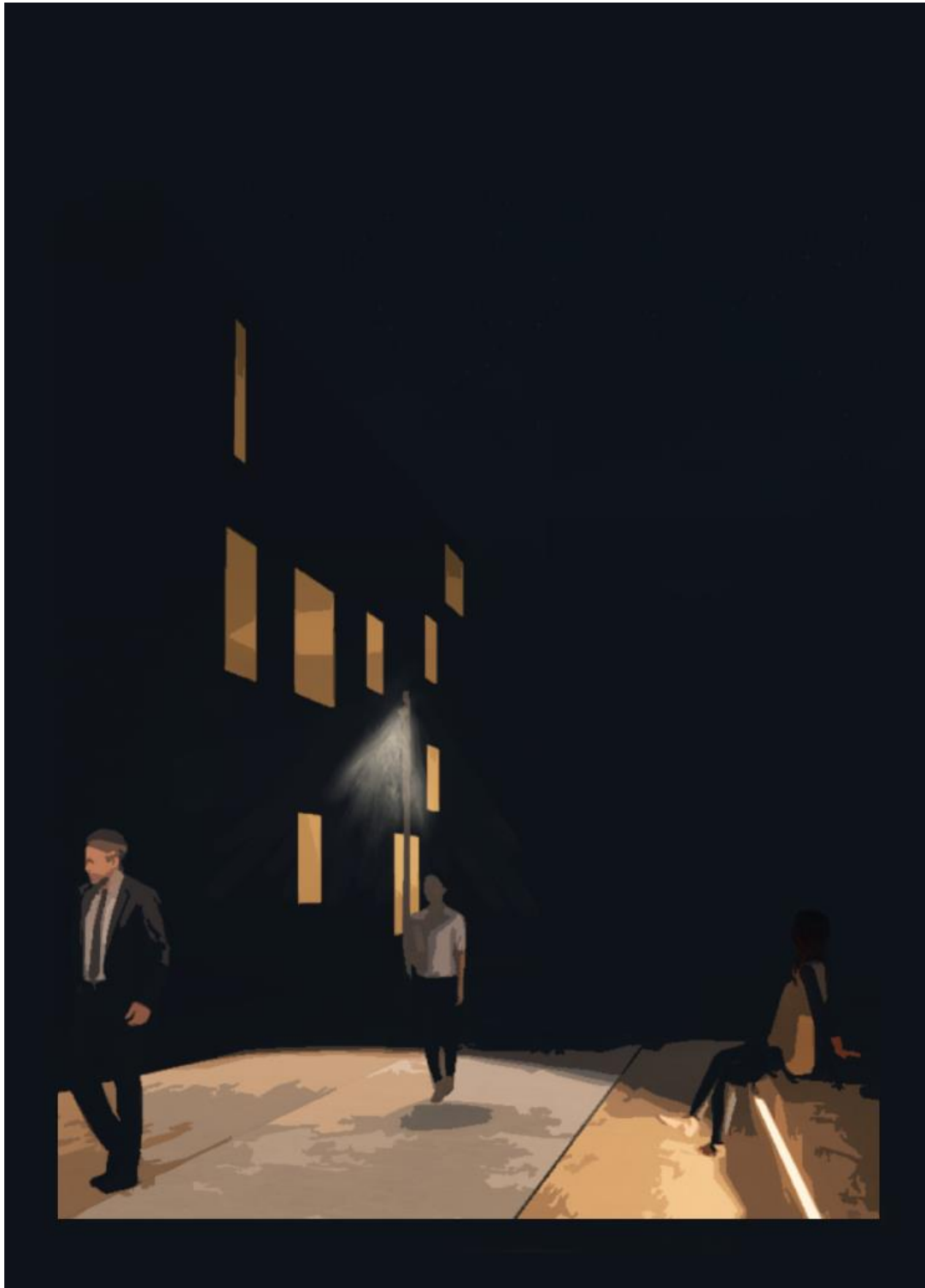


Fig.1

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1. INTRODUCTION

The thesis is an investigation of how theatrical lighting approach can be used in the context of urban space in order to encourage the bench user to stay longer and therefore stimulate the growth of outdoor life. The report focuses on the interaction between the users of benches and the pedestrians in the surroundings. In the project, the bench users are compared to the audience in a theatre, while the pedestrians are the actors of the play of the city.

“All the World’s a Stage” (Shakespeare, 1948)

The comparison of the world to a theatre stage and a concept of *Theatrum Mundi* was well known since ancient Greece. In modern urbanism we encounter a growing issue of newly-built neighbourhoods becoming non-places. On the other hand, the scenographic practice takes advantage of non-place properties that are created in a black-box theatre. Being inspired by the theatrical approach towards lighting, this report presents an innovative way of lighting urban benches with usage of theatrical tools.

Project Background

As a graduate constructing architect, I understand the nonobvious beauty of architecture and urban spaces and it is fascinating for me to just sit on a bench and analyse what I see: the buildings, their construction and the void spaces they create.

The interaction between the natural elements, like light and sound, and the built environment is enjoyable to observe. It is delightful to notice the details of textures, the shapes and patterns of the shadows they create and how it affects human perception of depth.

It all affects the sensible atmosphere of the space that the built environment creates and it can be experienced by everybody, not only architecture-trained eyes.

During my 8th semester of MSc in Lighting Design I learnt how to create atmospheres with lighting and got introduced to a concept and theories of scenography of urban spaces by my co-supervisor Mette Hvass, who is writing a PhD thesis on that subject (Hvass & Hansen, 2020). Therefore, for my 9th semester I chose an internship at the Danish National School of Performing Arts (Den Danske Scenekunstskole or DDSKS), where I joined 2nd year students’ production of theatrical play “Kain” and took a role of lighting designer of the play.

In the internship report I investigated how light can shape spaces and create atmospheres in theatrical performance in a context of a non-place black-box theatre.

The analysis was focused on the process of creating a lighting design for a play and theatrical principles of light that enables to create vibrant atmospheres for different locations and shape

the space. Due to unusual stage set-up in the play (the audience was placed on the opposite sides of the room with the stage in-between) I got curious about the relationship that can be created between the audience and the actors and how the lighting can influence it. Finally, the report compared the properties of light used for four different locations in the play and the transitions between them.

Motivation

The investigation is based on an absorbing issue that occurs in newly-built neighbourhoods. It is an increased tendency of new urban spaces which stay unused for a long time after being completed and a full identity in those places is never established or eventually, after a very long time. It is important to notice that some of the city benches are always occupied while some are never used. Those unused benches create a feeling of an empty city and make the pedestrians pass-by without stopping, slowly transforming those spaces into non-places . As Jan Gehl said: “[...] the view of city life and people has special status as main attraction” (Gehl, 2011), therefore it is essential to engage the citizens to use all benches in order to create a lively city.

The motivation for this report is to create a recommendation for urban lighting that would provide a pleasant atmosphere around the benches, therefore engaging the pedestrians to use the benches for extended periods of time.

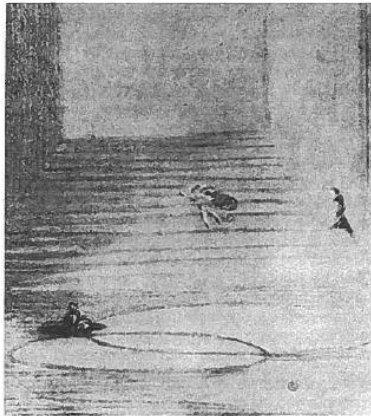
The theatrical lighting design takes advantage of non-place’s properties to create different locations with a minimal use of scenography. In this report I focus on how unused benches could be brought back to life with a usage of theatrical lighting approach in an urban environment.

Inspiration

The inspiration for the report comes from theatre where elements of everyday life, urban spaces, etc. are used in a creative way to tell the story. In this section, there are presented examples of different usage of urban elements in plays, but also how the art of performance moved out of the theatre buildings onto the streets to use the existing urban spaces as a scenography.

As theatre merges the different realms of life, it is quite common to see urban elements, like stairs used as a part of scenography. Scott Palmer refers to “The Steps” of Edward Gordon Craig from 1905 to describe possibilities to create different moods with usage of one scenography. But even after one hundred years the concept is still alive and used in contemporary plays like “Operation: Orfeo” produced by Hotel Pro Forma. The pictures below show stairs lit in two different ways. In “The space” the stairs are lit, so they create a three-

dimensional structure that enhances perceived depth of the stage. On the other hand, in the “Operation: Orfeo” the stairs are lit from the front, that makes them appear as a flat, vertical structure.



Craig's *The Steps*, c.1905: first mood

Fig.2 (Palmer, 2013, p.98)



Fig.3 (Hotel Pro Forma, 2007)

The inspiration for the master thesis came directly from the final concept that was used for the production of “Kain” that I worked on during my internship. The concept of the play was built around a “construction site’s vibe” that was created with usage of different construction equipment, including construction site lift and helmets. It was an eye-opener to see a hydraulic lift on stage that went up and down to the ceiling and made Cain and Lucifer get out of the Earth and pass through a layer of clouds straight to the Abyss of Space. In the tiny room the audience could experience that the characters are really travelling thousands of kilometers into the sky, like they just took-off in a spaceship.

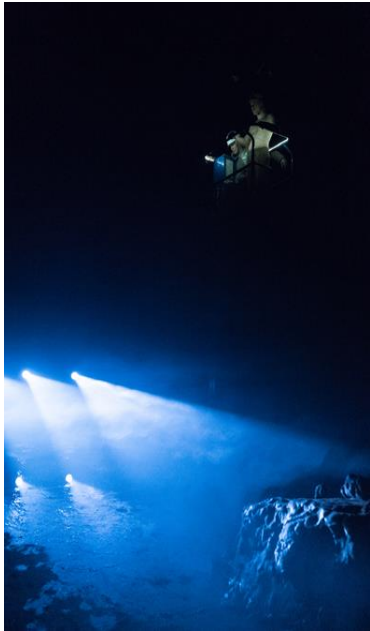


Fig.4 (Lundberg, 2019)

As the opposite of bringing the urban elements inside theatre, in performing arts urban spaces are used as a scenography for the artists. As Jekaterina Lavrinec mentions in her paper “Urban scenography: emotional and bodily experience”: “Citizens can be either passive or active “interpreters” of urban space: their bodies can passively follow spatial instructions or they can start developing alternative interpretations of public spaces [...].” (Lavrinec, 2013)

The artists who perform in public spaces show the citizens the possibility of alternative usage of urban features e.g. street furniture, thus bring out the performativity of those spaces, create engagement in pedestrians and enhance their awareness that they are part of the play of the Theatrum Mundi. This measure reinforces the concept of the Great Theatre of the World pointing that in the relationship between the actor and the audience can be equally strong outdoors, as it is in the theatre, if the pedestrians can clearly understand what is their role in the play.



Fig.5 (Dorner, 2016)

Vision

Why are some of the benches always empty and why are the others occupied for hours? This question was a starting point for the research and also a base for the vision of the thesis. In the report I imagined urban space as a theatre, bench users as the audience and pedestrians as the actors of the play. Afterwards, I formulated the vision of the project as:

What if lighting design could create an atmosphere that increases the audience's awareness of the play that is performed in their surroundings by the pedestrians (actors) and therefore encourage them to use the benches more and stay in the urban space for longer?

Methods

The report starts with the literature study chapter conducted through ProQuest research engine and reviews of physical books and art magazines. The theatrical lighting approach was established as a comparison between theatrical light principles described by Richard Palmer and architectural lighting principles of Hervé Descottes. The street lighting regulations were found in official documents provided by Copenhagen's Municipality, also some of the findings from my internship research were included in the report. Photo registration and anthropological observation methods of James Spradley were used for the research of existing lighting conditions on city's benches.

Usage of these methods allowed to understand the theory of non-places, lighting for theatre and urban spaces and the bench design and its importance for usability of a bench. After the research it was also possible to understand the basic issues of existing lighting and benches, as well as to set the direction for the next chapter.

The pre-analysis chapter started with describing which lighting properties can clearly define the actor of the space. Then the typology of benches was established as a tool of describing the distribution of light in the space and how the specific typologies impact the atmosphere of the space and the social interactions. The last step of the chapter was the practical use of the typology in connection with qualitative and quantitative methods for site analysis. The anthropological observations were combined with light measurements to understand the connection between perceived and measured illuminance levels and its impact on the usage of benches. The process also included an interview with a former Municipality Responsible to understand the existing lighting of the city and the ideas behind the actual design of urban spaces of Copenhagen.

From that knowledge it was possible to establish the problem statement, the research question and the success criterias for the design proposal that were followed throughout the design process and the tests.

The case analysis chapter included many of previously mentioned methods as e.g. observations and light measurements, analysis of urban space described by Kevin Lynch,

bench analysis according to Jan Gehl and practical usage of other knowledge established in the previous chapters.

The design proposal starts with light analysis of the study case made in DIALux evo 8. The space was modeled in the program and the lighting set according to the observations of the space, photography references and the light levels were set according to illuminance measurements taken in the space with a light meter Voltcraft MS-200 LED.

Next, the space was modeled in Unreal Engine 4 (version 4.24.3), where the light was recreated with the methods used for DIALux in order to create high-quality renderings.

The visualisations created in Unreal Engine were included in an online survey created in Google Forms. The surveys were sent out to understand how the different lighting designs can affect the audience-actor interaction in a space. After the first test, the renderings were adjusted and replaced in the survey, which was sent the second time.

All of the chapters contain different sorts of sketches, visualisations, graphs and tables created in order to clarify the presented data.

All light (illuminance) measurements were taken with Voltcraft MS-200LED light meter, horizontally at lap level, while seated (75 cm from the ground level) and chest level while standing (120 cm); vertically at eye level (while seating and standing).

Aim of the project

The thesis project aims to apply theatrical lighting design approach in an urban scenario. The report is based on the knowledge about architectural lighting and it's appliance in urban spaces gathered through the MSc education and inspired by the practice as a theatrical lighting designer during the internship at Den Danske Scenekunstscole.

Through my previous experience I have noticed that the architectural and theatrical lighting, even though so similar, tends to point towards opposite directions. In the theatre it is all about the audience and what they experience during the show; in urban spaces, there is a certain set of rules that have to be fulfilled in order to create a safe outdoor environment. Theatrical lighting approach could be a solution to add another layer on top of the existing lighting to enhance the atmosphere of an urban space.

2. RESEARCH

Introduction

The research chapter is divided into topics of lighting, urban spaces and human interactions concerning three main fields of the investigation: architecture, theatre and human science.

Firstly, the theatrical and architectural lighting are investigated in terms of their properties, with special focus on the differences between the two. Also, the street lighting regulations and the way they affect urban spaces are researched within the topic. Next, the research moves onto urbanism, where the topic of non-places unfolds, and continues onto the role of benches in public spaces: the design, part in social life and the effect that they have on street life. Further, I investigate how the design of the bench affects its users, their perception of the surroundings and social interactions.

The research aims towards understanding what are the criterias of choosing a bench to sit on and how it is connected with lighting conditions. The findings will allow for establishing the criterias that will be used in the following chapters and creating a tool to assess usability of the benches and their ability to support social interactions.

The following graph shows the research topics within the fields of interest:

	ARCHITECTURE	THEATRE	HUMAN SCIENCE
Research	lighting properties street lighting regulations non-places benches	lighting properties performativity of urban spaces	choice of the bench level of interaction

Fig.6

Lighting

The chapter consists of theatrical and architectural approach towards lighting properties and their comparison and street lighting regulations defined by Copenhagen's Municipality.

Theatrical lighting

In the theatrical lighting design the properties of light are defined by the atmosphere that light creates on stage and how it can affect the perceived space. There are eight "controllable properties of stage lighting" (Palmer, 1998) defined by Richard Palmer in his book *The Lighting Art: The Aesthetics of Stage Lighting Design* and they are as follows:

- Intensity - amount of light reflected from the stage
- Colour - hue, saturation and brightness of objects as influenced by the spectral composition of the light striking and reflecting from their surfaces.
- Form - shape of individual pools of light, patterns of light and darkness (visual composition)
- Movement - actual or apparent motion, also manipulation of light over time
- Direction - orientation of the apparent light source in relation to the lighted object and the viewer
- Diffusion - scattering of light through a translucent medium or inherent "hardness" or "softness" of a beam
- Frequency - intermittency of light
- Luminousness - quality of light (a variable created by a combination of other factors, but in very subtle proportions)

(Palmer, 1998)

These properties help in describing lighting overall outcome and all together create presets that are used for specific scenes in a theatre play. In the process of establishing the lighting score of a performance, some of the properties stay unchanged throughout the timeline of the play, while others vary a lot. The theatrical lighting has a strong “dramaturgical function” (Gröndahl, 2014) that helps to emphasize the events of the play, thus creating a proper atmosphere.

The theatrical lighting properties do not refer to any quantifiable units and their final usage is decided by the lighting designer only according to one’s personal perception of the outcomes because as Gernot Böhme said:

“Atmospheres are something entirely subjective: in order to say what they are or, better, to define their character, one must expose oneself to them, one must experience them in terms of one’s own emotional state.” (Böhme, 2013)

Architectural lighting

Architectural lighting properties regard similar qualities of light as the ones described above, however in a more quantifiable way. Herv  Descottes describes them as “specific light qualities and combinations of them” that create “visual features of light” (Descottes, 2011).

According to Descottes the principles are:

- Illuminance (Light from the light source – lux)
 - Luminance (Light reflected from a material – candela)
 - Color and temperature (color temperature and color rendering)
 - Height (the height of the installed light source)
 - Density (quantity and spatial composition of light sources)
 - Direction and distribution (the direction of the light beam and diffuse or spot)
- (Descottes, 2011)

Similarly to the theatrical properties different combinations of the features coming from different fixtures create one composition of light.

Another way to describe lighting properties in architecture presented R. Kelly who defined three layers of light:

- Focal glow which makes it easier to see
- Ambient luminescence that makes surroundings safe and reassuring
- Play of brilliants that stimulates the spirit

(Kelly, 1952)

In an urban environment that three layers respond accordingly and can be divided as follows:

- General street lighting and special utilitarian lighting for street furniture, appliances, etc.
- Ambient light from buildings and light pollution reflected from the cloudy sky
- Light art, installations, adverts, etc.

Another design criteria for architectural lighting presents William Lam in his book “Perception and lighting as formgivers for architecture”. He emphasises the importance of orientation in space and time, need for a view and ability to focus on activities, as well as “the need for definition and personalization of territory” (Lam & Ripman, 1992). Overallly, Lam states that “in most spaces, lighting which provides well for biological needs simultaneously takes care of most activity needs.” (Lam & Ripman, 1992).

The three layers of urban lighting depend on the specific case however in a general point of view, the street lighting is overly uniform and has to fulfill street lighting regulations, meet “biological needs for visual information” (Lam & Ripman, 1992), help to navigate and orientate oneself in the space, enhance way finding and boost the feeling of safety.

Ambient light is uncontrollable and depends on the neighbourhood, time of the night as well as weather conditions.

The play of brilliance in urban space is a layer that in many cases does not exist or happens by accident, rather than as an outcome of thoughtful design.

Street Lighting Regulations

The street lighting regulations are defined by the Municipality of Copenhagen in “Belysnings Masterplan” (Lighting Masterplan) that apply the cities requirements on top of international legislations. The main tasks of lighting regulations is to provide sufficient illuminance levels on streets with a proper uniformity of light. From the legal point of view, it is the street lighting that must fulfill the regulations and none of the other layers of light (ambient or play of brilliance) is not considered during the design of street lighting.

The municipality divided the streets into different types according to their width and specified the possible mounting height for the fixtures:

1. The biggest streets: 8 m
2. Feeder road: 6 and 8 m
3. Lokal street: 5-8 m; 3,5-6 m in historical and harbour areas; 6-8 m in industrial areas; 4-6m in new areas
4. The soft traffic: 4 m
5. Squares: 4-8 m

Each of the street types sets a different limitations range for the possible intensity, uniformity and colour temperature that can be used for the street lighting.. In overall the possible lighting properties must stay within the following limits depending on the width of the street:

The four possible scenarios for the illuminance levels and the uniformity are represented in the graphs below:

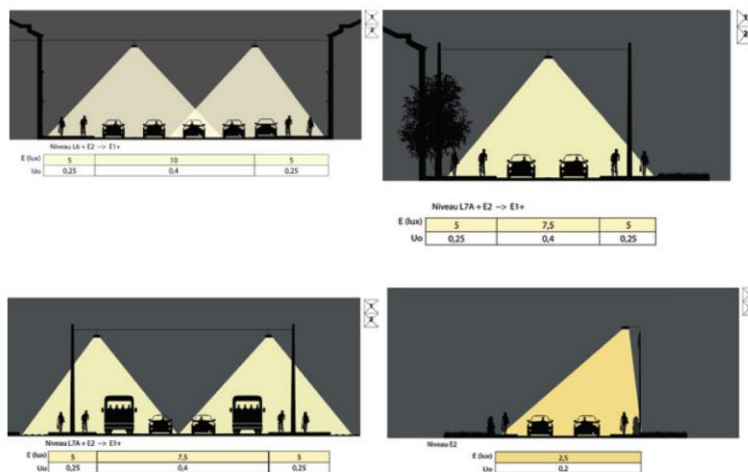


Fig.7 (Københavns Kommune, 2014, p. 34)

The following map of Copenhagen shows three types of roads within the city divided by the colour temperature of their lighting. The municipality set the scenarios as “daylight white” (4000K) - in white, “neutral white” (3500K) - in yellow and “warm white” (3000K) - in orange.



Fig. 8 (Københavns Kommune, 2014, p. 33)

Lighting Sum-Up

The lighting properties in both the architectural and theatrical approach describe the same aspects of light, however in different words. Architectural lighting uses the terms that allow us to assess light in a quantifiable manner, while theatrical principles are based on subjective judgment through observations. For the master thesis, the theatrical properties were used to enhance the existing lighting of the urban spaces which had been designed primarily to fulfill the lighting regulations, therefore using architectural properties. With adding the theatrical lighting layer on top of the existing architectural one, that hypothesis is that the light could recreate the atmosphere of the space with a stronger underline on the perceptual and emotional response towards the perceived scenario.

Urbanism

Urban spaces are not only the voids between the buildings and paths of transition, but originally they were the places where everyday life took place: the social life, work, trade, leisure, etc. Nowadays most of the activities (especially workplaces) are moved indoors, therefore public spaces do not support as diverse a pool of activities as they used to do.

One of the most important roles of the urban spaces in modern cities are leisure and transportation. Benches not only give an opportunity to stop by while commuting to have a break and rest, but they play a major role in leisure activities as they allow for social meetings and interactions. Therefore, they are the key element in creating life in outdoor spaces and establishing connections between the people and between the people and the space, as Jan Gehl (2011) said: "It is generally true that people and human activities attract other people. People are attracted to other people."

Therefore, in order to bring more life into urban spaces it is essential to enhance the existing street life of the city. A well designed bench has the ability to make the user sit on it longer, thus attracting more people into the space. The life between buildings "seems in nearly all situations to rank as more essential and more relevant than the spaces and buildings themselves." (Gehl, 2011)

The research upon urbanism starts with the overview of the phenomenon of non-places and then moves onto the benches and their role in urban spaces. The benches are investigated in terms of their design, placement and tendencies in choosing a bench. At the end, there are some examples of well and poorly designed sitting spots.

Non-places

The issue that some of the benches are never used, especially in new neighbourhoods can be related to the phenomenon of non-places and the properties that they have. Non-places are the spaces which lack an identity, shared social reference between the users and that create a feeling of anonymousness and isolation. An example of a typical non-place is an airport or a shopping centre. Some of the urban spaces may also share some characteristics of a non-place and in most of the cases it results in low usage of the space or complete lack of social life in there. As Marc Augé said in his book "Non-Places. Introduction to an Anthropology of Supermodernity": "There are spaces in which the individual feels himself to be a spectator without paying much attention to the spectacle." (Augé, 1995)

For Mark Augé the contrast between a non-place and a place is that the non-place is never completed, while the place cannot be completely erased. He also points out that the non-places are "the real measure of our time" as it is directly connected with the scale of modern cities and their urban spaces. Therefore, newly built neighbourhoods are especially endangered in becoming non-places as they follow "the negative process" in which "nothing happens because nothing happens" (Gehl, 2011) as "life between buildings is a self-reinforcing process" (Gehl, 2011) and new, empty spaces just stay as they were after the handover.

On the other hand, during my internship period I discovered that the same properties of the non-place are used in the theatre. The best examples are the black box theatres, in which the artists take advantage of the undefined space, to create generic places for the play.

This report does not focus on the typical non-places, but rather on the spaces that have some qualities to become one. In the project, the analysis aims to understand how a theatrical lighting approach that in a theatre situation can create different places with their own identity, could be used as a tool in urban space.

Benches

In this part, the research is focused on a definition of what a good bench design is, how a bench should be placed in urban space and what is the role of a bench in urban life.

Life between buildings offers an opportunity to be with others in a relaxed and undemanding way. One can take occasional walks, perhaps make a detour along a

main street on the way home or pause at an inviting bench near a front door to be among people for a short while. (Gehl, 2011)

Benches are crucial elements of any urban space for utilitarian use but also in the process of creating life in the outdoors. They provide a great opportunity to rest and stay for longer durations. As Jan Gehl mentioned:

Only when opportunities for sitting exist can there be stays of any duration. If these opportunities are few or bad, people just walk on by. This means not only that stays in public are brief, but also that many attractive and worthwhile outdoor activities are precluded. (Gehl, 2011)

Without the benches cities would lose a major part of their urban life, thus their identity and many functions. In that pessimistic scenario, people would just pass through the city spaces, moving from one place to another, without any purpose or opportunity to stop on their way.

If spaces are desolate and empty – without benches, columns, plants, trees, and so forth – and if the facades lack interesting details – niches, holes, gateways, stairs, and so on – it can be very difficult to find places to stop. (Gehl, 2011)

Bench properties

Jan Gehl defines the best sitting places as the one located “at the edges of open spaces, where the sitter’s back is protected, the view unobstructed, and the local climate most favorable.” (Gehl, 2011).

In his other book “Cities for people” he also mentions the “appropriately low noise level to allow conversation” and low pollution as the other aspects that define a good place for sitting. Another aspect which is considered in the choice of bench is the design of the bench itself. For young people it usually does not matter and they “can sit anywhere and on anything”, therefore frequently using “secondary seatings” (like steps, flower pots pedestals, etc.) However, old people tend to only use the “primary seatings” (street furniture designed for seating) and pay a lot of attention to the design of the bench they want to sit on. The preferable bench should have the back and armrests and should be made of materials that sustain well the heat transfer and rainwater.

In choice of the seating people tend to seek for places that are protected at least from one side. Therefore, the benches placed along the wall are more desired than the free-standing ones, placed in the middle of an open space. “Benches placed in the middle of open spaces

look interesting on architectural drawings but are definitely less inviting than more sheltered spaces.” (Gehl, 2011)

It is particularly attractive when the space is precisely defined and has “an individual local quality”. In that case benches which have “a small space within the space, a niche, a corner” (Gehl, 2011) are more desired as they provide a feeling of security and are more intimate.

Another aspect which a well placed bench has to fulfill comes from the unconscious part of human psychology. It is a basic feeling of security while our back is protected and we can see what is happening in the surrounding. That is the reason that “Benches that provide a good view of surrounding activities are used more than benches with less or no view of others.” (Gehl, 2011)

Therefore, the opportunity for a good view and protected back of the bench user, are the key properties of the well-designed bench and will be considered as necessary for the further development of the project.

Urbanism Sum-up

The phenomenon of non-places is an issue that is increasing nowadays and the newly-built neighbourhoods are especially vulnerable to the problem. Because the process of creating a lively place is a “self-reinforcing process” (Gehl, 2011), any existing social life in a space must be assisted with all possible means. Great bench design and its placement is the first step which must be followed with the proper lighting design afterwards. Therefore, for the further process, only the well designed and placed benches would be analysed in the terms of existing and possible lighting design.

Social Interactions

Social interactions in urban spaces can take different shapes. The report focuses on the interaction between the bench user and the pedestrian.

In the eyes of the bench user, the pedestrian is an actor and one’s activity is a performance. The audience (bench users) would stay on the bench for longer periods of time only if the play is interesting, thus allowing for possible interactions with the actors.

Low-intensity contact is also a situation from which other forms of contact can grow.

It is a medium for the unpredictable, the spontaneous, the unplanned. [...] From this

simple level, contacts can grow to other levels, as the participants wish. Meeting,

being present in the same space, is in each of these circumstances the prime prerequisite. (Gehl, 2011)

In this chapter, the research will describe the different levels of interactions, the importance of being present in the space, the possibility to observe and how the lighting design could create a theatre-like atmosphere in an urban space changing the bench user into the audience and the pedestrian into the actor.

As Jan Gehl (2011) said: “In streets and city spaces of poor quality, only the bare minimum of activity takes place. People hurry home. In a good environment, a completely different, broad spectrum of human activities is possible.”

Therefore the creation of a pleasant space to stay, by using lighting design, could contribute in better environment and “broader spectrum of human activities” (Gehl, 2011).

Level of interaction

In his book “Life Between Buildings” Jan Gehl describes “three types of outdoor activities” by dividing them into “necessary activities, optional activities, and social activities.” and the ratio of those regarding the “quality of the physical environment” where they take place in. (Gehl, 2011)

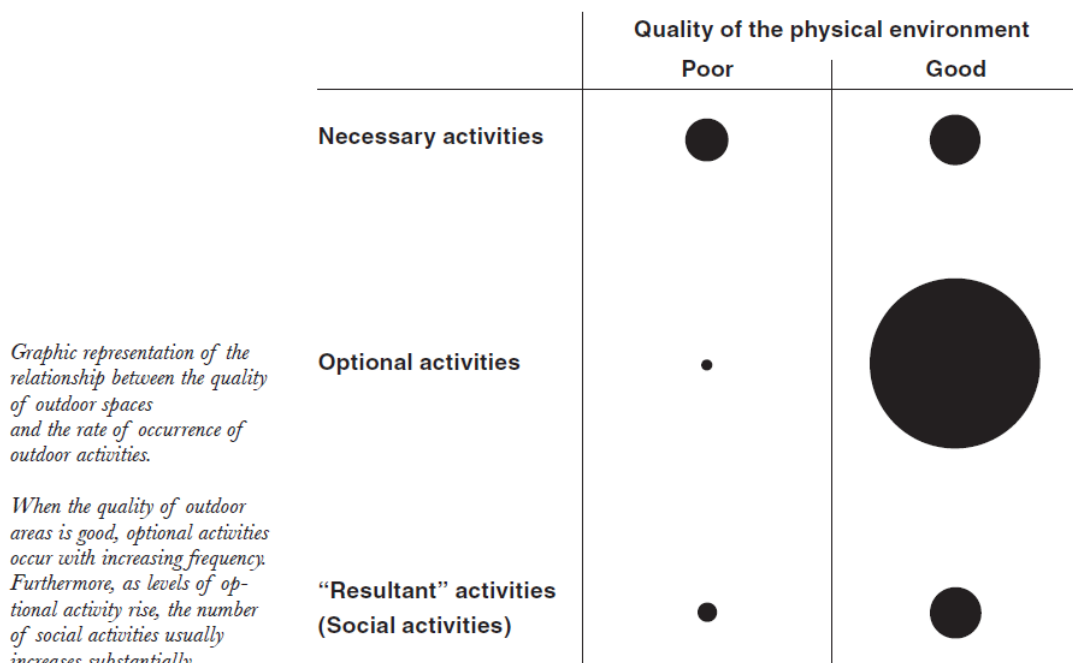


Fig.9 (Gehl, 2011, p. 11)

“Social activities occur spontaneously, as a direct consequence of people moving about and being in the same spaces. This implies that social activities are indirectly supported whenever necessary and optional activities are given better conditions in public spaces.” (Gehl, 2011)

The interactions of the low intensity are the base for any other interactions to happen. Jan Gehl describe the level of interaction with the following graph:

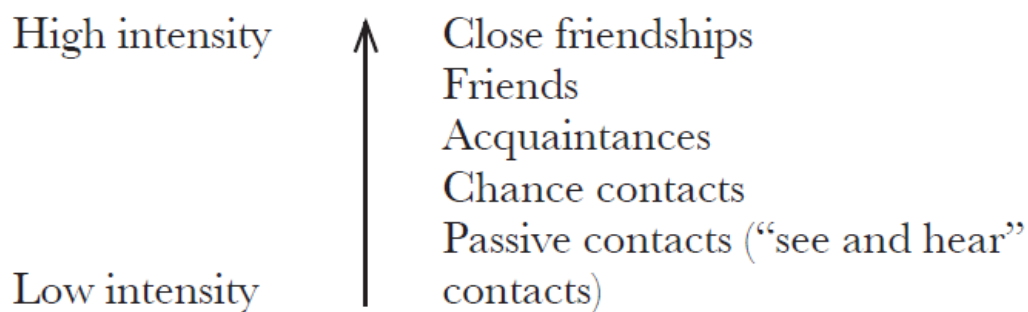


Fig.10 (Gehl, 2011, p. 15)

However, the issue that especially touches the non-places seems to be that nowadays “People are either alone or else with others on a relatively demanding and exacting level”. (Gehl, 2011)

As the Scale of social interactions in urban spaces is moving into the extremes and the middle range is disappearing, it is important to support the activities of the lower end of the scale, especially the observation which, as Jan Gehl underlines, is one of the basic activities that enable activation of the middle range social interactions. “If activity between buildings is missing, the lower end of the contact scale also disappears.” (Gehl, 2011)

Another element that strongly influences the social interactions between the audience and the actor is the distance between them, that Jan Gehl illustrates with the following illustrations:

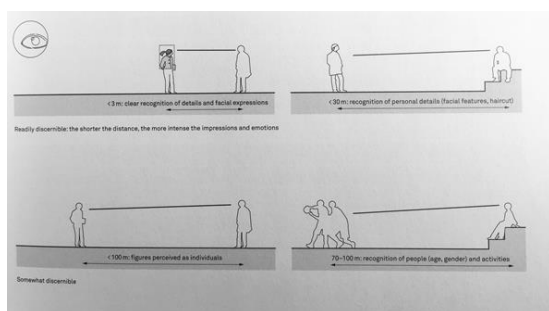


Fig.11 (Gehl, 1971)

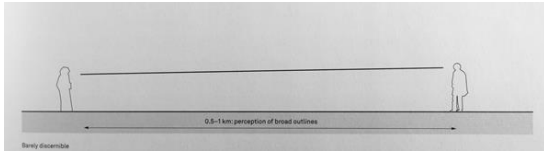


Fig.12 (Gehl, 1971)

From perspective of a bench user the possible roles in urban interactions can be divided into:

- Urban life participant - when the placement of the bench allow to direct interaction with the pedestrians
- Street life observer - when the distance between the bench and the pavement is small enough to notice facial expressions and the distance still allows for a conversation, however the distance is big enough to have an overview of the events on pavement and allows it to stay unnoticeable on the bench.
- Cityscape observer - when the bench is placed far from any pavement and the bench user is forced to observe the events that happen too far from the bench to be able to influence the ongoing events.

In the above pictures, the urban life participant would sit on the bench with less than 3 meters distance from the pavement and the street life observer would use a bench placed from 3 to 30 meters from the pavement. The cityscape observer would use a bench place on any bigger distance than 30 meters from the pavement.

The position of the urban life participant supports the possible interactions the most, however the small distance between the audience and the actor can be intimidating, or even create a feeling of insecurity (especially during the dark hours). Therefore, for allowing the audience to remain unnoticed if wished, but simultaneously allowing for a good view on the actor's facial expression and possible interaction, the distance of 5-10 meters provides best conditions for the observations.

Audience - actor relationship in the context of urban lighting

In a theatrical environment it is generally easy to define the audience and the actors. The actors are on the stage and the audience is seated in front of it. However, modern theatre not only breaks the 4th wall, but very often extends the performance into the audience. With unconventional placement of the audience (e.g. in the middle of the stage) or in productions in "In-yer-face theatre" drama style, when e.g. the cast members are blended between the audience members (like in Tim Crouch's "The Author"), proper lighting of stage can help to define the relationship between the audience and the actors, as Gernot Böhme said:

[...] the art of the stage set to leave the stage itself and spill over into the auditorium, or even into space itself. The spaces generated by light and sound are no longer something perceived at a distance, but something within which one is enclosed.

(Böhme, 2013)

Light seems to have extraordinary potential to change the ordinary space into a performance space, therefore could be used in the urban scenario where the pedestrians in movement are considered to be the actors for the ones sitting on the benches (the audience).

However, before the theatrical lighting could be used to provide a good actor-audience atmosphere there are some conditions that have to be fulfilled by the space itself - the scenography.

The actor audience relationship depends on several factors as:

- Audience – stage distance
- Scale of scenography - scale, distance, elements. texture, actors, activities, sensorial experience
- Number of users
- Activities in the place
- Bench placement and orientation
- Time and weather

The best experience of using a bench is when the bench - pavement relation is as close to the audience - stage relation existing in a theatre as possible. For that matter the distance between the two should be small enough to enable the audience to see facial features of actors, preferably facial expressions, while the actors must be able to see the presence of the audience: its shape or silhouette.

Scale of the scenography should correspond to the one from a playhouse. The distance between the bench and the pavement should match the scale of the surrounding buildings and urban spaces (squares, intersections, etc.) and allow the audience to see the details of the scenography: the used materials, difference in textures and props used by the actors (objects used by the actors). In terms of the number of actors on the stage, in an urban environment where most of the actors play in different plays and are unaware of the others, the audience will choose the most interesting play and follow it.

Choice of the following play is subjective and depends on the audience preferences, however it must be engaging enough to make the audience stay on the bench for long. The placement of the bench and stage lighting must provide conditions where the audience has the possibility to notice enough details to understand the play or make up the story from the pieces of information. Therefore, the bench must be placed a certain distance from the stage and oriented towards the actors. What is more, the most busy hours after the sunset e.g.

Friday before midnight, provide better opportunity to see an interesting play than e.g. Tuesday at 3 a.m. Similarly, summer nights offer better performances than during the winter time.

The key element that differs the theatrical and architectural lighting is that the light properties used in the theatre are assessed by the visual effect they create and have little to do with the physicality of the light. Theatre lighting does not have to fulfil any regulations; therefore, all the decisions are subjective and the only need that the lighting designer must fulfill is the need of the audience to see a coherent and a visually appealing play. Therefore, the whole focus of the lighting designer is set on the emotional response that the lighting should evoke in the audience.

By observing the people performing their everyday activities, the bench user can infer who the person might be and make up a story around it. This engagement into the street life is crucial to make the audience watch the play until the end and come back for the next one.

Conclusion

The research chapter investigated how the theatrical approach towards the lighting design and assessment of properties of light can be used in the urban spaces to support the bench usage and social life in newly-built neighbourhoods. Such places are particularly at risk of becoming a non-place and a lighting design that encourages the people to stay longer on the benches can be used to complement the existing lighting. The street lighting focuses mostly on fulfilling the biological needs of the people and the regulations, while the theatrical approach is mostly concerned with the emotional response of the audience. This merge could result in creating lighting conditions that support social interactions between the bench users and the pedestrians.

3. PRE-ANALYSIS

Introduction

In the pre-analysis chapter the outcomes of the research are compared with a general situation of bench design and lighting in Copenhagen. Firstly, the theatrical and architectural properties are compared to understand how they can be adjusted in an urban space. Next, the analysis defines what are the most important factors affecting the choice of the bench to sit on, and consequently presents different benches of Copenhagen assessing their design, placement and their usability. Also, the overall lighting for streets of different neighbourhoods of the city is analysed and compared with the theories to establish what are the existing typologies of bench lighting.

The outcomes are cross-analysed in order to establish what are the properties of the bench design, urban space and lighting that make the bench being frequently used during the night-time and the possibilities they provide for bench users - pedestrians interactions.

The vividness and coherence of the environmental image was singled out as being a crucial condition for the enjoyment and use of the city. This image is the result of a two-way process between observer and observed, in which the external physical shape upon which a designer can operate plays a major role. (Lynch, 1968)

Therefore, this chapter focuses on the existing scenarios of Copenhagen where the bench design, the urbanism and lighting design are linked all together in order to create one coherent space that encourages people to stay outdoors for extended periods of time. However, some poorly designed spaces are also presented as the examples of the solutions that should be avoided.

The following graph represents how the topics analysed in the Pre-Analysis chapter are distributed within the investigation fields.

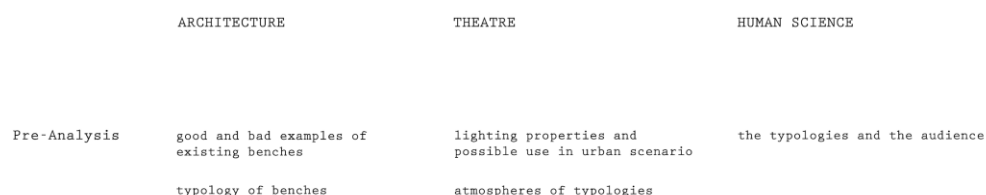


Fig.13

Lighting Properties

The following table shows how the theatrical and architectural lighting properties correspond to each other:

Theatrical Properties (Palmer, 1998)	Architectural Properties (Descottes 2011)
Intensity	Illuminance & Luminance
Colour	Color and temperature
Form	Density
Movement	-
Direction	Height & Direction and distribution
Diffusion	Direction and distribution
Frequency	-
Luminousness	(All together)

Intensity

Intensity of light is a property that “makes things visible or invisible” (Gröndahl, 2014) and has almost no limitation in theatre, while in the urban space it has to fit within the range of street lighting regulations: it cannot be too low as it must allow for safe navigation through the space and the top value is limited by the cost of energy and the risk of light pollution.

Colour

One of the most noticeable properties of light is its colour, which plays a significant role in creation of mood in theatre as humans unconsciously connect some colours with specific feelings and atmospheres, as Max Keller says in his book: “[...] individual evaluation of moods, situational and symbolic associations and personal relations to colour are important factors.” (Keller, 2010). Different hues of lights are also used in theatre lighting for their symbolic purpose, although in street lighting the colours hardly ever go beyond different hues (colour temperature) of white light. In the urban scenario the light colour other than white can be used only for special lighting (play of brilliance).

Form

The overall “visual composition” (Palmer, 1998) is created by the form that light takes. It is easiest described by the contrast between bright and dark spots in the space. This “pattern

of light and darkness” (Palmer, 1998) defines the shape of the space and “directs the focus and defines the mood of watching.” (Gröndahl, 2014)

The property of form is present in both theatre and urban spaces, however street lights tend to be placed in an uniform, grid-like manner and therefore the form of light is not coherent with the urban scenography. The form of light is limited to the existing lamp and fixture used in the space, but in case of spotlights it can be easily adjusted.

Movement and Frequency

Together the property of movement and the frequency create the rhythm of a play. While the first indicates the physical rhythm of the light moving around the stage, the latter defines the pace of changes between the lighting cues. Laura Gröndahl (2014) compares the light to a movie camera: “Lights have the same function as the camera has in films: they focus and create the rhythm and atmosphere.”

The rhythm of the play has a lot of power to keep the audience engagement at the high level through-out duration of a play and it is one of the main properties that makes a difference between theatrical and architectural lighting, as I concluded the investigation of my internship.

In the urban scenario the rhythm of light exists only as natural changes of the daylight and the traffic lights, however the usage of LED fixtures allows for creating different lighting scenarios that could vary depending on the weekday, season, etc.

Direction

Direction of light is the property that affects human perception of objects: their shapes and textures. Proper lighting angles can make the surface appear flat or convex. Direction of light should be chosen accordingly to the material that it is cast onto in order to take most benefits of the object's shape and texture.

In theatre the direction of light is very flexible, however in urban spaces the possibilities are more limited. Nevertheless, direction is the property that could be adjusted in a theatrical manner in order to enhance the appearance of urban spaces by a change of the existing fixtures or repositioning the existing ones in case of spot lighting.

Diffusion

In theatre, diffusion can be easily controlled by adjusting the fixture's lens or using diffusion gels. This property is a useful tool to control the shadows (sharp or diffused) and the direct perception of the light pools on stage.

On the other hand, in urban environments, it is the parameter that is hard to control unless predefined before the choice of lighting fixtures, as it depends on the used lamp and fixture.

Luminousness

Luminousness is the property of light that is defined as a subtle balance between all the above

principles and therefore will be skipped in the further parts of the investigation.

Lighting properties sum-up

The research chapter pointed out the main differences between theatrical and architectural lighting properties, however there are other differences that come with the ability to adjust the properties. The principles of intensity and colour can be easily changed in the street lighting however they are limited within the mentioned ranges. Usage of LED fixtures enables also to control the rhythm of the light, however in urban scenarios it is not a common practice and the possible changes must be properly synchronised with the cycles of natural light. On the other hand, direction and diffusion are the properties highly affected by the type of lamp and luminaire used in the fixture, therefore any changes would be very expensive and preferably would be made before the actual implementation of the lighting. The property of form is the least rigid, as it is the overall composition of light in the space created by many light sources and mostly dependent on fixtures' spatial distribution; moreover the form of light is not limited with any regulations and can be easily adjusted if the place is lit with movable fixtures (e.g. spotlights).

Choice of the bench

Once the bench fulfills all of the requirements described in the previous chapter, the potential user still has some factors to consider: the weather conditions and the lighting. As Jan Gehl (2011) said: " [...] the opportunity to see events in the area is a dominant factor in choice of sitting place, but other factors, such as sun and wind direction, are involved also."

In such a windy city as Copenhagen is, the weather factor plays a major role in choice of the seating. During some days one could walk around the city and could hardly spot any people sitting on the benches. Therefore, the few benches which protect from the blows of wind and provide a good shelter from the rain are in high demand and thus occupied for most of the time while the weather is bad.

Lighting is perhaps the last factor that decides on the choice of seating, however a bad lighting can change a well designed and placed bench into an almost unusable one.

During the night-time, light has the power to create a visual shelter or put the place into the spotlight and expose it onto the view of others. In the latter case, when a bench is in the spotlight and surrounded by the darkness around, the user feels insecure and vulnerable as one can be seen but cannot see the others.

The good lighting design for the benches should provide a similar feeling of protection as does the wall behind ones back and create an opportunity to enjoy the view from the bench even during the night-time. On the other hand, the bench cannot be placed in complete darkness

that might create insecurity in other people in the space and should provide enough light so the pedestrian can notice the bench user, which may result in an interaction.

The bench itself can be designed and implemented in many various ways which can define how frequently the bench is used. The sketch below shows the most favourable bench design for encouraging people to use the bench according to the information provided by Jan Gehl in his book “Life between buildings”.

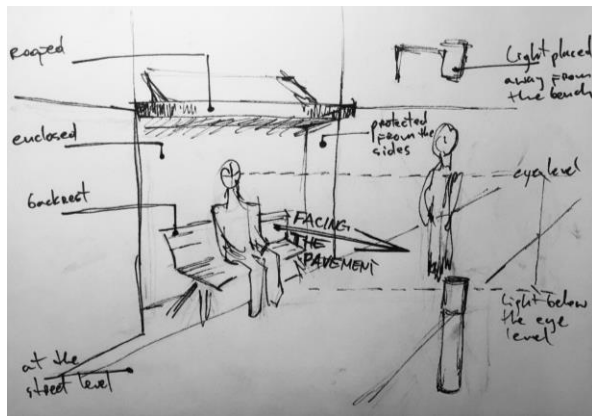


Fig.14

In case of a well-designed and placed bench, the lighting plays a major role in the possible audience-actor interaction. It is essential that the bench user has enough light to perform basic tasks on the bench, but excessive lighting can be very disturbing. Therefore, the lighting poles placed just next to the benches can interrupt the relationship, as the bench user is more lit than the pedestrian and very often glared. On the other hand, lighting embodied in the bench structure or low placed lights is a solution seen more often that prevent from the mentioned issues.

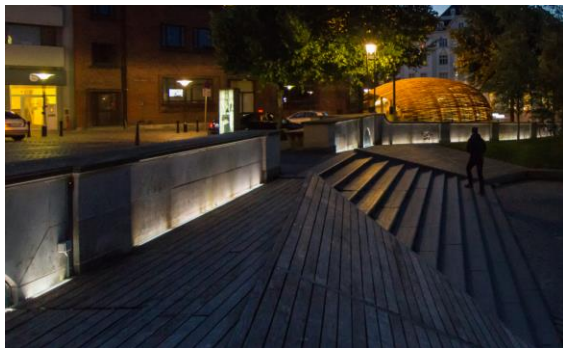


Fig.15 (Aarhus Kommune, 2019)

Benches of Copenhagen

Copenhagen has a huge variety of design and lighting scenarios for benches, ranging from great to very poor ones. The following examples present the variety of existing benches in the city. For the full list of benches examined during the analysis see Appendix 1.

Example 1 - Havneparken, Islands Brygge



Fig.16

Overall, the bench is quite well designed, as shown in the table below. The biggest issue of this furniture is the lack of any protection from the weather and very close placement of the light. In this case, the lamp is hung over the trees which block out a significant part of the light, creating a cosy atmosphere for the bench users. Unfortunately, during bad weather it is impossible to use the bench due to the lack of any protection.

The audience-actor interaction in the space is upset, as the bench has higher illumination level than the surrounding space. The bench user may feel exposed to the sight of pedestrians and due to brightness ratio, be unable to see the people staying in darker areas.

Bench type	Placement	Orientation	Protection from weather	Existing lighting on bench (placement)	Existing lighting on bench (height)
with backrest	close to pavement	facing pavement	not protected	just next to the bench	low (below eye level)
without backrest	far from pavement	back to pavement	protected from one side	close to the bench	medium (< 2m)
high	enclosed	facing a view	protected from more sides	far from the bench	Heigh (> 2m)
low	in open space		roofed	No light on bench	
free standing	at street level				
fixed to a wall	higher than street level				
multi-functional street furniture	lower than street level				

Fig.17

Example 2 – Fisketorvet, Vesterbro

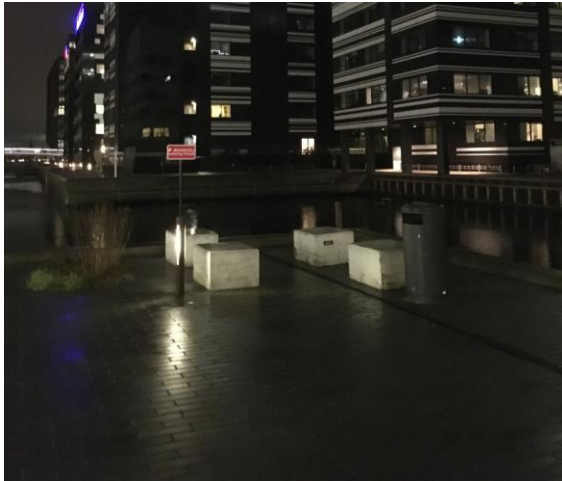


Fig.18

Lack of the backrest and any protection from the weather sentence the bench to be used only for short periods of time and only during sunny days. The unconventional design allows one to choose the direction of seating (and the view). What is more, even though the lighting pole is placed just next to the bench, the intensity of it is low and the fixture itself is short and casts the light below the eye level of a bench user.

Despite the design issue of the above bench, low lighting and lower illuminance level than on the pavement, boosts the audience-actor interaction of the space.

Bench type	Placement	Orientation	Protection from weather	Existing lighting on bench (placement)	Existing lighting on bench (height)
with backrest	close to pavement	facing pavement	not protected	just next to the bench	low (below eye level)
without backrest	far from pavement	back to pavement	protected from one side	close to the bench	medium (< 2m)
high	enclosed	facing a view	protected from more sides	far from the bench	Heigh (> 2m)
low	in open space		roofed	No light on bench	
free standing	at street level				
fixed to a wall	higher than street level				
multi-functional street furniture	lower than street level				

Fig.19

Example 3 - Teglholmen, Sydhavn



Fig.20

This bench provides a really interesting view towards the canal and has the backrest, which during a sunny day, makes it one of the happily occupied benches. However, the bench has no protection from the weather and is not enclosed in any way. The bench user might feel unsafe due to the big amount of pedestrians passing behind one's back and exposed during the night-time, as the bench is placed just under a high lighting pole.

The audience-actor interaction of the space is almost impossible, as the bench is facing away from the stage. Even if the audience was looking the opposite way (towards the pavement), the illuminance level is way higher on the bench than on the actors which might upset the possible interactions.

Bench type	Placement	Orientation	Protection from weather	Existing lighting on bench (placement)	Existing lighting on bench (height)
with backrest	close to pavement	facing pavement	not protected	just next to the bench	low (below eye level)
without backrest	far from pavement	back to pavement	protected from one side	close to the bench	medium (< 2m)
high	enclosed	facing a view	protected from more sides	far from the bench	Heigh (> 2m)
low	in open space		roofed	No light on bench	
free standing	at street level				
fixed to a wall	higher than street level				
multi-functional street furniture	lower than street level				

Fig.21

Example 4 - Østerbro



Fig.22

The benches of Østerbro are traditional freestanding benches placed with the backrest against vegetation and facing the pavement. In the space there is very high placed suspended lighting, however it follows the road, thus for the distance from the bench and the trees, the light on the benches is quite dim and inviting to stay.

The bench presented in the picture above provides great opportunities for audience-actor interaction. The bench is less lit than the pavement and all the previously mentioned design factors are fulfilled.

Bench type	Placement	Orientation	Protection from weather	Existing lighting on bench (placement)	Existing lighting on bench (height)
with backrest	close to pavement	facing pavement	not protected	just next to the bench	low (below eye level)
without backrest	far from pavement	back to pavement	protected from one side	close to the bench	medium (< 2m)
high	enclosed	facing a view	protected from more sides	far from the bench	Heigh (> 2m)
low	in open space		roofed	No light on bench	
free standing	at street level				
fixed to a wall	higher than street level				
multi-functional street furniture	lower than street level				

Fig.23

The most common issues in the bench design (especially in the new neighbourhoods) is that they are lacking the backrest. This design might be appealing on the visualisations, but does not support any longer stay in the space and in most situations would not be chosen to rest on by an older person.

From the urbanist point of view, the most recurring design mistake is the placement and orientation of the bench. It is very common that a bench is facing e.g. towards an open space, while a pavement is just behind the back. In such a case, the bench user might feel insecure as one cannot see what is going on in the space.

Lighting-wise, it is also the placement of the bench which may create the most reasons not to sit on the bench. It seems to be a tendency that the bench is placed just under the lighting pole and in most of the situations, such a placement will result with the bench being

illuminated more than the surrounding space. This kind of lighting scenario evokes the feeling of being exposed, as the bench user can be seen from afar, but cannot see oneself.

Lighting and benches

The research outcomes demonstrated the need for theatrical lighting approach towards urban lighting. In this chapter, the analysis is focused on the theatrical properties of light in the existing scenarios.

Light Properties

The following table shows the theatrical lighting properties with the limitations that affect street lighting. The property of luminousness is not included in the table and further analysis as it is created by a proper balance of the other principles.

Property	Limitations	Details
Intensity	regulations	Range (min. 2lux)
Colour	regulations	Range of white light (CCT)
Form	Regulations	Defined height and distance between the fixtures
Movement	Cost	Unused for street lighting
Direction	Fixture specific	Mostly toplights
Diffusion	Fixture specific	LED lamp range from fully diffused to sharp beam
Frequency	Fixture specific	Different presets can be programmed

The property of colour cannot be changed due to the regulations, while the diffusion is strictly connected with the used lamp type and fixture. Also the movement of light is unused for lighting of benches, therefore these three properties will not be analysed in the further parts of the report.

The properties of direction and frequency are close related to the used fixtures and relatively hard to control, however adjustable. These two properties would be considered as additional changes that could be applied in the space.

The two main properties which are scrutinized below are the intensity and the form.

The property of form is the one that defines the typologies of the benches as it creates the visual composition of the space.

The intensity of light can be changed, even though within some limits, and is a key factor in defining the atmosphere of the space.

Typology of benches

The typology of benches is created according to possible light placement and the form it takes in the urban spaces which consists of a well designed and placed bench and the urban scenario that could represent theatrical setting.

I assume that some of the typologies have bigger potential to create good actor-audience relationships, while the others are completely unable to make one. Probably the typologies which have similar light source placement as in a traditional theatre could create an atmosphere that is more recognizable as a theatrical, therefore clearly defining who is the actor and who is the audience. The typologies where the pavement is more lit than the bench should support that feeling, especially, when the light is cast on the actors from the direction of the audience (as in the sketch below).

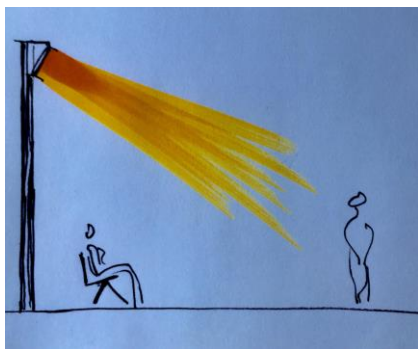

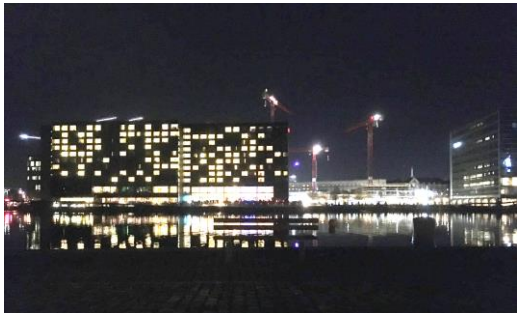





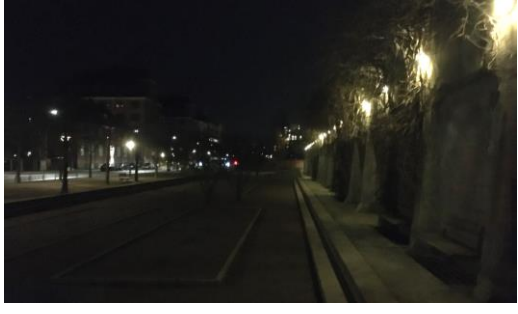





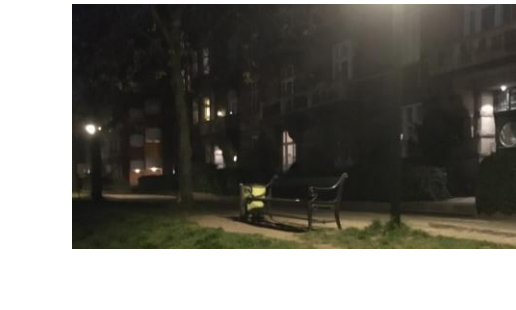
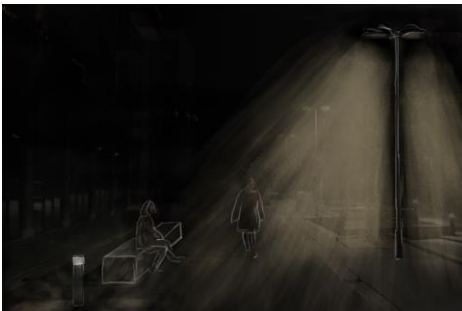
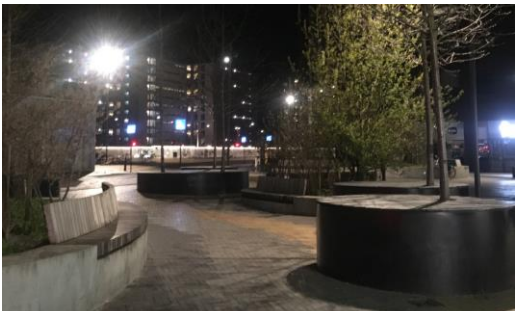


Fig.24

The typology of benches is established according to lighting conditions existing on the sites in Copenhagen. The bench typology consists of eight possible scenarios depending on the light placement, represented in the table below.

In the bracket under the typology name there is an indication of the light distribution, describing whether there is more light on the audience or on the actor.

Typology	Graph	Example
A (audience and actor in the darkness)		
B (light only on the actor)		
C (light on the actor and the space in-between)		
D (light on the actor and on the audience; in-between space remains dark)		
E (audience and actor in the darkness; The space in-between is lit-up)		

<p>F (light on the audience and on the space in-between; no light on the actor)</p>		
<p>G (light only on the audience)</p>		
<p>H (the entire space is lit-up)</p>		

The typologies and the audience

In the following table the bench lighting is evaluated according to the strong and weak sides that it creates in the specific typology concerning the feeling they evoke in the audience.

Typology	Pros	Cons
A (audience and actor in the darkness)	If the ambient lighting is strong enough, can provide intimate atmosphere and good opportunity to observe animals' nightlife	Can be too dark and create a feeling of insecurity; Might be hard to navigate
B (light only on the actor)	The actor is in the spotlight and is easy to watch	The actor might feel anxious if one is observed but cannot see the audience
C (light on the actor and the space in-between)	Smooth transition between lit stage and dimm audience create very natural theatre-like atmosphere	If there is more light on the space in-between than on the stage, the actor might be confused about one's role
D (light on the actor and on the audience; in-between space remains dark)	The dark void between the actor and the audience create a visual division between the two	The division could discourage the interactions; If there is more light on the audience, the participants might be confused about their roles
E (audience and actor in the darkness; The space in-between is lit-up)	Intimate feeling for both sides	If there is more light on the audience, the participants might be confused about their roles
F (light on the audience and on the space in-between; no light on the actor)	If the bench is backlit (especially with a low fixture), the light spill can create a subtle flood of light on the pavement and highlight only the silhouette of the audience without exposing one's face.	High light poles and light from top/side put the audience in the spotlight, while the stage is dark; the participants might be confused about their roles; The audience might feel exposed and insecure
G (light only on the audience)	Same as typology F, but more intimate atmosphere on the bench	Same as typology F; It might be impossible to see the actor at all
H (the entire space is lit-up)	Smooth transition from bright stage to dimm audience can create theatre-like conditions	If the audience is lit more than the actor, or the space is generally too bright, both of the sides might be confused about their roles and feel exposed.

Light intensity and the choice of bench

Along the lakeshore of Sortedams Lake (Sortedams Sø) there are two rows of benches: one just by the lake and the second one on top of the hill, a bit further from the water. There is only one placement of the lighting, which is on top of the hill, next to the second row of benches, therefore the benches can be categorised into the typology F (the second row) and typology G (the first row). Despite the proximity between the rows (less than 5 meters), the lighting conditions are diametrically different.



Fig.25 the first row - typology G



Fig.26 the second row - typology F

Due to the difference of illuminance levels on the benches, a clear pattern was observed that the first row benches are happily occupied while all of the second row benches remain empty.

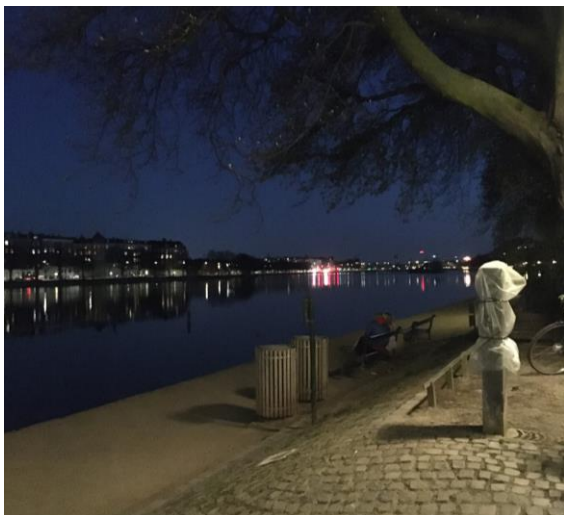


Fig.27

The illuminance measurements taken on the benches show a huge difference in light levels between the rows:

1st row: 1.0 lux horizontally | 0.6 lux vertically

2nd row: 20 lux horizontally | 4 lux vertically

An interesting example that could be an exception from the pattern occurring by the Sortedams Lake are the benches of the second row that are not affected by the high illuminance levels coming from the direct light. In some cases there is a tree growing in between the bench and the light sours effectively blocking out the light and allowing for a clear view onto the pavement.



Fig. 28

Direction

This property is highly dependent on the light placement and hard to adjust in an urban scenario. Therefore the placement of a light fixture should be carefully planned before implementing on the site. With the use of spotlights as street lighting, there is a possibility for some adjustment of the direction without changing the placement of the lighting pole.

Frequency

The property of frequency could be used in urban spaces thanks to modern technology as remotely controlled LED fixtures. Since then, it is possible to control every single fixture in terms of intensity, colour, etc. This possibility could be used to create lighting schemes that would change throughout the week, months or seasons providing best lighting for a specific moment. Electric street lighting could be adjusted according to the seasonal changes of the daylight and therefore create spaces that the user would be able to rediscover throughout the year. Although the potential of frequency in creating engagement for the bench user, this thesis limits the lighting design only to a static scenario of light implemented on the bench.

Lighting and audience actor interaction

Intensity

In all of the typologies the intensity of light is a crucial factor as a too high illuminance level on the audience contrasting with dim actors, can end up with flipped audience – actor relationships. In such a case, the audience is exposed to the actors, therefore feeling themselves the actors. Similar move is used in the theatre, when the play should intimidate the audience. In an urban scenario the bench user should feel secure and therefore one must not feel like being watched and be certain who is the actor.

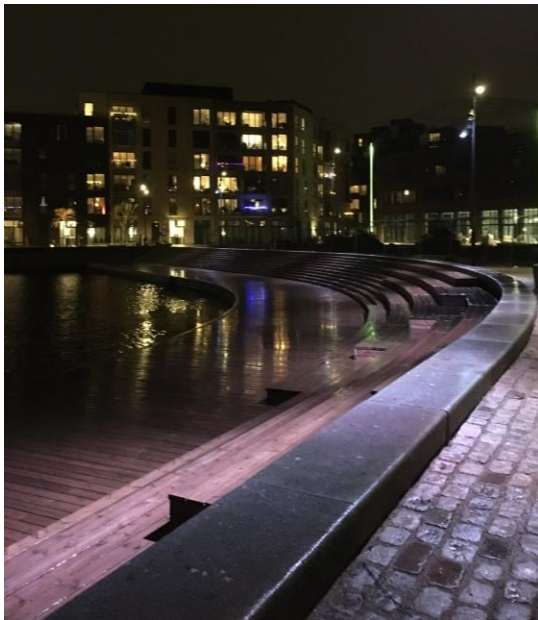


Fig. 29

In the picture, the bench is lit more than the wooden deck (stage) indicating that the bench user is the actor.

Form

The typologies represent a property of form and each of them have a different impact on the atmosphere that is created between the bench user and the pedestrian. The form creates the visual composition defining the shape of the stage and what is in light and what remains in dark.



Fig. 30

In the case presented in the picture, the form of light is shaped into pools and it is focused on the bench, while the pavement remains in the dark. This form of light could suggest that the bench is the focus point while the pavement is less important.

Direction

In an urban scenario direction of light is very often a random outcome of light fixture and bench placement, instead of a careful design. Thus in some cases, despite the good illuminance level and form of light, the audience is unable to see the actors' faces.

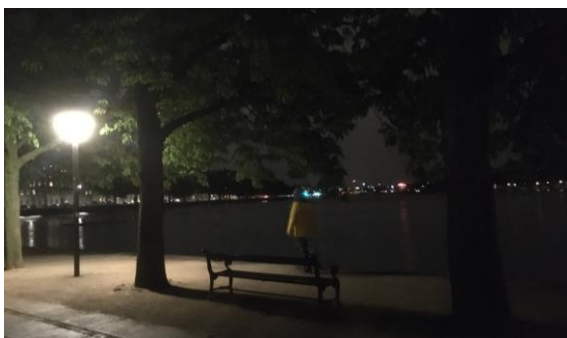


Fig.31



Fig. 32

The pictures show how the placement of the lighting pole (and therefore the direction of light) creates the situation, when the actor's face remains in the dark until the point one passes the audience. However, then the bench user can only see the back of the actor who is already moving away.

Interview

In order to get a better insight into the street lighting regulations and existing practices, an interview was conducted with Thomas Maare - a former City Lighting Responsible in Copenhagen (2006 - 2015). The interviewed was asked several questions regarding the lighting regulations, most common practice and motivation behind specific choices. The most important information that was found out are as follows:

- There is no regulations describing lighting for benches
- Typically the municipality would light-up the path and do not care about the benches
- Each single [LED] fixture is monitored and remotely controllable
- The municipality tries to mount the fixtures above 3,5 meter to prevent them from vandalism

Conclusion

The site observations and analysis of good and bad examples of lighting for benches pointed out that the general issue of the existing lighting is the uniformity. Despite it being a crucial part of lighting regulations and a practical solution for lighting of the roads, in many cases it creates an unpleasant atmosphere on the bench. The bench lighting is not defined by any legislation, therefore usually it is random if a bench will be placed just under a lighting pole in the middle of spotlight, stay in the deepest dark shade or somewhere in between. This practice yields in the cases where many of the benches being frequently used during the day are abandoned at the night-time.

The main outcomes of the analysis are that:

- The light level on the bench must be lower than on the pavement

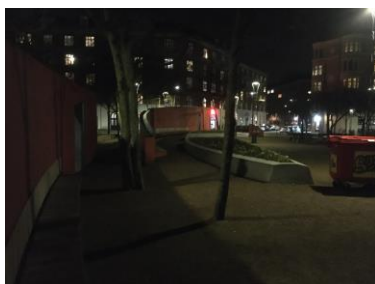


Fig.33

- the space between the audience and the actors can create an intimate void (barrer of darkness)

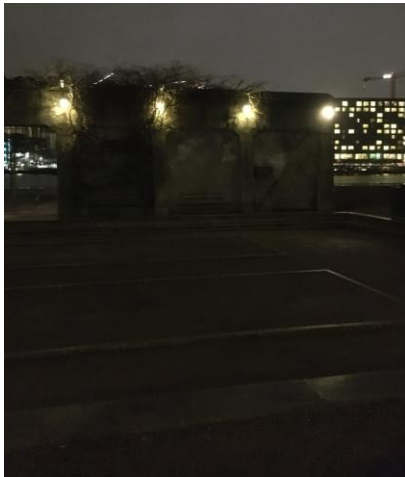


Fig. 34

- the space between the audience and the actors can be a lit surface that could be used as the transition space (an extension of the stage, similar to the proscenium in theatre)



Fig.35

As the street lighting must be maintained within the regulations, further analysis would investigate existing cases for the three chosen benches of the typology H as the one which is the most common in urban spaces and appears in many variations depending on the light intensity and direction.

4. PROBLEM STATEMENT

Street lighting in many cases is designed for the transportation rather than for pedestrians and users of urban benches. Consequently, many benches become almost unattractive to use at the night-time as the lighting does not support the audience-actor relationship of the space.

Unattractive to use at the night-time:

During the day time most of the benches are used and the quality of the bench design and its placement will define the way and frequency it is used. However, during the dark hours, due to misplaced lighting (just next to the bench) or lack of any light, some of the benches that are happily used during the day, might become impossible to be used. In case a bench is placed in total darkness, one might find it unsafe to use or simply too dark to perform any activity (see face of one's converser). On the other hand, if the bench is placed just under the light pole, the user might feel being exposed to the surroundings (feel like in a spotlight) and even unsafe if one cannot see what is happening around due to high contrast between the lit up bench and the dark surroundings.

5. RESEARCH QUESTION

How the theatrical lighting approach towards urban lighting properties could affect the relationship between the bench user and the pedestrians?

Theatrical lighting approach:

Lighting design based on the methods used in theatres for lighting a play. Approach for lighting that assess its quality by qualitative methods e.g. observation, subjective feeling, etc. Theatrical lighting approach uses the principles of light described by Richard Palmer in his book "The lighting art. The aesthetics of stage lighting design" and adjust them in order to evoke specific feeling in the audience. The theatrical lighting approach is characterised by well-lit actors and audience remaining in shade and well-visible facial expression of the actors. This lighting approach enhance the atmosphere of the space and engages the bench user in the play of the city and encourages them to use urban spaces more frequently (during the night-time)

Urban lighting properties:

The lighting design that exists on the site of the analysed case. The analysed properties of urban lighting are based on the "principles of light" described by Herv   Descottes in his book "*Architectural Lighting, Designing with Light and Space*".

The existing lighting created by the street lights and ambient light is assessed in terms of the atmosphere it create on the bench and how it affects the audience-actor interaction. The properties are set according to street lighting regulations and analysed with usage of quantitative methods.

Relationship between the bench user and the pedestrian:

The relationship between the bench user and the pedestrians of any scale, from the observation until the conversation, based on the "scale of interaction" defined by Jan Gehl in his book "Life between buildings". The relationship is examined according to the existing lighting, bench design and placement and the possibility those factors create for the interaction. The project focus is set on the lowest end of interaction scale, which is the possibility to observe.

6. SUCCESS CRITERIA

The success criterias are divided into the same three categories as are the fields that the project touches upon: architecture, theatre and human science. Each of the fields has one success criteria which describes how the design proposal could change the existing situation in order to be a successful recommendation.

The success criterias for the project are divided into three fields that the report touches upon, which are architecture, theatre and human science. established as follows:

	ARCHITECTURE	THEATRE	HUMAN SCIENCE
	properties of urban lighting	theatrical lighting approach	bench user - pedestrians relationship
Success Criteria	Activation of abandoned benches to be usable at the nighttime	Clear definition who is the actor and who is the audience.	Frequent usage of the bench that support observation and provides possibility of interaction.

Fig.36

Activation of the abandoned benches to be usable at the night-time:

The project aims towards a lighting recommendation that will change existing lighting design into one that supports longer stays on the bench and promotes audience - actor interactions during dark hours, thus activating the benches which are abandoned, to be usable at the night-time. The design proposal will present the best possible solution, however it might be expensive and hard to implement in an existing scenario. Therefore, the recommendation will also consist of a proposal which provides the mentioned improvements, but without any needed changes in the existing structure in order to minimize the costs and complexity of the adjustments.

Clear definition who is the actor and who is the audience:

The goal of the lighting adjustments is to create a visual composition where it is clear that the bench user is the actor and the pedestrians are the audience. It means that the audience

cannot feel exposed to the actors and they must feel comfortable to stay on the bench for extended periods of time and be engaged in the play revealing in front of their eyes.

Frequent usage of the bench that support observation and provides possibility of interaction:

A project can be called successful when the final proposal (after implementation) would engage people to stay on the bench for longer periods of time, enjoy to observe the others and their surroundings and that the lighting design would allow them for the interactions of low intensity (observation, greeting, etc.) and encourage for the more demanding as conversation.

All of the success criterias will be validated with an online survey that shows the change in an average usage of benches during the night-time in comparison to the usage of bench after implementation of the design proposal.

7. CASE ANALYSIS

Introduction

The second part of the report focuses on three benches located in different neighbourhoods of Copenhagen. All of the focus areas are located in newly built neighbourhoods with the seating providing view to a pavement and water (canals) in order to provide as similar visual space as possible for the analysis. The choice of new neighbourhoods was motivated with the increased risk of becoming a non-place in such areas, as there are no yet established social connections between the inhabitants and this lack creates an opportunity for the theatrical lighting approach to enhance the existing interactions in the space.

All three cases are therefore similar in the urbanism and architecture of their surroundings and they are examples of well designed benches as described in the research chapter. Each case represents a different type of lighting solution for the same bench typology, in order to establish how lighting design can affect the actor-audience relationship in similar urban conditions. In all the cases, the audience-actor relationship is upset, as the light distribution and illuminance levels do not clearly define who the actor is.

In all three cases, there were taken measurements of the illuminance level of the space, both on horizontal and vertical surfaces.

The horizontal measurements were taken in order to describe which areas have higher illuminance level - the bench or the pavement, which would help to define how the space is perceived by the people and therefore to define who is the actor of the space.

The vertical measurements were taken to describe possible issues of glare that might interrupt observations of the space from the perspective of the bench user or the pedestrian coming into the space.

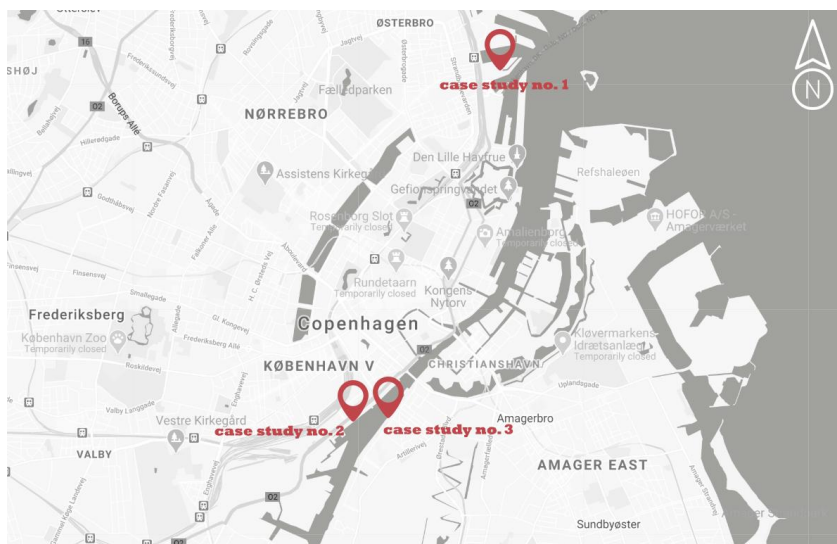


Fig.37 – Placement of places of interest on map of Copenhagen

Disclaimer:

It was impossible to conduct any valid on-site analysis concerning social activities due to the Covid-19 situation. All the site analysis can be biased as the public spaces were not used as usually. The analysis is based on the remaining interactions during the pandemic and logical assumptions based on previous experience.

Case Study no.1 - Marmorvej, Nordhavn

The case study of the seating area by Marmorvej (Nordhavn) was chosen due to it being a newly built area of Copenhagen, it provides an interesting view on the pavement and to the canal and also to its very bad existing lighting.

The Space

Nordhavn is one of the most recently built neighbourhoods in Copenhagen and still an ongoing construction site. Historically it was an industrial harbour area and some parts of it operate until today: a container terminal, ferry berths, marina, etc. It is only for the last ten years that the area is changing into a residential neighbourhood with spaces for businesses, schools and leisure.

During the site analysis the space remained empty for the entire time, however it can be justified by the occuric pandemic and bad weather conditions. However, from previous analysis of similar spaces (analysis of Nordhavn and Ørestad during my 8th semester) and personal experience, I can assume that the space is not used frequently. Spaces like that tend to be used for extended periods of time only by groups of friends, while individual people usually only stop by for a few minutes.

Due to the proximity of UN City the bench can be used by the employees and visitors of the institution during the breaks and after work.

Architectural Site Analysis

The Case study no.1 is located next to Marmorvej street and is divided into 2 parts by a pavement. The South part is a wooden bench-platform, while the North part is the steps descending towards the canal and made of the same material. There are no traditional benches in the space, but both parts of the furniture are designed for seating. In front of the space there is a canal with residential buildings on both sides, while behind the bench there is a bike lane and further the street.



Fig.38 (Google, n.d.)

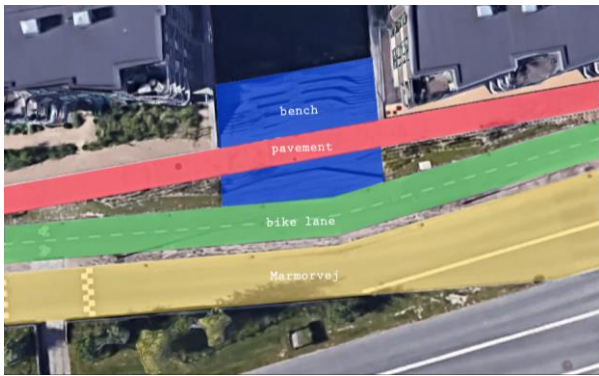


Fig.39

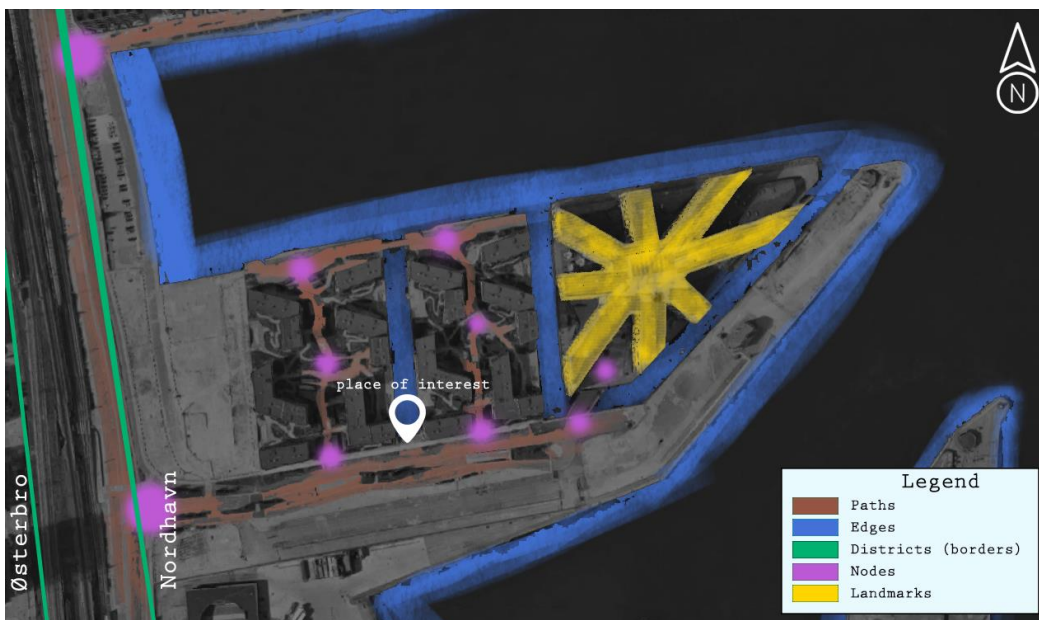


Fig.40

The above site plan shows a part of Nordhavn with the place of interest and the surroundings within a radius of approximately 300 meters divided into “elements of the city” described by Kevin Lynch in his book “The Image of the City”.

The place of interest is located by the edge of the canal, right by the pavement that crosses through the spot and is a main path of the area that connects its landmark - UN City with the

main node of the neighbourhood located at the edge of the district and leading to the adjacent neighbourhood - Østerbro.

This location gives some advantages to the place as it can be a great spot to rest while on the way to the landmark, but can also be a local meeting point because of its proximity to the two local nodes and providing a great view towards the water.



Fig.41 - Landmark: UN City (FN Byen)

UN City is a huge office building opened in 2013 that accommodates over 1200 employees. It is located at the very edge of the district and generates huge traffic through the path that crosses through the point of interest.

The benches, their placement and orientation



Fig.42

As mentioned before, there are no traditional benches in the space, but the whole area is designed as a seating furniture. The space is divided by the pavement: the southern part

consists of one platform and the northern part - of a set of steps. Both of the furniture are made of wooden boards and provide a view towards the canal.

The platform does not have any back support or protection, however its size and distance from the bike lane provide a feeling of security. The set of stairs are shaped in different sizes and forms, some of them in bench-like proportions with a wall behind the back providing the support and protection. In both cases the irregular shapes and small architectural details create a feeling of “space in the space” which supports a feeling of safety on the bench.

Lighting

Existing Lighting

The space is lit with 6 spotlights distributed evenly on 2 lighting poles placed at the opposite ends of the sitting area (see the plan below). There is very dim ambient light coming from the nearby buildings and from the lighting of the street.



Fig.43

Observations

- The point of interest is the brightest spot in the surrounding space.
- The pavement that leads into the space is dimly lit with low light poles
- The benches are brightly illuminated from high lighting poles.
- The light on the furniture is provided by 6 spotlights that create huge contrast with very dark surroundings.
- The space feels like a very brightly lit stage as the light takes the circular form from the spotlights
- The material of the seating area is different from the surroundings
- There is a huge brightness difference between the bench and the dark space around.

- The entire space reminds of a theatrical stage, including the bench which in the case is even brighter than the pavement.
- The high and bright poles are very glary and unable to see anything outside of the pools of light creating a feeling of insecurity as there might be one in the darkness whom we cannot see, simultaneously being exposed to the others.
- The bench is easily seen from far away and encourages people to come and see it, but once in the space, the intensity of light and contrast to the surrounding does not encourage to stay in there.
- The lighting of the space covers 2 of 3 layers described by R. Kelly: the functional pole lighting and ambience from the buildings and the street. The third layer - “the play of brilliance” does not exist in the area.



Fig.44



Fig. 45



Fig.46

Illuminance measurements

The illuminance of the space was measured in 6 points (see the graph below) in order to quantify the existing lighting conditions.



Fig.47

Placement	Point A	Point B	Point C	Point D	Point E	Point F
Horizontal illuminance	11 Lux	390 Lux	5 Lux	12 Lux	189 Lux	140 Lux
Vertical illuminance	13 Lux	30 Lux	9 Lux	25 Lux	91 Lux (following the bike lane) 56 Lux (towards the road) 112 Lux (towards the canal)	201 Lux



Fig.48 (Københavns Kommune, 2014, p. 33)

- Strøggade: neutralt hvidt lys
- Bydelsgade: neutralt hvidt lys
- Lokalgade: varmt hvidt lys

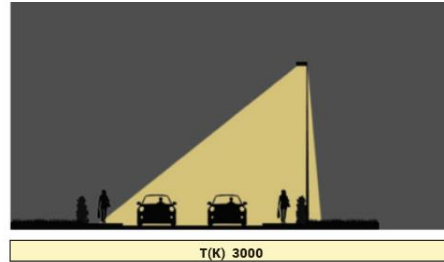


Fig.49 (Københavns Kommune, 2014, p. 32)

According to the Copenhagen Municipality Lighting Masterplan, the street lighting of Marmorsvej is set at 3000 K (warm white) as it is a local street.

Uniformity:

Horizontal uniformity= 0,04

Vertical uniformity= 0,15

Audience - actor relationship

The audience - actor relationship of the space is upset, as the whole space is filled with light and high illuminance level on the bench brings the attention to the audience instead of the actor. The direction of light creates glare in the audience, while the back lighting of the actor pops-out one's silhouette, but not the face. The pedestrians might rather feel like the audience passing next to the stage, instead of being on the catwalk stage.

Sum-up

In the first case study at Marmorsvej, the bench is a well- designed big seating area that provides good view opportunities, possibility to choose the seating place with secure spaces within the space. The platform of the Southern part of the bench lacks in back rest and back protection, however its size and placement make up for this disadvantage.

As opposed to the great bench design, the lighting of the space is quite poor. High lighting poles do not match with the small, human scale of the space, the illuminance levels are extremely high in some spots and the luminaires glare at the bench users. The existing lighting takes an interesting form of pool of lights, however unfortunately distributed in the space.

PROS	CONS
Form of light (pools)	Illuminance level (390 Lux)
Colour temperature (3000 K)	Direction of light (backlit actors)
	High lighting poles (>4m)
	Glare
	Audience brighter than the actors

The space and the success criterias:

1. Activation of the abandoned benches to be usable at the night-time:

The bench location and the existing lighting does not support the night-time usage of the bench. There is a possibility that the bench is used by the UN City employees during the breaks, however it is a slight possibility that may occur only during the winter.

2. Clear definition who is the actor and who is the audience:

The illuminance level on the bench is significantly higher than on the pavement, as well the entire area stands out from the dark surroundings. Every person in the space is exposed to the sight from the outside and the bench users can be confused who the actor of the space is.

3. Frequent usage of the bench that support observation and provides possibility of interaction:

The bench is not used frequently either by the inhabitants of the neighbourhood or the UN City's employees. High exposure and lack of intimacy in the space does not create good conditions for interactions, while the huge contrast between the bright seating area and the dark surroundings disable the observations. What is more, the space users get glared by the existing fixtures.

Case Study no. 2 - “Genmab”, Vesterbro

The case study of the bench placed next to “Genmab” company building (Vesterbro) was chosen due to it being a modern area of Copenhagen, it provides an interesting view on the pavement and to the canal and also to its poor existing lighting.

The Space

The waterfront of Vesterbro is one of the modern areas of Copenhagen filled with hotels, office buildings, companies’ headquarters and shopping facilities.

During the analysis it was observed that the space is frequently used by the soft traffic. Many cyclists and pedestrians enjoy the way along the canal and stop by to have a rest on the benches. As the space is located far away from any residential buildings, the only users besides the passers-by, are the workers of proximate offices and hotels. There is also a big chance that the benches support social interaction between employees of nearby businesses, as well as the pedestrians that stop-by to have a break.

Architectural Site Analysis

The Case study no.2 is located behind the building of “Genmab” company, on the promenade of the main canal of Copenhagen. At the spot, there are 3 wooden benches fixed into a wall behind them. In front of the benches there is a wide pavement of the promenade and further - the canal.

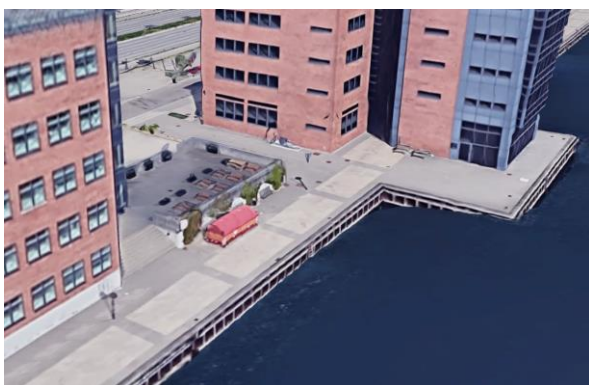


Fig.50 (Google, n.d.)



Fig. 51

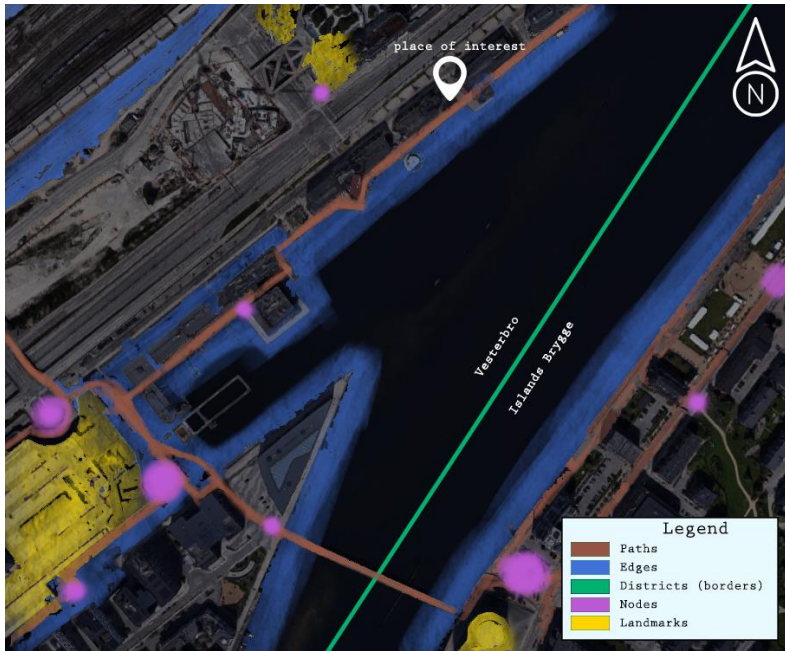


Fig. 52

The above site plan shows the main canal of Copenhagen with the promenade on Vesterbro side (North) and Islands Brygge on South with marked place of interest and the surroundings. The map shows the area divided into “elements of the city” described by Kevin Lynch in his book “The Image of the City”.

The place of interest is located by the edge of the canal, right by the pavement of the promenade passing next to the spot. It is a main path that connects one of the landmarks - Fisketorvet shopping mall with the city centre. The picture shows only the paths and nodes for the soft traffic and indicates the edge defined by the water and the train tracks on the North. The main nodes of the neighbourhood are located next to the shopping mall and are the meeting spots for hundreds of people visiting the neighbourhood.

Location of the place of interest gives some advantages to the spot as it can be a great spot to rest while on the way to the landmark from the city centre, or for pedestrians enjoying the promenade walk. The spot can also be a great meeting point for the employees of nearby businesses and because it provides a great view towards the water.

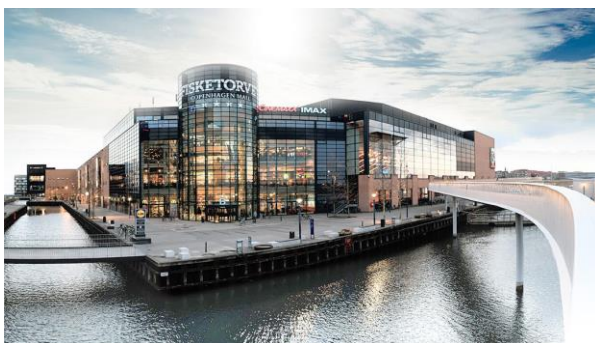


Fig. 53 (n.d.) - Landmark: Fisketorvet shopping mall

Fisketorvet is a huge shopping mall located by the waterfront of Vesterbro and a shopping and meeting place for thousands of people. Next to the mall there is a soft traffic bridge (Bryggebroen) that connects the waterfronts of Vesterbro with Islands Brygge. The location by the promenade and possibility to pass onto the other side of the canal makes Fisketorvet an easily recognised and heavily trafficked place and a landmark of the area.

The benches, their placement and orientation

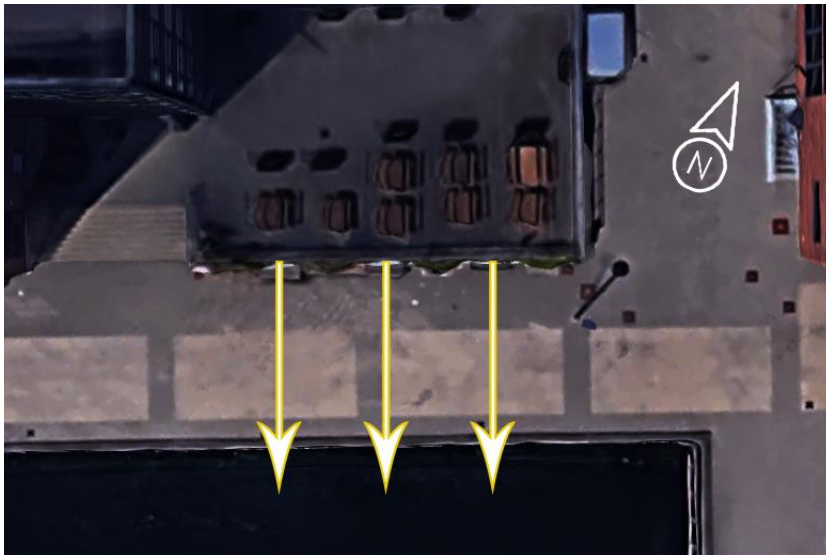


Fig.54

The place of interest consists of 3 benches fixed to a wall and facing the canal, between which there is a pavement of the promenade. The benches are made of wooden boards and are shaped in an ergonomic way, have back and arm rests.

Between the benches, there is some vegetation growing on the wall which provides more intimacy, visual division between the benches and creates space in the space with a pleasant microclimate. Thanks to the fixing into the wall, the user's back is entirely protected while an open space in front gives a good overview. All together, the design of the bench is really good and supports creating a feeling of safety and interest.

Lighting

Existing Lighting

The space is lit with flood light evenly distributed lighting poles (every 28 meters) on the promenade. In the focus area there is only one lighting pole, however the space is affected by the next pole and significant amount of ambient light coming from nearby office buildings.



Fig. 55

Observations

- There is only one lighting fixture, however the space is highly affected by the next lighting pole and the ambient lighting coming from the buildings.
- There is noticeably different illumination level on each of the benches, however in overall, the brightness level is too high in comparison to the pavement's illumination.
- The bench placed directly next to the pole is brightly lit and stands out from the darkness, creating an uncomfortable feeling for the user of being seen from far away, but without the ability to observe.
- Placement of the lighting pole creates a situation when the bench user is glared every time one wants to look sideways.
- The condition disables to observe the pedestrians until they get very close to the light source.
- At the moment that the pedestrian passes the lighting pole, one becomes backlit and therefore it is impossible to see one's face.

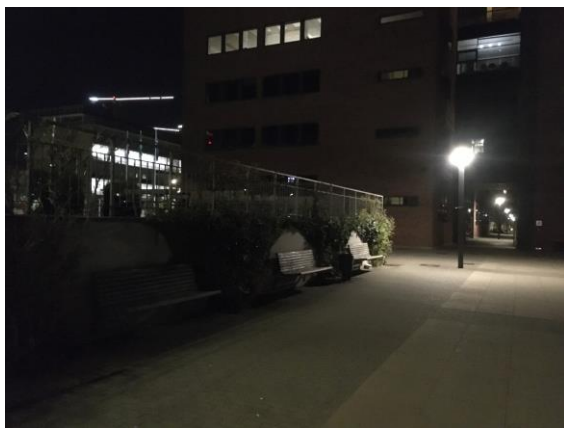


Fig.56



Fig. 57



Fig. 58

Illuminance measurements

The illuminance of the space was measured in 6 points (see the graph below) in order to quantify the existing lighting conditions.

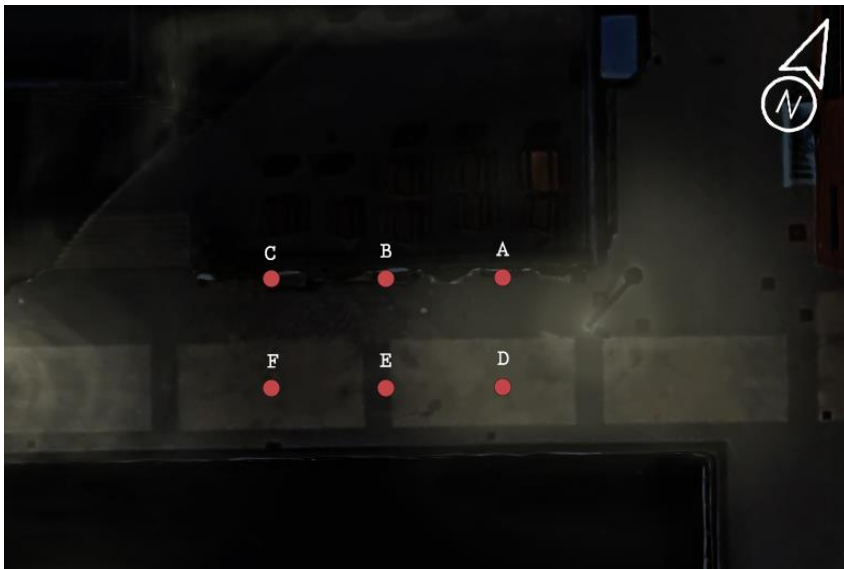


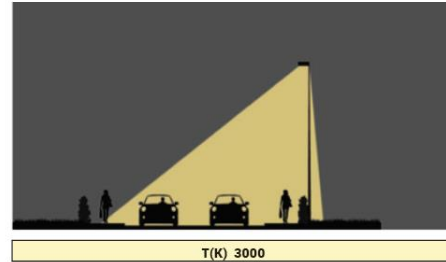
Fig. 59

Placement	Point A	Point B	Point C	Point D	Point E	Point F
Horizontal illuminance	11.3 Lux	2.3 Lux	2.7 Lux	7.8 Lux	1.9 Lux	2.7 Lux
Vertical illuminance	11.5 Lux	1.3 Lux	0.7 Lux	7.4 Lux	2.0 Lux	3.1 Lux



Fig. 60 (Københavns Kommune, 2014, p. 33)

- Strøggade: neutralt hvidt lys
- Bydelsgade: neutralt hvidt lys
- Lokalgade: varmt hvidt lys



ig. 61 (Københavns Kommune, 2014, p. 32)

According to the Copenhagen Municipality Lighting Masterplan, the street lighting of the promenade is set at 3000 K (warm white) as it is a place close to nature and recreational area.

Uniformity:

Horizontal uniformity= 0,39

Vertical uniformity= 0,16

Audience - actor relationship

The audience - actor relationship of the space is slightly upset, as there is a bit more light on the benches than on the pavement. In this situation, the bench user is placed in focus instead of the pedestrian. The pedestrians might feel secure as they can see the bench from far away, however the audience might feel insecure and exposed. The bench user can see the actor only when one is already very close and even then, mostly the backlit silhouette.

Sum-up

The case study of benches placed at the promenade next to Genmab office building, represent the situation when the bench is well designed (provide back protection, back support and a good view), but the lighting design is slightly off.

The rather dim and warm light placed on the medium-high pole creates an overly pleasant atmosphere in the space. Lighting pole placed next to the bench could create theatre-like conditions (when the lights are above the audience), however the direction and distribution of light is set in a wrong way. The uniformly distributed toplight is directed evenly in all directions, therefore the bench is the most lit object in the space as it is the closest one. In these conditions, the bench user feels uncomfortable as one is exposed to being seen from far away, simultaneously being unable to see the approaching pedestrians.

PROS	CONS
Colour temperature (3000 K)	Illuminance level (>11 Lux)
	Direction of light (backlit actors)
	Audience brighter than the actors

The space and the success criterias:

1. Activation of the abandoned benches to be usable at the night-time:
The bench location fosters the night-time usage of the bench, however the existing lighting might confuse the users.
2. Clear definition who is the actor and who is the audience:
There is a slightly higher illuminance level on the benches than on the pavement, which may evoke a feeling of being exposed in the bench users and confuse the understanding who the actor of the space is.
3. Frequent usage of the bench that support observation and provides possibility of interaction:
The bench is frequently used and there is a good possibility to interact between the bench users. On the other hand, the bench users are glared from the fixtures, which does not allow for comfortable observations.

Case Study no. 3 - Havneparken, Islands Brygge

The case study of the bench placed next to the old railway car of Havneparken (Islands Brygge) was chosen due to its location in a recreational area, with a good view onto the pavement and water in the background. Simultaneously with the good design and placement, the bench is lit in an improper way, which might result in it not being used.

The Space

Havneparken is a recreational area built between 1983 and 1995, when an previous industrial quay was transformed into a park. The waterfront of Islands Brygge with its promenade is one of the busiest areas of Copenhagen, especially during summer.

The space is frequently used as its central location and the waterfront of Havneparken attracts not only the inhabitants of Islands Brygge, but all the people from around the city. During the night-time the place is dominated by locals walking their dogs, young people partying, runners and pedestrians enjoying the promenade walk.

Havneparken is the place that always hosts groups of people partying, couples on the benches and people walking. In this environment, it is very easy to observe the opposite sides of the interaction scale described by Jan Gehl. Mostly, there are either huge groups of youngsters or lone individuals.

Architectural Site Analysis

The Case study no.3 is located in the middle of the park, on the edge of the promenade of the main canal of Copenhagen. At the spot, there are 2 wooden, free standing benches facing the promenade's pavement and the water.

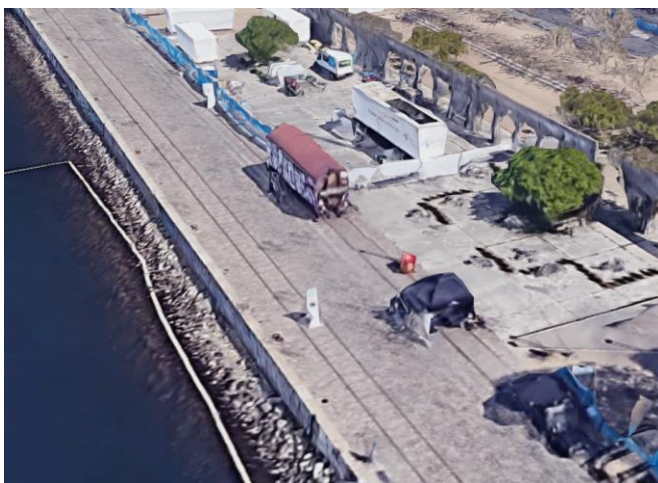


Fig. 62 (Google, n.d.)



Fig. 63

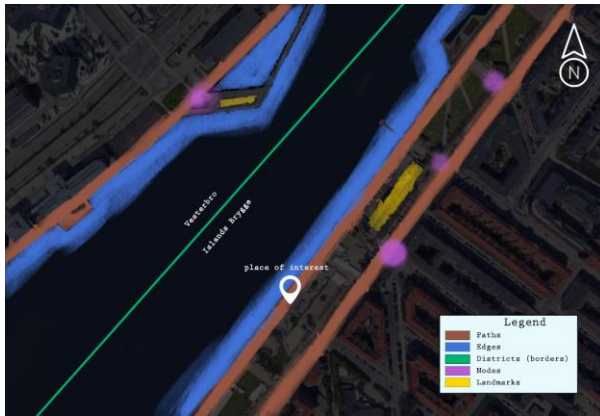


Fig.64

The above site plan shows the main canal of Copenhagen with the promenade on Vesterbro side (North) and Islands Brygge on South with marked place of interest and the surroundings. The map shows the area divided into “elements of the city” described by Kevin Lynch in his book “The Image of the City”.

The place of interest is located by the edge of the canal, right by the pavement of the promenade passing next to the spot. It is a main waterfront walk in the city that passes by many landmarks, including a local landmark of Islands Brygge - the culture house (Kulturhuset) of Islands Brygge. Waterfronts of Islands Brygge and Vesterbro define edges and the borders between the districts. The main nodes of the neighbourhood are located next to the culture house and along the promenade and are meeting points for hundreds of people every day.

The location of the point of interest on the main path and edge of Islands Brygge as well as its proximity to the landmark (Kulturhuset) and the nearby node, makes it a very trafficked area, therefore providing a variety of activities on the pavement that can be observed from the bench.



Fig. 65 (2019) - Landmark: Kulturhuset Islands Brygge

The culture house of Islands Brygge is an important art and meeting facility in the neighbourhood that provides great view to the water. In the building there are several stages, rehearsal rooms and a cafe and frequent cultural events attract many people from the district.



Fig. 66 - The benches, their placement and orientation

In the place of interest there are many benches, while only 2 of them are placed, so the user can enjoy the view of the pavement and the canal in the background.

The benches are made of wooden boards, they are free standing and have back and arm rests. The benches are fixed with approximately 6m of distance and there is some vegetation behind each of them and there is a small table in front of the bench "B". The user's back is not entirely protected at the benches, however the backrest and vegetation make the small space behind the bench rather unused, therefore providing sufficient feeling of safety.

Due to some obstacles placed in front of the bench "B", which block out a significant amount of the view. The further analysis is conducted only regarding the bench "A" which provides a full, unobstructed view to the pavement and the canal (except the railway car, which is itself an interesting part of the scenography to look at).

Lighting

Existing Lighting

In the space there is only one lighting pole that provides flood light for the benches, however there is a lot of light spill from other nearby fixtures and overly, there is a lot of ambient light. The promenade is light with evenly distributed lighting poles (every 30m), however every facility (playgrounds, skatepark, Kulturhuset, restaurants, etc.) has its own lighting, therefore the lighting in the space seems quite random.

For the analysis I focused only on the single lighting pole that is placed within the area of interest as the other lights do not affect the space to a bigger extent.



Fig. 67

Observations

- There is only one lighting fixture, however the space is highly affected by the next lighting pole that floods the space with warm light and is placed between the bench and the pavement.
- The illuminance level of the bench is quite good and so the closer part of the pavement.
- Due to its placement, pole height (3,5-4m) and light distribution, the light cannot reach the further end of the pavement which remains covered in complete darkness.
- The bench user can see only the pedestrians which walk close to the bench, while the ones that stay closer to the canal, remain unlit.
- There is a noticeable imbalance in illuminance ratio between the bench and the pavement which, despite low illuminance level, might create a feeling of being exposed to the view of the pedestrians.



Fig. 68



Fig.69



Fig. 70

Illuminance measurements

The illuminance of the space was measured in 3 points (see the graph below) in order to quantify the existing lighting conditions.



Fig. 71

Placement	Point A	Point B	Point C
Horizontal illuminance	1.4 Lux	1.9 Lux	0.7 Lux
Vertical illuminance	1.25 Lux Towards the canal	0.9 Lux Towards the bench	0.9 Lux Towards the bench



Fig.72 (Københavns Kommune, 2014, p. 33)

- ▶ Strøggade: neutralt hvidt lys
- ▶ Bydelsgade: neutralt hvidt lys
- ▶ Lokalgade: varmt hvidt lys

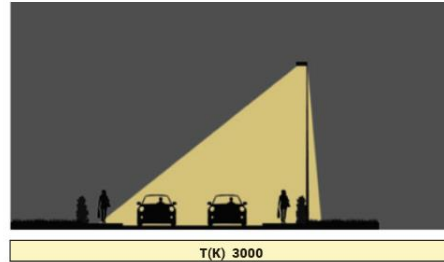


Fig.73

According to the Copenhagen Municipality Lighting Masterplan, the street lighting of the promenade is set at 3000 K (warm white) as it is a place close to nature and recreational area.

Uniformity:

Horizontal uniformity= 0,54

Vertical uniformity= 0,89

Audience - actor relationship

The audience - actor relationship of the space depends on the position of the actor. If the pedestrian moves far from the bench (by the canal), the audience would notice the movement but will not be able to see the face. On the other hand, if the actor is closer to the bench, one is well lit and can be easily seen.

On the other hand, the audience is placed closer to the light source for most of the time, therefore easy to notice by the actors. Due to the lighting pole placement in between the audience and the stage, both sides are lit from the same angle and it is easy to see each other's faces.



Fig. 74 - 4m from the luminaire

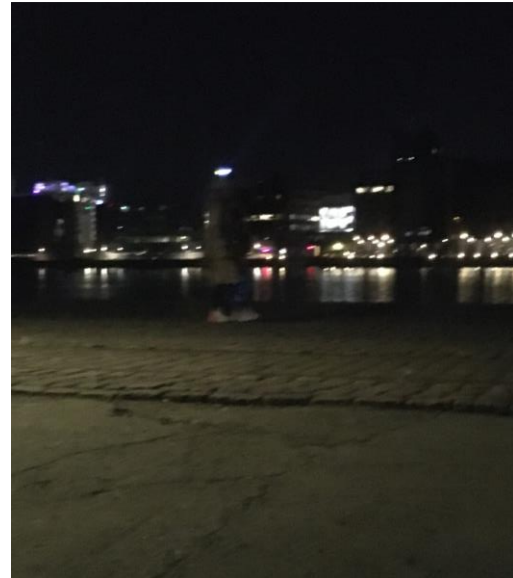


Fig. 75 7m from the luminaire

As in the pictures above, the difference of 3 meters in actors' placement makes the appearance of one's face completely different. At the distance of 4m the actors and their faces are clearly visible, it is possible to recognize the person and one's facial expression. However, at the distance of 7m, the faces are almost completely in shade and it is only possible to see the shape of the person.

Sum-up

The case study located next to the old railway car in Havneparken (Islands Brygge) represents the situation when the bench is well designed (provide back protection, back support and a good view), but the lighting design is slightly misplaced.

The pole height, illuminance level and colour temperature create a pleasant atmosphere in the space, however the placement of the pole disturbs the audience-actor relationship. In the existing situation, there is more light on the audience than on the actors and half of the stage remains unlit.

PROS	CONS
Illuminance level (<2.0 Lux)	Distribution of light (parts of the stage in dark)
Colour temperature (3000 K)	High lighting poles (4m)
Direction of light (side- and frontlit actors)	Audience brighter than the actors

The space and the success criterias:

1. Activation of the abandoned benches to be usable at the night-time:

The bench location fosters the night-time usage of the bench, and the lighting of the bench creates an intimate atmosphere that supports the night-time usage of the bench.

2. Clear definition who is the actor and who is the audience:

Due to the fixture placement, there is a slightly higher illuminance level on the benches than on the pavement, which may confuse the users about who the actor of the space is.

3. Frequent usage of the bench that support observation and provides possibility of interaction:

The bench is frequently used and there is a good possibility to interact between the bench users. However, the further part of the pavement remains in the darkness which does not support the observation of the pedestrians.

Conclusion

From the analysis of the three cases of benches in Copenhagen (in Nordhavn, Vesterbro and Islands Brygge) there are established common issues that might affect the bench of Typology H and make the bench unusable at night-time. The concerns are as follows:

- Illuminance level on the audience is higher than on the actor
- The lighting poles are too high
- Bad light distribution - bench fully lit and the stage with dark spots

Referring back to the success criterias, the benches of Case Study no.2 and 3 are placed with big soft traffic, therefore they are used quite often in comparison to the Case Study no.1. The bench from Nordhavn is the most abandoned and needs to be activated for the night-time usage. In all of the cases there is no clear division into the audience and the actors, however it is again the Case Study no.1, where this definition is the most upset. When it comes to the possibility to observe and interact with other bench users, Cases no. 2 and 3, even though with some issues, do not interrupt those actions as much as the situation existing on the bench in Nordhavn.

Therefore, the first Case Study – the bench at Marmorvej in Nordhavn is the one with the biggest risk of becoming a non-place. In the next chapter of the report, a proposal of a new lighting design for the Case Study no.1 will be presented due to above mentioned issues.

8. DESIGN CRITERIAS

The design proposal aims to adjust the existing lighting design of the space into one that would support more the night-time usage of the bench:

- create a pleasant atmosphere to encourage people to use the space for longer
- clearly define who is the actor of the space to engage the audience for longer
- allow the bench users for observations and interactions

The design proposal focuses on the adjustment of the existing lighting in order to create a solution that is:

- Realistic (easy to implement and cheap)
- Universal (applicable to most of the benches)
- Sustainable (use of the existing fixtures)

Therefore, the proposal does not intend to create a completely new lighting for the space, light installation, etc. Instead the design is focused to take as much advantage of the existing solution as possible and readjust it to the previously mentioned characteristics.

Design Parameters

The design parameters are based on the theatrical properties of light to redefine the space. Therefore in the proposal the following properties are changed in order to create a theatrical atmosphere in the space:

- Intensity
- Form
- Direction

The adjustments of these three variables allow for significant changes in space's lighting without interfering with lightning regulations or changes of existing fixtures.

In order to make a proposal that uses all the previously mentioned properties, the existing lighting pole will be moved into a different place, the luminaries will be lowered down on the poles and refocused and their output will be lowered down.

Due to the four variables, a simple survey test is not enough to get any firm results. Therefore, the design proposal will be assessed with two tests, where the first one will create a baseline for the second one. The second test will differ from the first one only by the illuminance levels, therefore the variable will be limited only to one - the intensity of light. With the comparison of two tests it will be possible to investigate how the difference in illuminance level affects the perception of the space, essentially how the intensity of light can define the actor and the audience of the space.

9. DESIGN PROPOSAL

Introduction

The design proposal aims to fix the issues found out in the analysis chapters, which are:

- Illuminance level on the audience is higher than on the actor
- The lighting poles are too high
- Bad light distribution - bench fully lit and the stage with dark spots

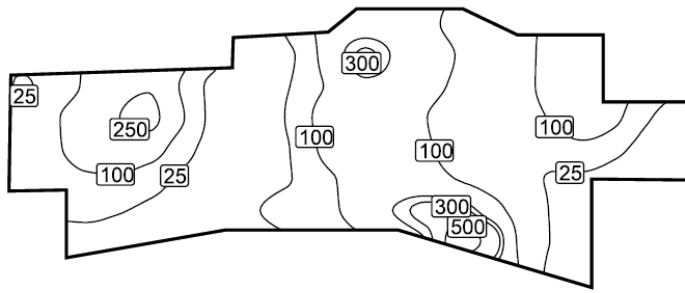
With the theatrical approach towards lighting of the space, the proposal will demonstrate the possible solution, how an urban space can be easily adjusted to bench users' needs and stimulate growth of urban life in newly-built neighbourhoods.

The design proposal chapter starts with Dialux analysis of the existing case and a redesigned lighting for the proposal. Next, the space was modeled in Unreal Engine to create visualisations of the design proposal which were tested in an online survey.

Dialux

The space of Case Study no.1 - a seating furniture at Marmorvej, Nordhavn was modeled in Dialux Evo 8.0 with reconstructed existing lighting to understand the distribution in the space. The chosen luminaire is a pole mounted Stage Round Spot produced by Simes (see Appendix 2 and 3), which choice is an estimation based on the observations of the existing luminaires, however there is no any similar luminaire included in the "Lighting Master Plan of Copenhagen".

The light distribution over the place was set according to observations, the photographs and illuminance levels measured on site in order to recreate existing lighting conditions. The graphs below present the light distribution in the space.



Scale: 1 : 200

False colours [lx]

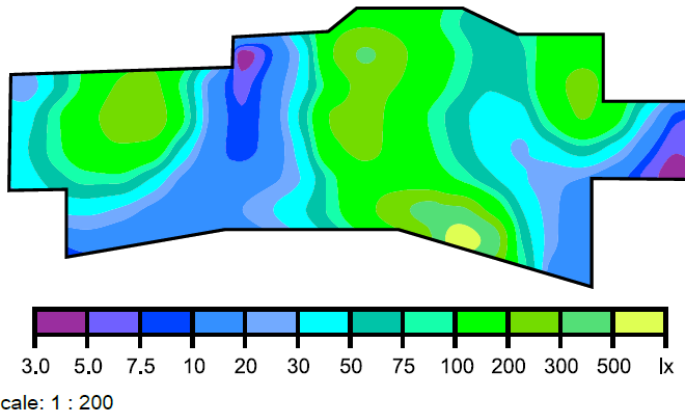
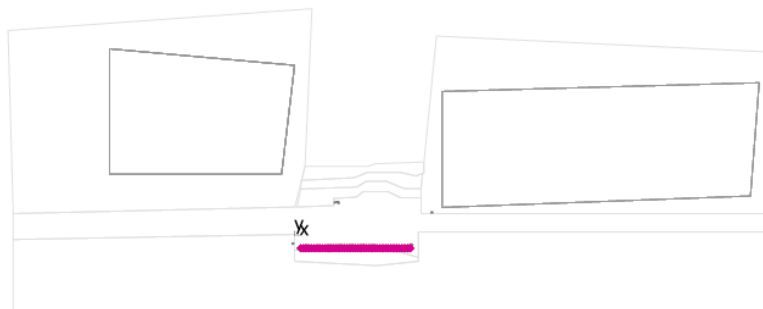


Fig. 76

Another issue of the existing space is the high illuminance level on vertical surfaces - the eyes of the bench user as well as the pedestrians. The analysis of the vertical illumination on the audience is presented in the graphs below.



Maintenance factor: 0.80

Calculation surface 6: Vertical illuminance (Grid)

Light scene: Light scene 1

Average: 104 lx, Min: 1.06 lx, Max: 331 lx, Min/average: 0.010, Min/max: 0.003

Rotation: 0.0°, Height: 1.000 m

Fig. 77

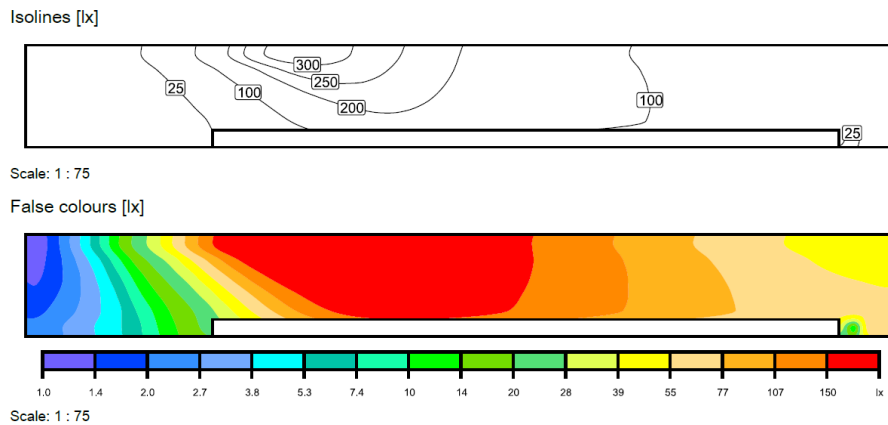


Fig. 78

As mentioned in the case analysis chapter, the existing distribution does not support audience-actor interaction as the bench is more lit than the pavement. In the design proposal, the distribution should be set, so the pavement is in the light, while the bench remains dark. What is more, the proposal must lower the illuminance levels, lower down the fixtures and set them in order to prevent glare and light-up well actors' faces.

For the design proposal the existing light fixtures were lowered from over 4,5 m to 4 m above the ground, repositioned (as in the picture below) and dimmed down to 30% of power. In the existing case there are 6 fixtures used, in the proposal only 2.

The existing fixtures are marked in orange, while the ones marked in green show the placement for the design proposal.

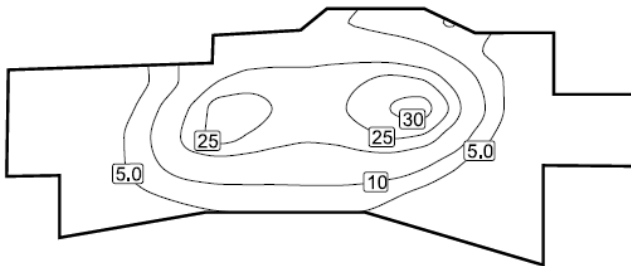


Fig. 79

The adjusted lighting resulted with improved light distribution - more uniform light on the pavement, and little light on the bench; and limited risk of glare for the audience. The following graphs present the light distribution of the proposal.

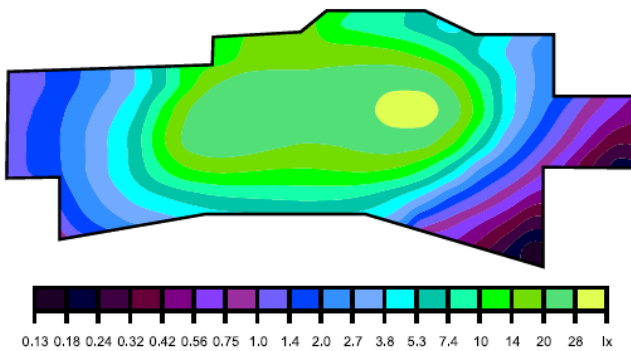
Calculation surface 2: Perpendicular illuminance (Grid)
 Light scene: Light scene 2
 Average: 9.93 lx, Min: 0.15 lx, Max: 31.5 lx, Min/average: 0.015, Min/max: 0.005
 Height: 1.200 m

Isolines [lx]



Scale: 1 : 200

False colours [lx]

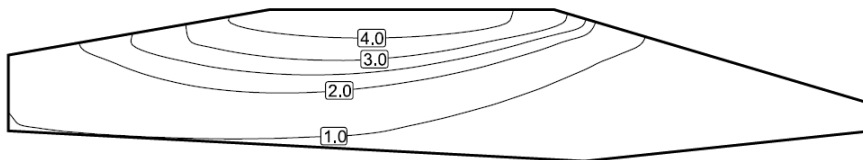


Scale: 1 : 200

Fig. 80

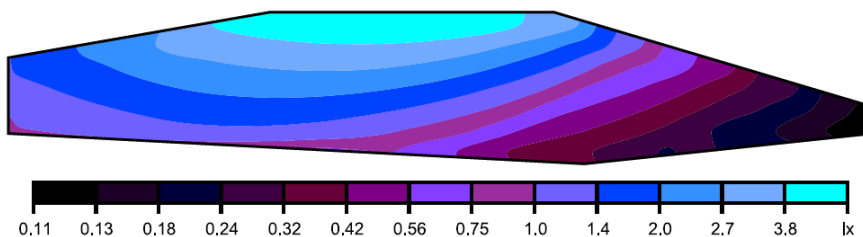
Calculation surface 1: Perpendicular illuminance (Grid)
 Light scene: Light scene 2
 Average: 1.64 lx, Min: 0.11 lx, Max: 4.94 lx, Min/average: 0.067, Min/max: 0.022
 Height: 0.750 m

Isolines [lx]



Scale: 1 : 100

False colours [lx]



Scale: 1 : 100

Fig.81

Visualisations

Afterwards, the design proposal was moved into Unreal Engine 4, where the site of Case Study no.1 (Marmorvej in Nordhavn) was modeled and then the lighting was redesigned, so the bench is noticeably darker than the pavement and there is no glare issue. Therefore, the lighting poles were moved, the fixtures lowered and the illuminance levels fixed according to previously mentioned criterias and the analysis form Dialux.

The picture below shows the site plan of the design proposal with new placement of lighting.

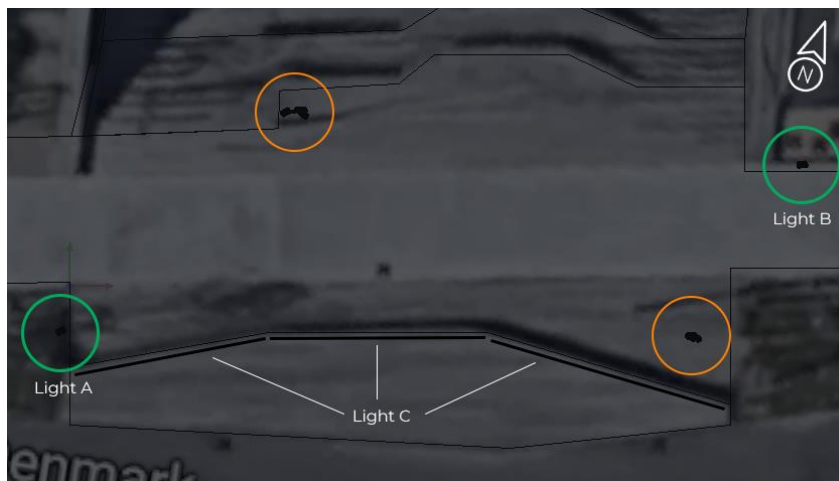


Fig. 82

Lights “A” and “B” are spot light placed on the poles (the same as the existing solution), while the Light C consists of three fixtures embodied in the bench.

The design used for the proposal follows a theatrical practice, where one of the lights is a “key light” (in this case - Light A) that is the brightest and defines the perceived direction of light. The second one is a “fill light” (Light B) that fills in the space from the opposite site to soften the deep shadows. In the case of the proposal, Light B also performs a function of a “back light” - the light that highlights the silhouette of the actor from behind accentuating one’s shape and adding the third dimension. Light C of the design is used as an accent light which does not provide the light for the actors, but adds in shaping of the scene.

Due to the “catwalk” shape of stage, the lights were placed as described above, so depending on the direction from which the audience looks at the actors, Light A and Light B swap their functions as the key light.

The proposal uses the spotlighting placed on poles in order to show the potential of existing lighting. In the recommendation the spotlights are placed 4m above the pavement which is the lower end of the range defined by the lighting regulations and 0,5 - 1 m lower than in the original design. Lowering down the lights enhances the human scale of the place and creates a more cosy atmosphere.

The replacement of the lighting poles changes the light distribution in the space to clearly define the actors, the changes in illuminance levels emphasize the difference between the stage and the audience, also prevent glare and allow for easier observation. Lowering down the fixtures, enhances the intimacy of the space allowing for users interaction and therefore, together with other adjustments, making the bench more inviting to be used during the night-time.

The following picture represents the view seen by a pedestrian approaching the space in with the existing lighting Scenario A and the proposed design (Scenario B).



Fig. 83 - Scenario A

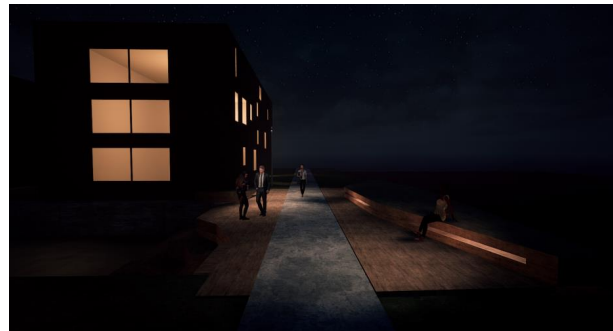


Fig.84 - Scenario B

From the comparison of the above pictures it can be observed that in the design proposal:

- The space does not stand out from the surroundings
- The area is not over lit
- There is no glare from the fixtures

What is more, the pedestrian approaching the space firstly sees the people standing in the middle of the space on the opposite site from the bench. Next, the focus goes to the pedestrian approaching from the opposite site. The bench user does not bring much attention, however one is visible thanks to the low lighting behind one's legs.

Such a lighting of the space clearly defines that the actors are the people standing closest to the canal and the pedestrians, while the bench users are the audience which should not be exposed.

The following two visualisations show the point of view of the bench user.



Fig. 85



Fig. 86

In both spots, the audience can clearly see the actors without being glared or having trouble to notice the facial expressions.

The variables of the tests consist of five variables: the position of lighting poles, the number of fixtures and the height of their fixing, direction of light and illuminance levels on the surfaces.

Tests

In order to test the design proposal there were performed two tests - online surveys, where the interviewee were presented with the visualisations of the existing and the redesigned space. The questionnaires included the same questions in both tests, which asked, among others, about the duration of stay on the bench, choice of the audience of the space and willingness to interact with other users. Both tests were answered by 30 people, however as

shows the statistics of age and sex, they were not the same interviewees answering both tests. For the full questionnaire see Appendix 4.

Test 1

In the first test, the levels of light intensity were set according to DIALux analysis, in order to recreate the illumination measured on the surfaces. The following pictures present the view of the space in Scenario A (existing lighting design) and Scenario B (the design proposal).



Fig. 87 - Scenario A (test 1)

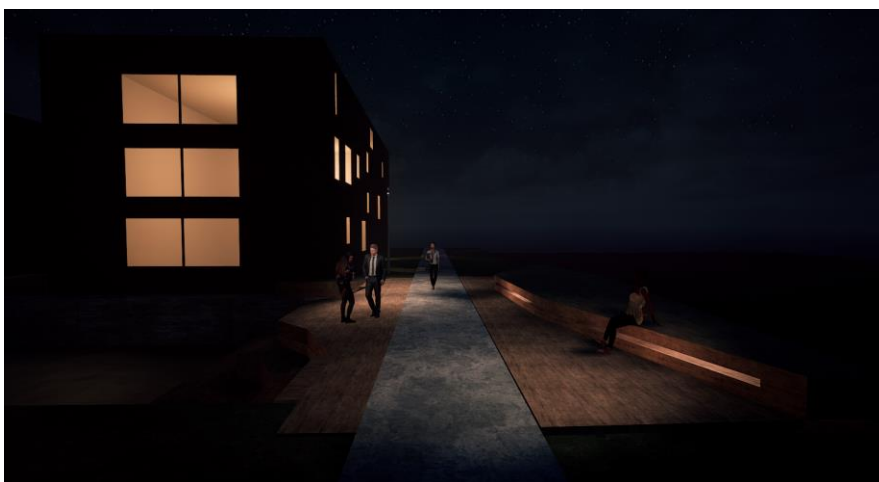


Fig. 88 - Scenario B (test 1)

Firstly, the users were asked about the average time they spend sitting on a bench during the night-time (dashed line) and then how the duration of stay would change in the scenarios shown in the pictures. The following chart shows that the Scenario A significantly prolongs the time spent on the bench, however the Scenario B supports only the stays for a duration of 5-10 minutes.

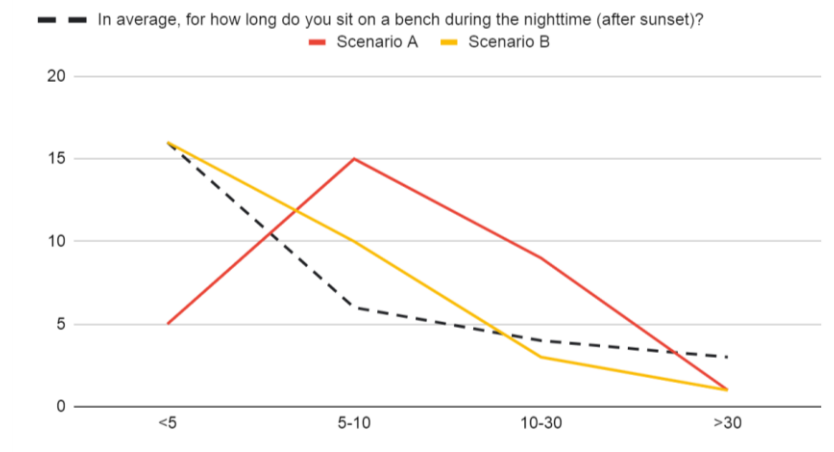


Fig. 89

Next question attempts to answer, what is the feeling evoked in the bench user while staying on the bench. The two pictures show the space from the point of view from the bench in both scenarios.



Fig. 90 - Scenario A (test 1)



Fig. 91 - Scenario B (test 1)

The interviewees were asked if the lighting of the space makes them feel as being the observers of the space or rather being observed, while sitting on the bench. The two charts below show the responses to that question. In both cases, most of the people answered that they would rather feel as the observers of the space. The distribution of answers is different, but it seems that no matter the lighting of the space, the evoked feeling is similar.

As the bench user, would you rather feel as being the observer of the space or being observed?
30 responses

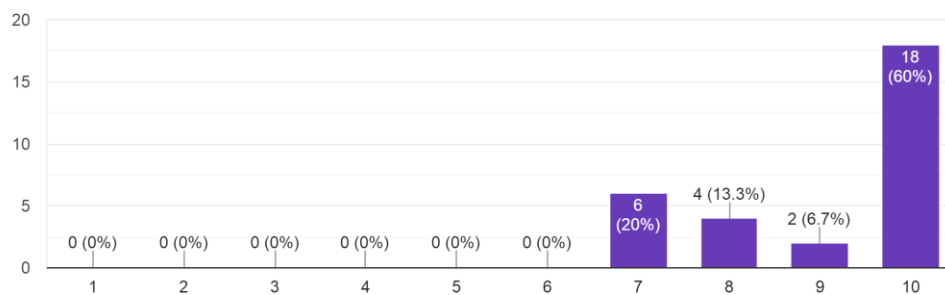


Fig. 92 - Scenario A (test 1)

As the bench user, would you rather feel as being the observer of the space or being observed?
30 responses

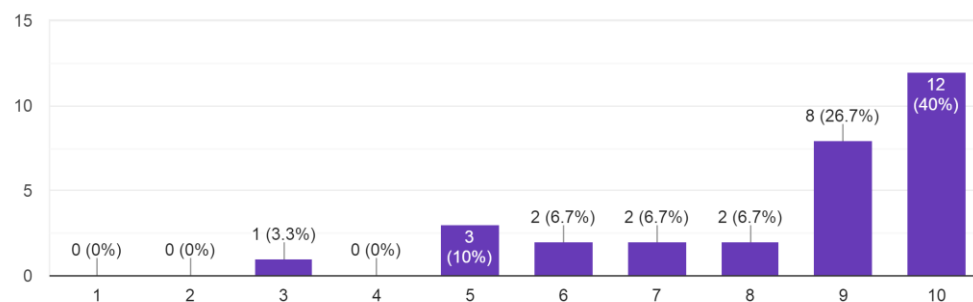


Fig.93 - Scenario B (test 1)

As a sum-up of the survey the interviewees were asked to compare the two scenarios. In both questions the Scenario A was definitely more liked, as it feels safer to be in space and seems more inviting to stay in there for a longer period of time.

The last question asked which of the scenarios supports more the interaction with other bench users (strangers), but according to most of the answers, none of the scenarios would change the approach.

Which of the two presented scenarios (A or B) encourages you to have an interaction with another users of the space?

30 responses

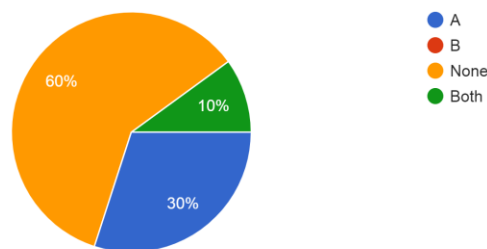


Fig.94

Test 1 sum-up

The outcome suggests that the test was biased due to the form of handling, as one cannot experience the space with all of the senses. What is more, the difference between the screens used by the interviewees can affect the judgment. The pictures below compare the image quality and brightness levels of the same visualisation on two different screens (both set at 100% of brightness).

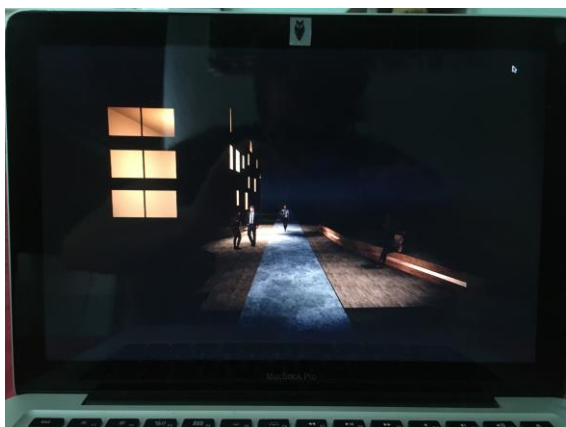


Fig. 95



Fig. 96

The test's result suggests that the visualisations created for the survey assessment should not represent the lighting design based on the quantifiable measurements used in the program,

but exaggerate the visual outcome, so the picture creates the desired feeling of the space, rather than try to use the realistic intensity values. Presented design proposal is especially susceptible to misjudgment as it operates with very low light levels and does not have regard to eye adaptation.

For the full list of responses see Appendix 5.

Test 2

After the first test, the visualisations were corrected by adjusting the intensity of light levels in the model and the new renderings were used for the second survey. The second questionnaire was sent out with the questions asked remaining the same as in the first survey.

The corrected visualisations have the same lighting properties as the previous ones and the only aspects that were changed are the intensity of light. The illuminance in the new renderings was exaggerated in order to create pictures that evoke the desired feeling of the space, rather than follow the realistic light levels.

The following pictures show how the space looks in real life, in the first visualisation and in the corrected one.



Fig. 97 - picture of the space



Fig.98 - rendering for test 1



Fig. 99 - rendering for test 2

The comparison of the above pictures clearly show that the first visualisation had too dim light levels, which did not convey the feeling of being exposed to the outside while being in the space. However, the second visualisation looks more similar to the realistic conditions.



Fig. 100 - Scenario B

The other two visualisations included in the survey depict the point of view of the bench user. For these renderings the sitting character was moved so the face is visible in the pictures for better assessment of light levels.



Fig. 101 - Audience's POV (Scenario A , Test 2)



Fig. 102 - Audience's POV (Scenario B , Test 2)

In the first picture, the other bench user is lit in the same way (illuminance level), as the standing people, which creates confusion who really is the actor in the space. In the second picture, there is a significant difference in the light levels between the actors and the audience. The bench user stays in shade (however the face is still visible), while the actors pop-out from the dark background.

Outcomes

In the second tests users were asked the same question as in the first one, however due to the change of intensity levels, the answers were significantly different.

In the question about the average duration of stay on the bench after sunset, in the Scenario A the amount of people who would stay on the bench from 5 to 30 minutes increased, and in the Scenario B the interviewee answered that the space looks more inviting to stay for 5 to 10 minutes (comparing to the baseline).

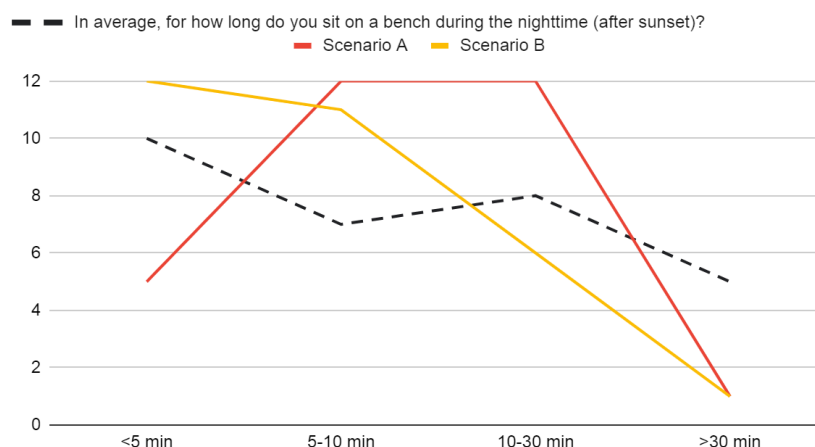


Fig. 103

In the question about the feeling of being the observer or observed in space, the interviewee chose the Scenario B as the one in which the bench user is the observer. The graph below shows how the answers were distributed on the scale (0 - being observed; 10 - being the observer), with a significantly more favour to the Scenario B.

As the bench user, would you rather feel as being observed or being the observer of the space?

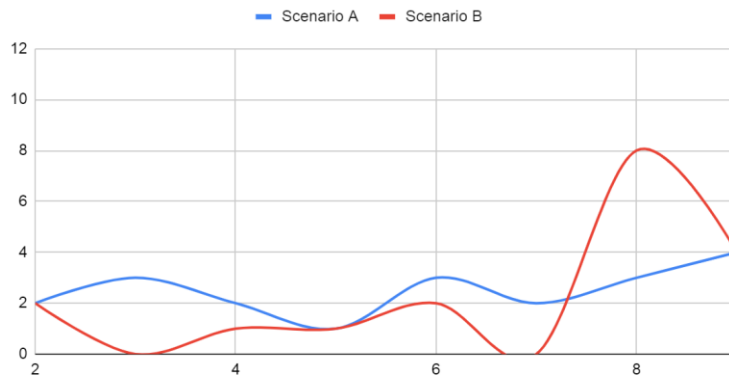


Fig. 104

In the last question, where the interviewee were asked to choose the scenario that encourages more for the social interactions, more than a half of them chose the Scenario A and 30% said "None of the scenarios".

Which of the two presented scenarios (A or B) encourages you to have an interaction with another users of the space?

30 responses

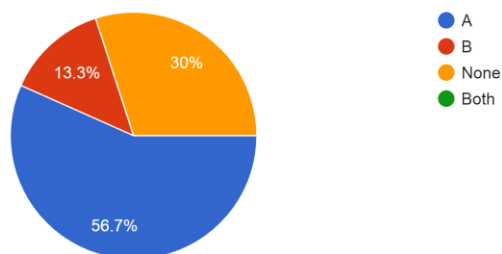


Fig. 105

Test 2 Sum-up

In the second test the interviewee supported more the design proposal in terms of clear definition of the audience of the space. On the other hand, the existing scenario was more likely chosen as the one that encourages for longer stays in the space and supports the social interactions.

For the full list of responses see Appendix 6.

Tests comparison

The two tests consisted of the same questions, however included different renderings. The only variable between the presented pictures was the level of light intensity used to light-up the spaces. The most important question asked in the questionnaires was the one which defined who is the audience of the space, as the analysis showed, this is the most common issue occurring in urban spaces and confusing the users. The unclear definition of the audience of the space results in short usage or abandonment of the bench and lack of social interactions at all levels.

The following chart is a comparison of the answers between the tests that concerned only the Scenario B. It is clear that in the second test, the interviewee felt more like the bench user is the audience of the space.

As the bench user, would you rather feel as being observed or the observer.
Scenarios B

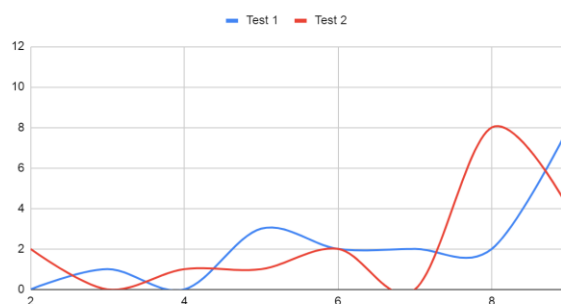


Fig. 106

The pictures below show Scenario B in the first and in the second test. The most noticeable is the difference of light level on the bench user. In the first picture (fig. 107), the bench user is placed outside the light, therefore it may appear as one is excluded from the space. In the second picture (fig. 108), the bench user is slightly light-up, however significantly less than the pedestrians. In this manner, the bench user of the second test looked more like the audience that is part of the play, but without confusing that the pedestrians are the actors.



Fig. 107 - Test 1



Fig. 108 - Test 2

The following graph is the comparison of the preferred duration of stay on bench of Scenario B from the first and second survey. As the illustration presents, there is a small but steady increase in the length of stay on the bench from the second test.

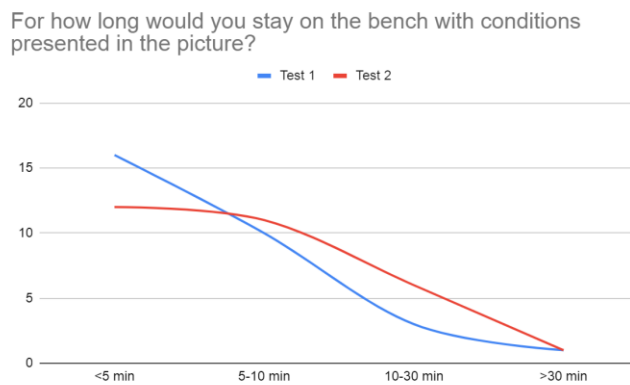


Fig. 109

The graph below shows the difference in the willingness to interact with other bench users presented in the Scenario B in the first and second survey. The results only slightly differ, therefore it is not clear if the lighting proposal could affect the social interactions directly. Comparing the results with the baseline question and the outcomes of Scenario A (from both tests), it seems that the lighting does not affect much the interactions between the bench users.

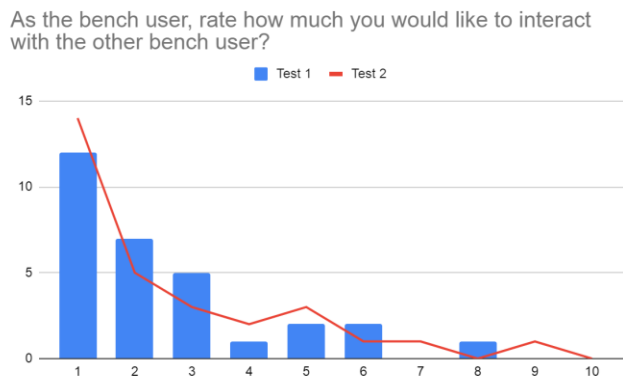


Fig. 110

Real life tests

Due to the extraordinary situation of Covid-19 pandemic occurring during the period the report was developed, it was impossible to perform tests in real life situations. However, the real life tests are the key in the development of the project. In another situation, the tests would consist of making a survey among the users of the space (inhabitants of the neighbourhood and UN City workers) in order to get their feedback on the design proposal. The initial test could be a survey made as an assessment of a visualisation of the design proposal, however to get the most accurate results, some tests with real-life lighting of the space should be conducted afterwards. Those tests could consist of refocusing of the existing fixtures without changing their placement, blocking out 2-4 out of 6 spot lights and field observations of the user's behaviour and differences in usage of the space.

Conclusion

The design proposal was based on the findings of the case analysis and followed the theatrical approach towards lighting design. The existing lighting scenario was rearranged in DIALux in order to correct the light distribution, to create a clear difference between the actors and the audience using the space and prevent the issue of glare. The first test of the proposal was established with regards to the correct (realistic) light levels, and was used as a baseline for the second survey. For the second test, the visualisations were corrected: the light levels were exaggerated without changes in light distribution or any other property. In this case the two tests could be compared together regarding only one variable which was the light intensity. After the analysis of the responses gathered through the tests and comparison of both with the design criterias, it was found out that the proposed lighting design has a significant impact on the perception of the space, where the bench users were clearly defined as the observers (audience) of the space. On the other hand, the proposal did not encourage people directly to spend more time in the space - the design proposal increased the duration of stay in the space, however Scenario A got even better results in doing so.

What is more, there is no clear connection between the lighting design (of any Scenario) and the possible interactions in the space. It seems that the people who do not tend to interact with strangers in urban spaces, would not do it regardless of the lighting conditions.

10. CONCLUSION

The report underlines the importance of thinking about perceived lighting of the space as an extension of measurable lighting design and the potential of theatrical lighting approach in reestablishing the relationship between the bench users and the pedestrians. Firstly, the research presented the similarities of an urban space and a theatre stage, as well as the analogy between theatrical and architectural lighting. Then, in the analysis of Copenhagen's benches the major issues that occur on similar benches were revealed and organised into a typology. From that finding the research question was formulated as "How theatrical lighting approach toward properties of urban lighting could affect the relationship between the bench user and the pedestrians?" The research question was therefore divided into three focus areas to establish the success criterias for the project.

Next, through thorough studies of three different cases, the design criterias were established as follows:

- create a pleasant atmosphere to encourage people to use the space for longer
- clearly define who is the actor of the space to engage the audience more
- allow the bench users for observations and interactions

What is more, the design proposal aimed for a solution that is easy to implement and does not involve drastic changes in the existing space. Therefore, the existing fixtures were moved following the theatrical rule of three lights, their fixing point was lowered down to create more intimate atmosphere, the light intensity was dimmed down and the lamps were adjusted, so the light distribution enhance the visibility of pedestrians' faces while the bench users remain in shade. All these adjustments reinforced the atmosphere of the space, supported the possibility to observe and helped to define the actor of the space.

Thus, the proposal recreated the existing lighting with usage of theatrical approach to adjust the light intensity, form and direction in the space. The design proposal was tested in two online surveys which limited the variables only to the intensity to make investigation more reliable. The findings from the test showed a clear correlation between the light intensity and the perception of the space. It turned out that the ratio between the illuminance of the audience and the actors is essential to create a visually coherent space that clearly defines what is the user's role in the space.

11. DISCUSSION AND PERSPECTIVATION

There are many factors that must be considered in applying theatrical approach in urban lighting which may not tone in the traditional lighting practices. The most controversial are the cost and safety issues. The usage of theatrical approach can be cheap and easy to implement as described in the design proposal, however there are many opportunities for great lighting of benches which could provide even better scenarios, however costly. In comparison to general street lighting, it is expensive and sometimes can be seen as a waste of money, to create a special lighting for benches, for example lighting embodied in the street furniture. Despite the cost, this kind of solution enables great lighting design as shown in the chapter "Best practice".

Another issue is the feeling of safety in urban space. In general, people tend to associate bright spaces with safety which in many cases is deceptive, as one staying in a brightly lit space cannot see what is happening in the darker surroundings. This is one of the biases of the test based on the visualisations, where the respondents assume that the brighter space is more safe, however do not take account of the eye adaptation and the issue of glare.

For the development of the project, it is necessary to make real life tests, where the design solution is implemented in the space and the users' behaviour would be examined. Another aspect that would be interesting to investigate is the potential of the rhythm of light, as it does not exist in urban lighting, but it is one of the strongest lighting principles used in theatre to keep the audience engaged in the play. With the existing LED fixtures it is possible to add the element of light change into the urban lighting scenarios, which could result in urban spaces which lighting changes according to weather conditions or season. However, this information was gathered through the interview, which was conducted too late to apply this knowledge into the project.

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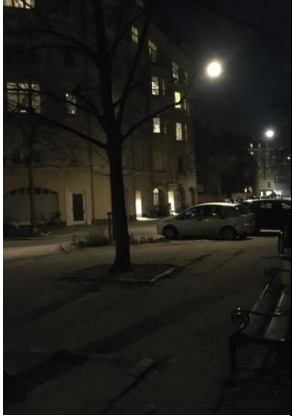
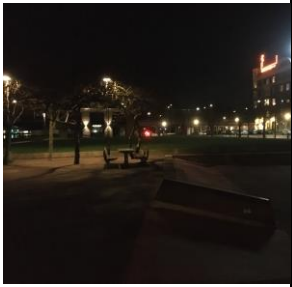
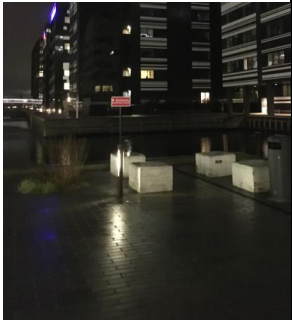
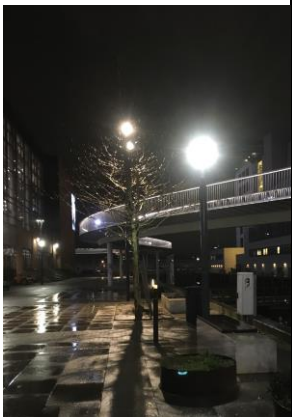
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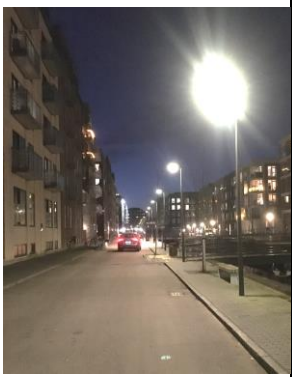
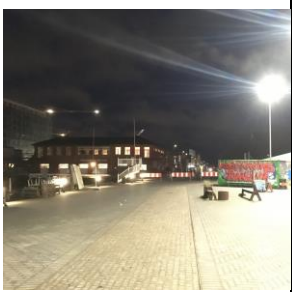
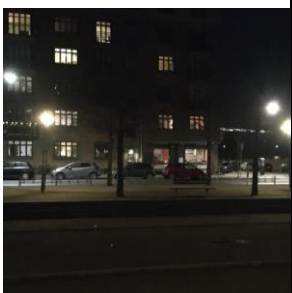
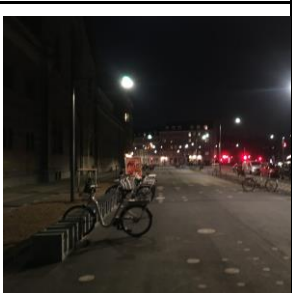
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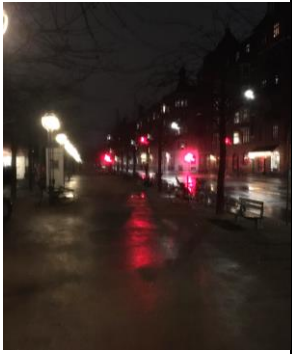
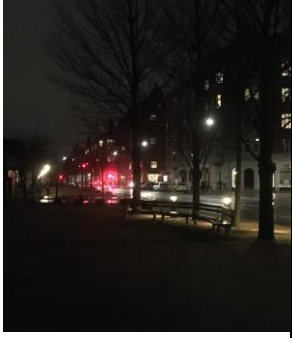

13. APPENDIX

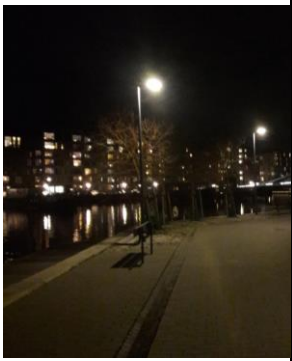
Appendix 1 - the full list of examples of benches

Example	Pros	Cons	Comments
	<ul style="list-style-type: none"> - Back protected - Good view - Backlight - Possibility of choice of seating 		
	<ul style="list-style-type: none"> - Bench (POV) in the shade, with a good view onto the street - Street is the most lit space, gradually getting darker towards the bench. 		
	<ul style="list-style-type: none"> - possibility to choose the direction of sitting - bench in the shade, square in light - View on a busy square 		Due to location (Christianshavn Metro) frequently used by homeless people
	<ul style="list-style-type: none"> - Pavement is brightly lit - illuminance gradually decreases - Bench remains in darkness; - Protected back 	<ul style="list-style-type: none"> - very tall light poles - Dull view 	

	<ul style="list-style-type: none"> - Light on the street gradually decreasing towards the bench - Back protected 		
	<ul style="list-style-type: none"> - the space in between stays in darkness. 	<ul style="list-style-type: none"> - The pavement and the bench have similar illumination 	Regardless the placement directly under the lighting pole, the illuminance level is pleasant to use the bench due to the tree that absorbs big part of the light
	<ul style="list-style-type: none"> - the bench is slightly lit - the space in between is darker - Possibility to choose the direction of sitting - low-placed lighting 	<ul style="list-style-type: none"> - The pavement is brightly lit with high poles 	
	<ul style="list-style-type: none"> - the space in between is darker 	<ul style="list-style-type: none"> - The pavement and the bench are bright lit with high poles - Low light level on the pavement and more light on the bench. 	

	<ul style="list-style-type: none"> - The space in between remains dark. 	<ul style="list-style-type: none"> - High lighting pole next to the bench - low lighting pole next to the pavement 	
	<ul style="list-style-type: none"> - Possibility to choose the view 	<ul style="list-style-type: none"> - High illuminance - High lighting pole - Lighting pole placed just next to the bench - More light on the bench than the street - Unprotected back - Dull view 	
	<ul style="list-style-type: none"> - Protected back - Interesting view 	<ul style="list-style-type: none"> - High illuminance - High lighting pole - Lighting pole placed just next to the bench - More light on the bench than the street 	The square is placed just next to a construction site. Perhaps the lighting will be changed after handover of the building, so it fits the adjacent street.
	<ul style="list-style-type: none"> - darker space in between. 	<ul style="list-style-type: none"> - Lighting poles are placed next to the benches 	
		<ul style="list-style-type: none"> - High illuminance - High lighting pole - Lighting pole placed just next to the bench - More light on the bench than the street - Dull view - Unprotected back 	

	<ul style="list-style-type: none"> - Protected back - Illuminance gradually decreasing from the street to the bench - Slightly roofed 		
	<ul style="list-style-type: none"> - Protected back - Illuminance gradually decreasing from the street to the bench - Placed in a niche - 		Probably the bench belongs to the adjacent shop.
	<ul style="list-style-type: none"> - The pavement is lit and the light level gradually decreases towards the bench. 		
	<ul style="list-style-type: none"> - Low lighting is placed behind the bench - the space in front of it remains in complete darkness. 		
	<ul style="list-style-type: none"> - The space in front is unlit 	<ul style="list-style-type: none"> - High lighting pole is placed behind and next to the bench - Bench facing back to the pavement 	

		<ul style="list-style-type: none"> - High lighting pole placed next to the bench - The bench is in light that gradually decreases towards the pavement - The bench is facing back towards the pavement 	
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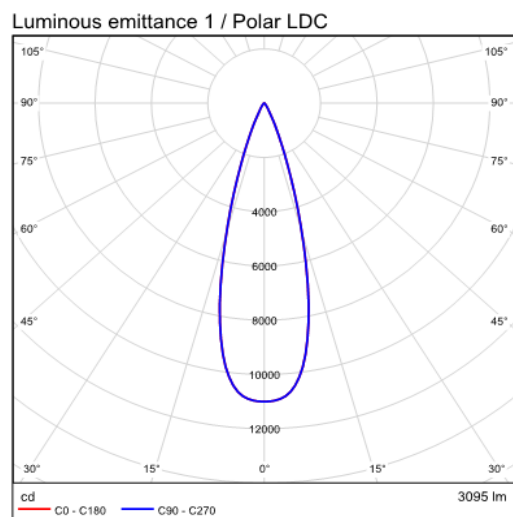
Appendix 2 - Light fixture used in DIALux (Stage Round Spot produced by Simes)



Absolute photometry
 Luminaire luminous flux: 3095 lm
 Power: 37.0 W
 Luminous efficacy: 83.6 lm/W

Colourimetric data
 1xLED 3000K: CCT 3000 K, CRI 91

Appendix 3 - Light distribution curve (Stage Round Spot produced by Simes)



Appendix 4 - Online survey (questionnaire of Test 1)

11/06/2023

Lighting design for urban seating furniture

Lighting design for urban seating furniture

The survey is a part of master thesis that investigates lighting design for urban benches. The aim of the questionnaire is to understand social preferences for bench lighting that support extended usage of urban benches at night. The survey shouldn't take more than 5 minutes to complete.

1. What is your age?

Mark only one oval.

- ☐ 18 or younger
☒ 19-24
☐ 25-34
☐ 35-44
☐ 45-54
☐ 55-64
☐ 65-74
☐ 75 or older

2. What is your sex?

Mark only one oval.

- ☒ Male
☐ Female

3. In average, for how long do you sit on a bench during the nighttime (after sunset)?

Mark only one oval.

- ☐ <5 min
☒ 5-10 min
☐ 10-30 min
☐ >30 min

4. Generally, how often do you tend to interact with other bench users (strangers) sitting next to you?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Always

Design
proposals

You will be presented with visualisations of a lighting design of an urban seating furniture (bench). To answer the following questions, imagine that you are having alone walk during the nighttime (after sunset) and approach towards the presented space.

Scenario A



5. Does the space look inviting to have a break on the bench?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not inviting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very inviting

6. Does the space look safe to stay in it?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Unsafe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very safe

Scenario B



7. Does the space look inviting to have a break on the bench?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not inviting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very inviting

8. Does the space look safe to stay in it?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Unsafe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very safe

View from
the bench

In the visualisations below, you are presented with a view from bench user's perspective. Imagine that you are sitting on the bench (alone), while answering the following questions.

Scenario A



9. For how long would you stay on the bench with conditions presented in the picture?

Mark only one oval.

☐ <5 min
☐ 5-10 min
☐ 10-30 min
☐ >30 min

10. As the bench user, would you rather feel as being the observer of the space or being observed?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Being observed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Observing

11. As the bench user, rate how much you would like to interact with the other bench user?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Really want to interact

Scenario B



12. For how long would you stay on the bench with conditions presented in the picture?

Mark only one oval.

☐ <5 min
☐ 5-10 min
☐ 10-30 min
☐ >30 min

13. As the bench user, would you rather feel as being the observer of the space or being observed?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Being observed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Observing

14. As the bench user, rate how much you would like to interact with the other bench user?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Really want to interact

Sum-up

Scenario A



Scenario B



15. Which of the two presented scenarios (A or B) makes you feel safer?

Tick all that apply.

- ☐ A
☐ B

16. Which of the two presented scenarios (A or B) makes you feel you are invited to stay in there for longer period of time?

Mark only one oval.

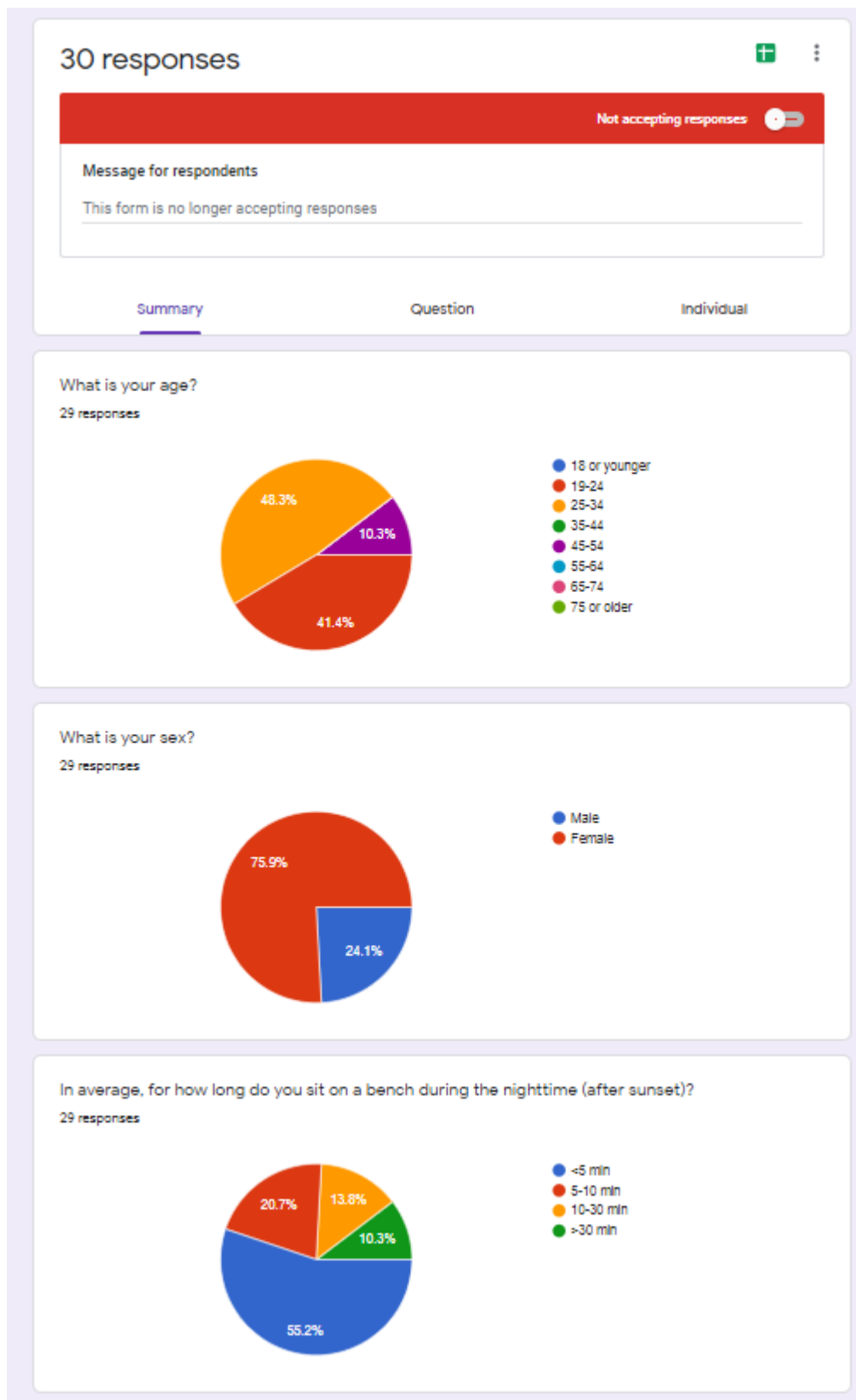
- ☐ A
☐ B

17. Which of the two presented scenarios (A or B) encourages you to have an interaction with another users of the space?

Mark only one oval.

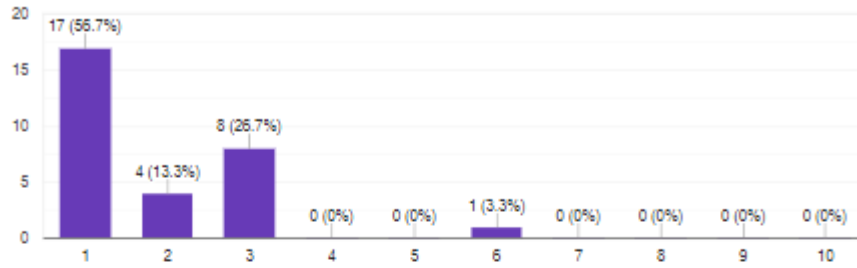
- ☐ A
☐ B
☐ None
☐ Both

Appendix 5 - Online survey (responses from Test 1)



Generally, how often do you tend to interact with other bench users (strangers) sitting next to you?

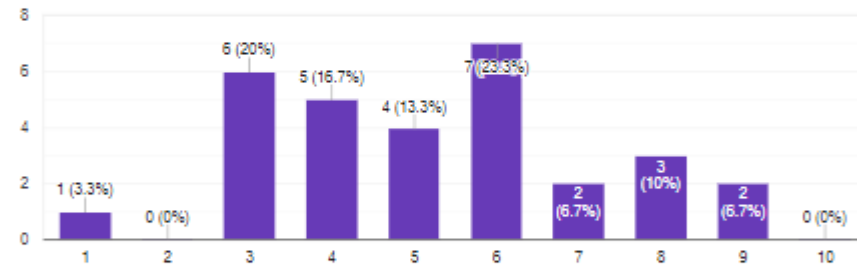
30 responses



Design proposals

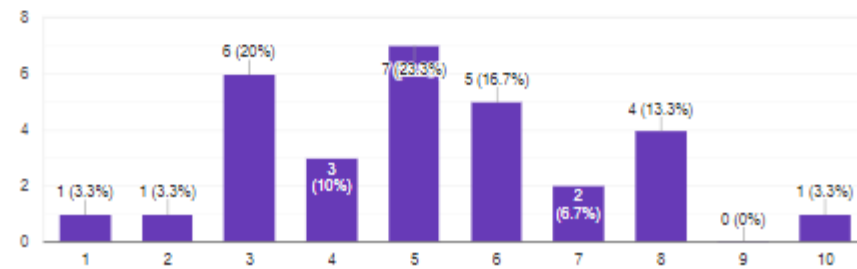
Does the space look inviting to have a break on the bench?

30 responses



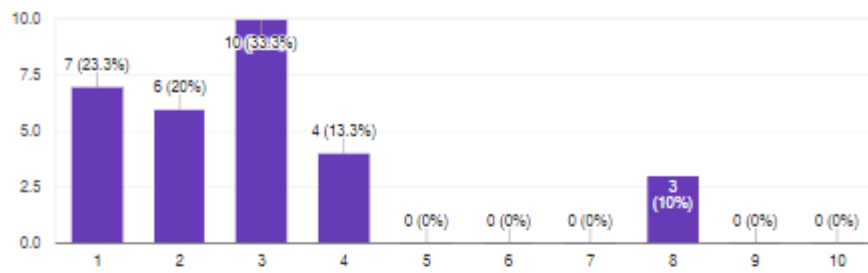
Does the space look safe to stay in it?

30 responses



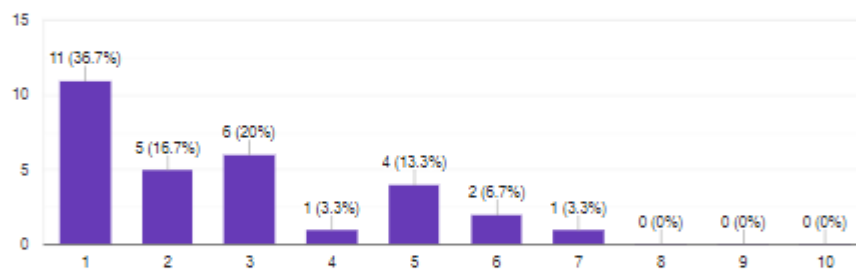
Does the space look inviting to have a break on the bench?

30 responses



Does the space look safe to stay in it?

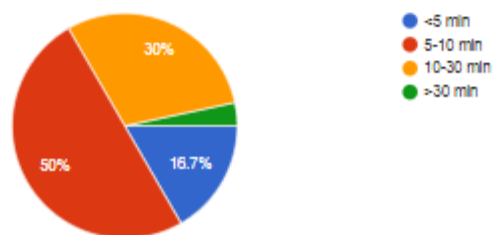
30 responses



View from the bench

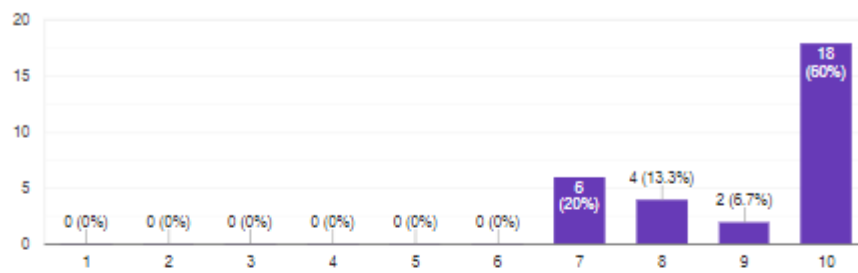
For how long would you stay on the bench with conditions presented in the picture?

30 responses



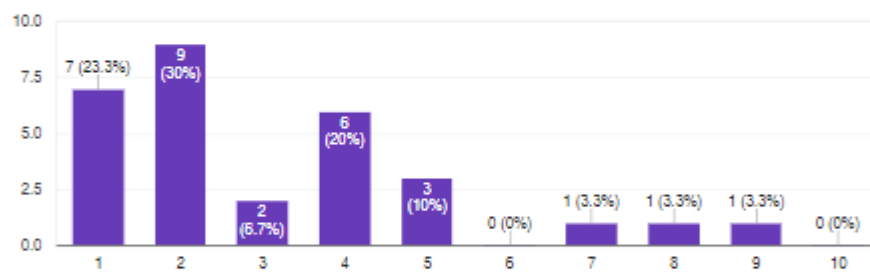
As the bench user, would you rather feel as being the observer of the space or being observed?

30 responses



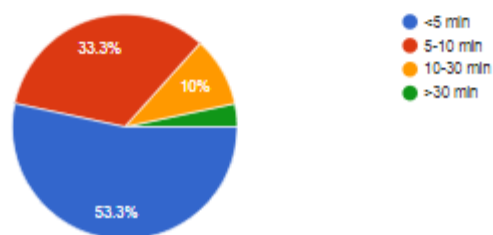
As the bench user, rate how much you would like to interact with the other bench user?

30 responses



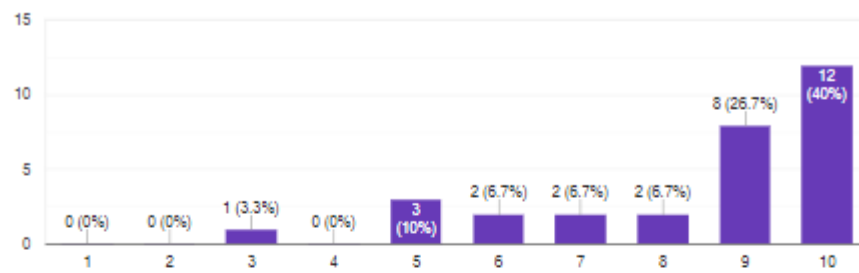
For how long would you stay on the bench with conditions presented in the picture?

30 responses



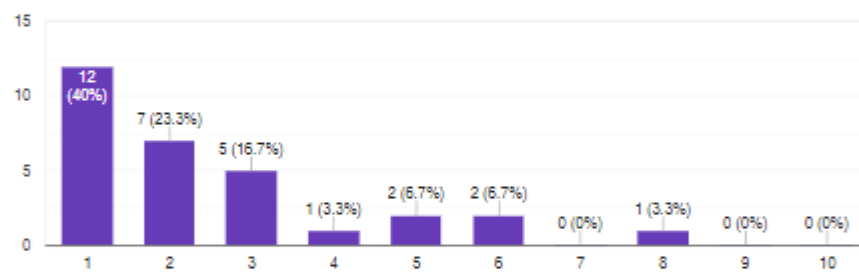
As the bench user, would you rather feel as being the observer of the space or being observed?

30 responses



As the bench user, rate how much you would like to interact with the other bench user?

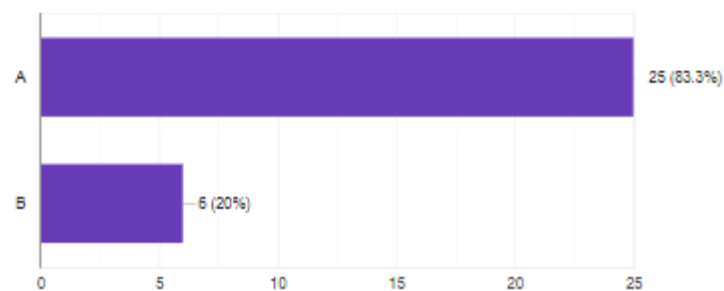
30 responses



Sum-up

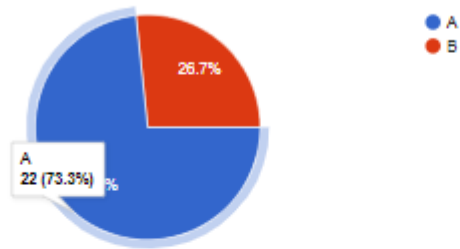
Which of the two presented scenarios (A or B) makes you feel safer?

30 responses



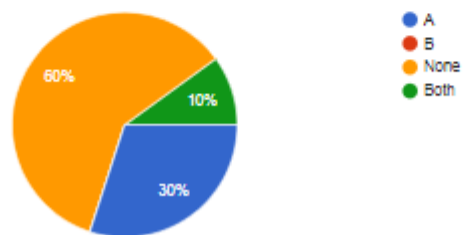
Which of the two presented scenarios (A or B) makes you feel you are invited to stay in there for longer period of time?

30 responses



Which of the two presented scenarios (A or B) encourages you to have an interaction with another users of the space?

30 responses



Appendix 6 - Online survey (responses from Test 2)

30 responses



Not accepting responses

Message for respondents

This form is no longer accepting responses

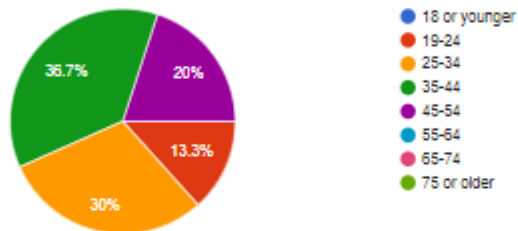
Summary

Question

Individual

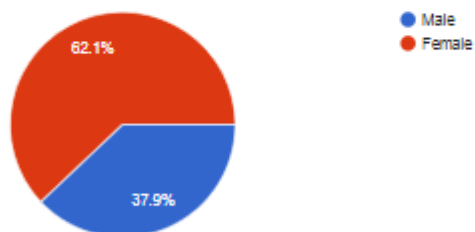
What is your age?

30 responses



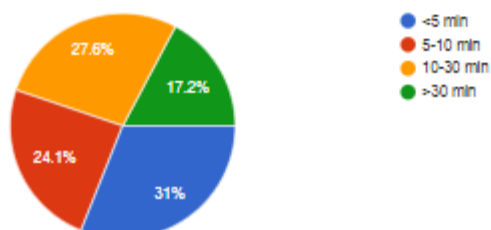
What is your sex?

29 responses



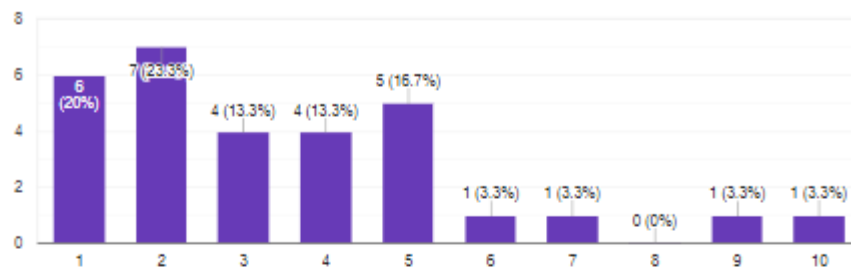
In average, for how long do you sit on a bench during the nighttime (after sunset)?

29 responses



Generally, how often do you tend to interact with other bench users (strangers) sitting next to you?

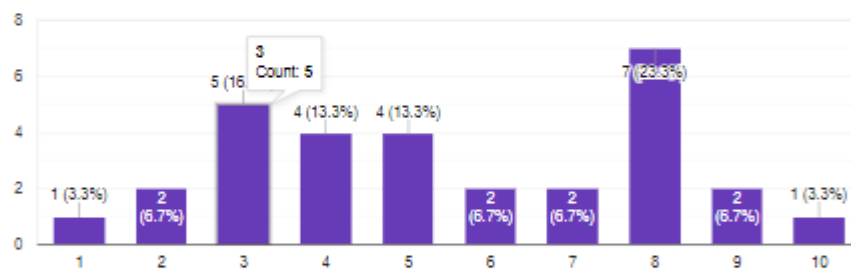
30 responses



Design proposals

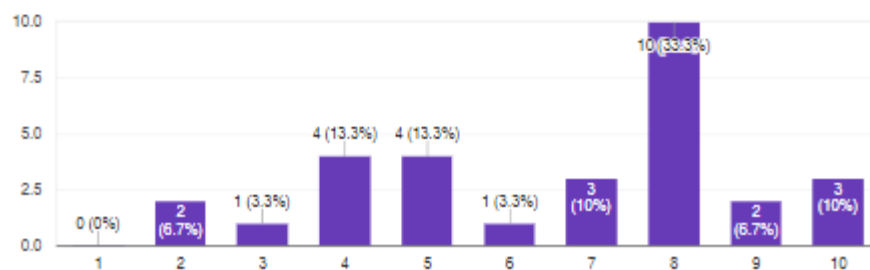
Does the space look inviting to have a break on the bench?

30 responses



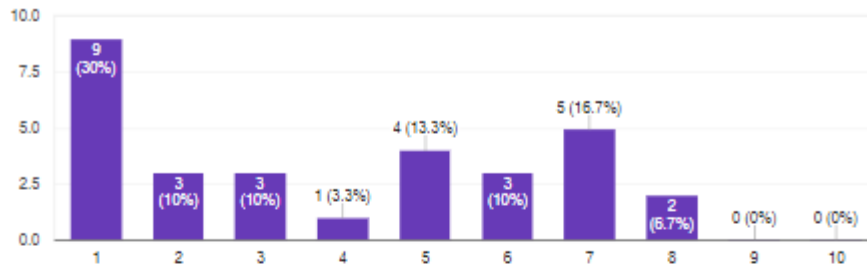
Does the space look safe to stay in it?

30 responses



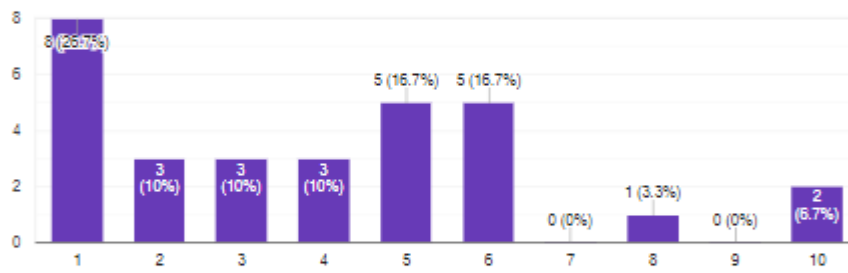
Does the space look inviting to have a break on the bench?

30 responses



Does the space look safe to stay in it?

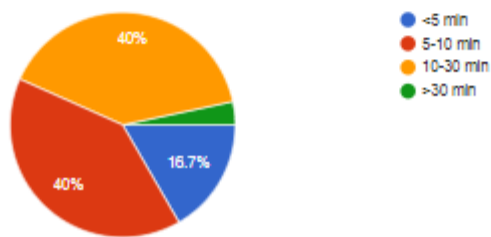
30 responses



View from the bench

For how long would you stay on the bench with conditions presented in the picture?

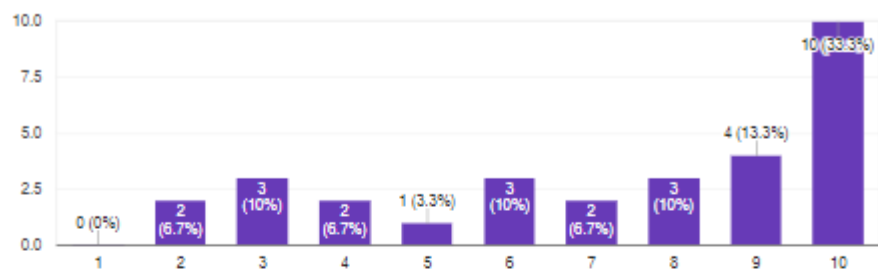
30 responses



As the bench user, would you rather feel as being the observer of the space or being observed?

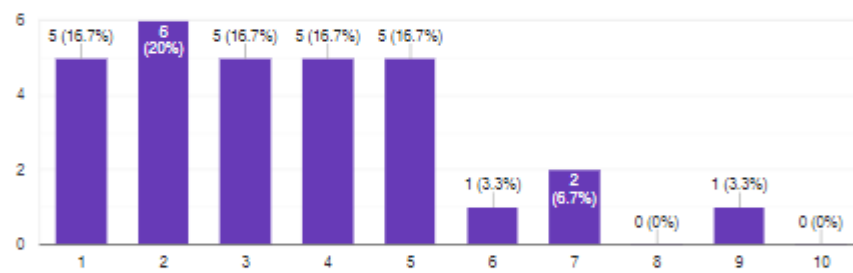


30 responses



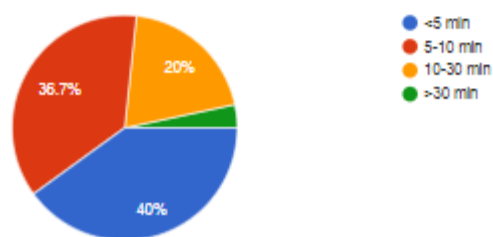
As the bench user, rate how much you would like to interact with the other bench user?

30 responses



For how long would you stay on the bench with conditions presented in the picture?

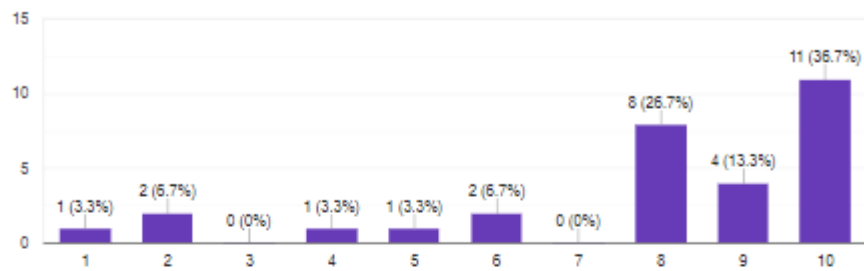
30 responses



As the bench user, would you rather feel as being the observer of the space or being observed?

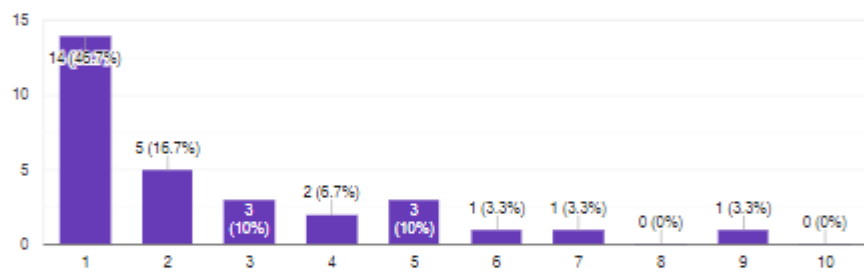


30 responses



As the bench user, rate how much you would like to interact with the other bench user?

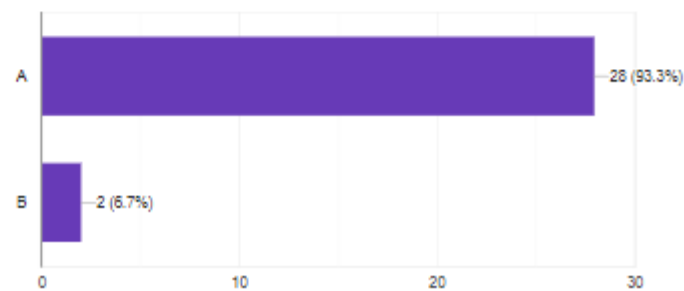
30 responses



Sum-up

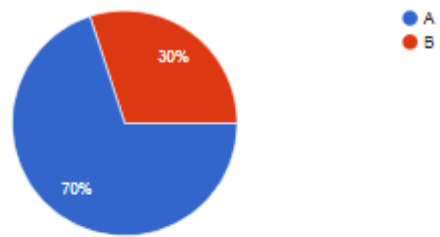
Which of the two presented scenarios (A or B) makes you feel safer?

30 responses



Which of the two presented scenarios (A or B) makes you feel you are invited to stay in there for longer period of time?

30 responses



Which of the two presented scenarios (A or B) encourages you to have an interaction with another users of the space?

30 responses

