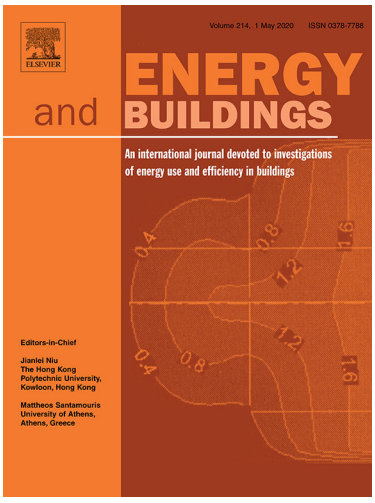

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Lighting conditions in Home Office and occupant's perception: an international study

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Abstract

The global pandemic and physical distancing restrictions are forcing us to rethink how residential buildings are used regarding the visual environment. This paper describes home office lighting conditions within different countries and continents. The aim is to define the current limitations of home offices in providing a resilient visual environment. The work was developed by a team of international experts working together on Subtask A: User perspective and requirements, in International Energy Agency IEA SHC Task 61/EBC Annex 77 "Integrated Solutions for Daylighting and Electric Lighting". The method included an international online survey in 6 countries in South America, Europe and East Asia containing 37 questions about general data, physical characteristics of the home office and occupant's perception, behaviour and needs regarding the visual environments, and photos taken by the occupants. Descriptive statistics, inspection of the photos, and qualitative analysis from the open-ended question were performed. In total, 694 responses and 453 photos were analysed, making it possible to identify the occupants' perceptions about the lighting and visual environment in the home offices both for professionals and students. The results indicate cultural differences in styles of residential buildings and interiors, in the custom of using lighting, and between continents and occupational categories. Possible improvements are suggested.

Keywords: Home office; lighting; visual environment; survey

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1. Introduction

A measure to mitigate the spread of the Sars-CoV-2 virus that causes the COVID-19 disease during the first year of the pandemic was to stay at home. Thus, working and studying activities have migrated to dwellings, under the so-called home office scheme. In this context, exploring the lighting conditions in home offices from the occupant's perspective is essential for understanding the quality of the perceived visual environment. According to Chen et al. [1] and the WHO [2], circa 30% of the world population was forced to stay in lockdown, and 80% of workplaces were partially or entirely closed. Consequently, dwellings have reinforced the role of the most used indoor environment, expanding the kind of activities performed there, including more work tasks. As a response to the pandemic measures, the home office scheme has been adopted by most people, transferring the workplace to home.

In this crisis scenario, in which the broad public health strategy has been based on the concept of "homeworking"; i.e. "remote work relying on the use of information and communication technologies (ICTs)", daily life has been turned into "homeworking" as a sub-type based on the location in which work is carried out [3]. Homeworking has expanded and is often introduced without adequate planning and training. Recently, surveys have been designed and submitted to several users to provoke a discussion on homeworking, mainly involving professionals and students as direct players in this trending working arrangement; these studies mostly investigated the effects of housing built environment characteristics on mental health during the COVID-19 lockdowns.

During the summer of 2020, shortly after lockdowns were introduced, an international survey commissioned by the Royal Institute of British Architects [4] acquired feedback from 1,500 homeowners, aged 24 to 64, from across the UK, to investigate the impact of the coronavirus pandemic on how people want to live and work at home. About 70% of survey respondents agreed that the design of their home had affected their mental wellbeing during the pandemic: spending more time in their current home had made people more stressed (11%) anxious (10%) and depressed (10%). They found it was harder to relax (9%) and it has negatively impacted their productivity (6%). Some of the outcomes of the survey help us to imagine how the future home could be designed: the reconfiguration of existing spaces with a home extension, change of the open-plan design to create separate rooms, enhancement of environmental-design features improving the amount of natural daylight/energy-efficiency/soundproofing, more living flexibility, easily divided rooms, creation of office space and more personal space.

A second survey provided data for an exploratory analysis of the situation of a Spanish residential park and the resilience demonstrated in the pandemic period by both households and their usual dwellings [5]; the method combined quantitative and qualitative approaches, which resulted in obtaining more than 1800 surveys and 785 qualitative responses, based on data collected from 30 April 2020 to 22 June 2020. The observed dwellings, with floor spaces between 61–90 m2 where households of between 2 and 3 or more members lived, were predominantly located in an urban context. The overall analysis pointed out the lack of space for the continuous presence of other family members; regarding the quality of the spaces, the aspects least pleasant to endure were the small, narrow, untidy, poorly lit, or uncomfortable spaces. Furthermore, the needs for the improvements that should be made to the dwelling were mainly related to the building design and envelope.

A third large, web-based survey was conducted from 1 April 2020 to 1 May 2020 with 8177 students from a university institute in Milan, Northern Italy, one of the regions most heavily hit by the pandemic in Europe [6]; the analysis showed a positive association between poor housing and increased risk of depressive symptoms during the COVID-19 lockdown. The individuals with moderate-severe and severe depressive symptoms very often lived in apartments with insufficient space (60 m^2), with an unusable balcony, poor quality of the indoor area and a poor-quality view from the apartment.

All of the surveys considered have revealed a strong association between poor or bad quality housing and its services or equipment, with a more negative spatial perception, and even greater potential for the development or worsening of mental health, and vice versa.

1.1 Background: a visual environment in Home Offices

The multiple benefits of adequate lighting and daylighting exposure have been highlighted in the last few years specially since the beginning of 2000, when nonvisual impacts of light were clearly defined [7–11]. However, the current health crises have increased interest in such matters since March 2020, when the Covid-19 pandemic became serious and lockdown measures were necessary in many countries. Lighting conditions, in general, influence the circadian cycle and the occupants' wellbeing through windows [12,13] and access to an external view [14–16].

The combination of daylight and electric light affect surface colours and light distribution, creating shadows and patterns that are visually attractive and support human wellbeing [17,18]. External view access is also essential to the health of the eyes, as an interesting view can motivate workers to frequently refocus their eyes, in order to maintain muscle tone and lubrification, preventing

problems such as dry eyes and eye strain [12]. Residential lighting has for a long time been associated with bringing a sense of comfort and protection [19]. However, under the present scenario, occupants must adapt the spatial configurations in their homes, as they require specific lighting conditions to perform a wide range of visual tasks. The pandemic-related conditions may lead to rethinking how housing is traditionally perceived and designed. The situation may convey a broader understanding of the needs of the future building's occupants.

The effects of the COVID-19 lockdown on the sleep and rest-activity rhythms have been newly studied and published [20] ~~and~~[21]. Practical recommendations were also developed [22]. The view out of the window in the context of pandemic lockdown was also studied [23]. Still, little is known about lighting conditions in these new improvised workplaces, called home offices.

Because people spend much time indoors, there has been a growing number of studies on how indoor environmental quality (IEQ) affects human health and quality of life. In particular, the window is one of the crucial indoor architectural factors affecting the mental health of occupants, as it changes the IEQ [24].

Narayanamurthy and Tortorella [25] mention that the spread of COVID-19 triggered interventions by organisations to contain its impact on the professionals' performance. The authors state that increased stress and inadequate infrastructure, among others, are some of the factors that can negatively impact work performance [25]. Lighting, in this case, may be a potential element for comfort or stress within the visual environment in home offices.

Another important aspect regarding home offices that can be further explored is related to energy consumption. Occupancy in residential buildings is a crucial factor influencing energy consumption, with an even more significant effect in commercial buildings [26]. Cultural practices in different countries, environmental awareness and individual preferences are known factors that can affect behaviour in terms of lighting use [27].

Considering the pandemic emergency, Aslanoğlu and Pracki et al. [28] performed a short-term analysis on people's assessments on residential lighting. They focussed on the day- and electric lighting systems in the living rooms of residential buildings, using an internet-based survey in July–August 2020, which was answered by 60 participants across Poland, Turkey, the UK and Sweden. Several interconnected factors related to residential lighting were explored, showing that the amount and uniformity of lighting were the most effective cues connected with the respondents' satisfaction [28]. The authors mention some results regarding the physical characteristics of home-offices: most of the living areas were south oriented, with one or two windows, and an unobstructed view-out. Floor area was 10–20 m^2 and 3 m high, with ceilings and walls in shades of white and floors in saturated

brown. Curtains were primarily used in living areas in Poland, the UK and Sweden. Thus, blinds in Turkey were used for privacy and to prevent direct sunlight. Regarding electric light, LED lamps were mainly used in ceiling light fixtures. Portable fittings also supported interior illumination. The amount of electric lighting was very satisfactory in the respondents' living areas, as the distribution and colour rendering were scored highly [28].

Continuing this research, Aslanoğlu and Kasaki et al. [29] conducted a more extensive international survey on residential lighting in the same countries to provide an overall perspective for raising the standards of luminous environments. In this second study, a total of 500 participants provided detailed self-assessments of the lighting conditions in their living areas. The study identified interrelated factors associated with residential lighting using descriptive statistics, correlation coefficient functions and thematic analysis. As the results reveal, the satisfaction with daylighting quality depends on daylighting sufficiency, daylighting uniformity, and the number of sunlight hours, view-out and ratio of windows in the living area. Thus, satisfaction with electric lighting quality depends on electric lighting sufficiency, electric lighting uniformity, electric lighting brightness, and electric lighting colour rendering index. The study's findings exposed the potential factors that can be used to change the daylighting and electric lighting effectively in residential areas, leading to a sustainable and better lighting environment [29]. This study is limited to living rooms, assumed to be used as home-offices in all situations, which can be quite different in some cases.

In this context, this article presents the part of a home office survey aiming to understand lighting conditions for professionals and students in home offices in different countries and continents, meaning to create foundations for future research towards the design of buildings accommodating occupants' perceptions and needs.

1.2 Study Motivation and Objectives

The global pandemic and social distancing restrictions are forcing us to rethink how residential buildings are used regarding the visual environment. An international effort was made due to the emergency need of using home offices during the pandemic period of Covid-19, in which the home office became a typical situation of work. A better understanding of the occupants' perception of lighting can assist in reviewing how people arrange and use the space. The primary research question inquires: How do occupants perceive the lighting conditions in their home offices during the pandemic of Covid-19, and do their perceptions vary by country and occupational profile? Thus, the objective of this paper is to define the current limitations of a home office in providing a resilient

visual environment, that is, a condition that facilitates a preferable and comfortable visual environment with daylight, electric light and/or both. The specific objectives have been identified as:

- Identifying lighting conditions in home offices in different continents;
- Identifying occupants' (two categories of occupation: students and professionals) perception of their home office;

One hypothesis is that an international study will reveal cultural and climatic differences that influence space arrangements and lighting perception on different continents. Another is that there are significant differences between students and professionals as those two categories have different socio-economic conditions.

This paper has been developed in the scope of IEA SHC Task 61/EBC Annex 77 "Integrated Solutions for Daylighting and Electric Lighting" [30].

2. Method

The study used a direct online survey as the primary method. Carpino et al. [31] mention that questionnaires are mainly employed as a tool for investigations about occupants' behaviour and energy consumption in residential buildings or other purposes. In 80% of the selected studies, the questionnaire is used as the tool for data collection, sometimes coupled with other techniques, such as field measurements and time use surveys. In over 80% of the cases, the collected data are subjected to statistical processing [31].

The survey was developed in September–November, partially inspired by the online survey on work at home in Norway [32], and distributed from December 2020 to March 2021 through the Google Survey tool across South America (Brazil and Colombia), Europe (Italy, Denmark and Poland) and East Asia (Japan), in the native languages of each country. The survey was distributed across Japan as a representative country of East Asia, without implying that it is, on its own, East Asia. Occupants' subjective assessments were collected. Google Forms was used to implement the survey, while its dissemination, among professionals and students from each country, was done by diverse social media platforms – Mailing lists, LinkedIn, ResearchGate, Facebook, and Instagram. In order to confirm similar situations in the participating countries, Appendix 1 present the lockdown measures during the survey period.

2.1. Participants

694 participants answered the survey, with more than 50 professionals or 50 students representing each continent. In East Asia, only Japanese students took part of the survey. Table 1

summarises the number of participants by continent, country and category (professional or student). Most of the students were from Italy and Poland, with lower numbers from Colombia and Japan.

Table 1 – Summary of number of participants by category and country/continent

By Country				By Continent			
Country	Professionals	Students	Subtotal	Continent	Professionals	Students	Subtotal
Brazil	97 (41.1%)	93 (20.3%)	190 (27.4%)	South America	162 (68.8%)	149 (32.5%)	311 (44.8%)
Colombia	65 (27.5%)	56 (12.2%)	121 (17.4%)				
Italy	15 (6.4%)	138 (30.1%)	153 (22.0%)	Europe	74 (31.4%)	248 (54.1%)	322 (46.4%)
Poland	28 (11.9%)	110 (24.0%)	138 (19.9%)				
Denmark	31 (13.1%)	-	31 (4.5%)				
Japan	-	61 (13.3%)	61 (8.8%)	East Asia	-	61 (13.3%)	61 (8.8%)
Total	236 (100%)	458 (100%)	694 (100%)	Total	236 (100%)	458 (100%)	694 (100%)

Even though the participant's location does not reflect their nationality, especially for participants in Europe – where we found more participants from other continents – in this paper, we use the terms East Asians, Europeans and South Americans when discussing the answers by continent. The gender distribution was similar among the European and South American participants. In the group of professionals, female participation was rather high (58%) and among students even higher: 69.8% of Europeans, and 63.1% of South Americans were female. On the other hand, only 21% of East Asians answered to being female (Figure 1, Q3).

Regarding age, most participants were young – below 40 years old (66%). Europe had a higher percentage of younger professionals (43% were between 21 and 30 years old) than South America. East Asia had a high percentage of very young students, between 10 and 20 years old (57.38%). While, in Europe and South America most were between 21 and 30 years old. East Asian students were predominantly male and younger compared with European and South American participants, where the gender distribution was similar. In the group of professionals, the female participation was high (58%). Between students, higher: 69.8% of Europeans, and 63.1% of South Americans were female; but between East Asian students, only 43% (Figure 1, Q3).

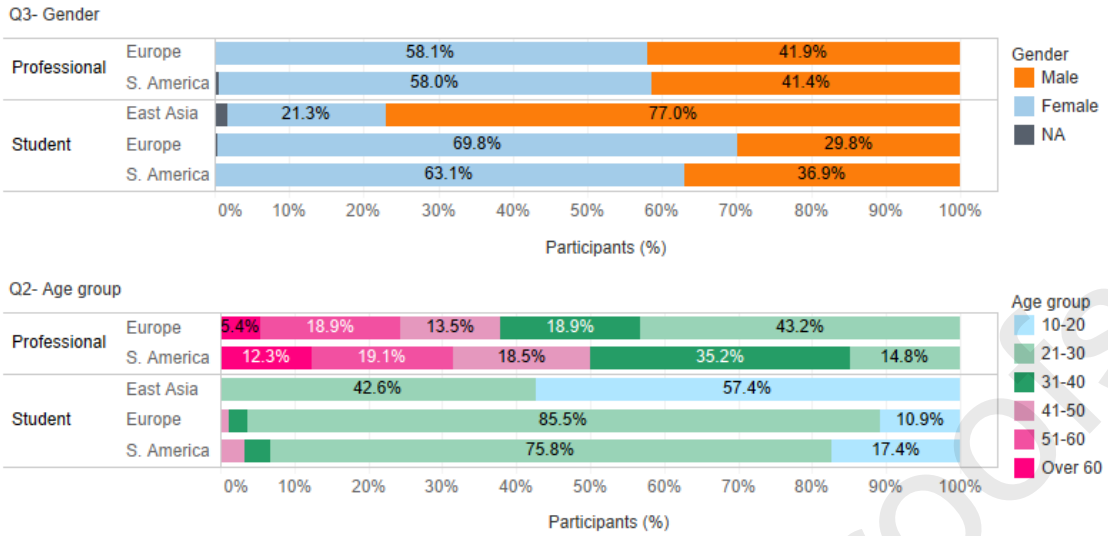

Figure 1 – Description of participants' gender and age group

Most participants worked or studied in public institutions (69%). Among professionals, 43% worked in public companies, 42% in private companies and 15% were self-employed. South American participants had higher self-employment (17.9%). Most of the students were studying at public universities (85%). All East Asian students were studying in a public institution (Figure 2, Q5).

The study has a distinct sample of participants: the majority of the students were from faculties related to the built environment sector, while the majority of the professionals are employees and teachers from universities, but also professionals from the built environment and lighting sectors. It narrows down the pool of responders significantly. Most of the professionals stated their jobs could be summarised by office tasks (58.7%) or educational activities (29%). Arts, industry and research were other mentioned activities (Figure 2, Q6). Most of the Europeans' work related mainly to office tasks (67.57%), as for half of the South Americans. 36.4% of South Americans and 21.6% of Europeans were employed within the education sector.

The time in the institution for 53% of professionals was between 1 and 5 years. In Europe, the respondents were many newly employed – less than one year (31%).

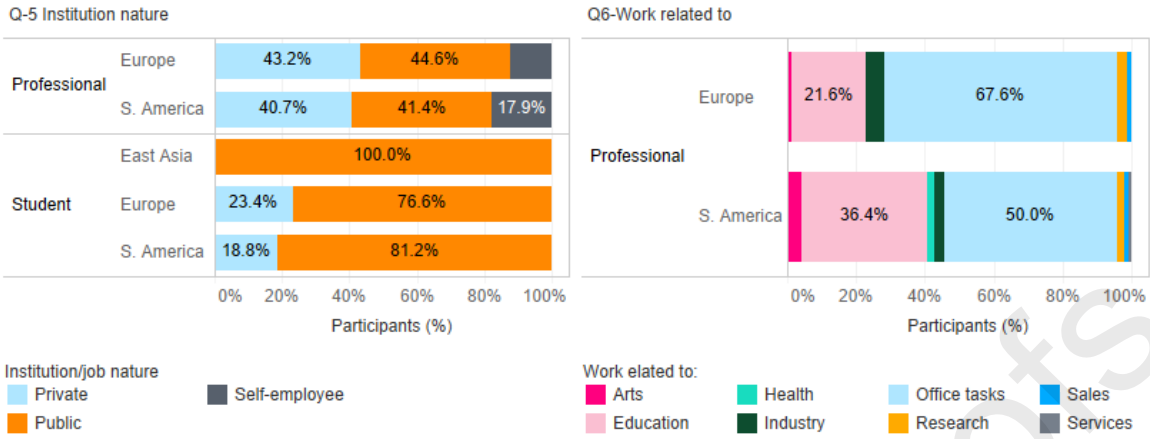

Figure 2 – Nature of the working/educational institution and work activities (only for professionals)

2.2. Survey description

The survey was divided into six sections, namely: "General Information", "Lighting Condition in the whole Home Office now", "Lighting Condition in the Home Office room now", "Picture of the Home Office", "Employment Information" and "Description of the Home Office". With 37 questions answered by professionals and 34 by students, the survey takes about 7–8 minutes [33]. Figure 3 shows the survey's structure and its six sections. The complete questionnaire can be found in Appendix 2. Each section provided information about at least one of the following main themes: personal data, spatial or physical features of the room, satisfaction with lighting, perception of lighting and occupants' behaviour and needs (coloured boxes).

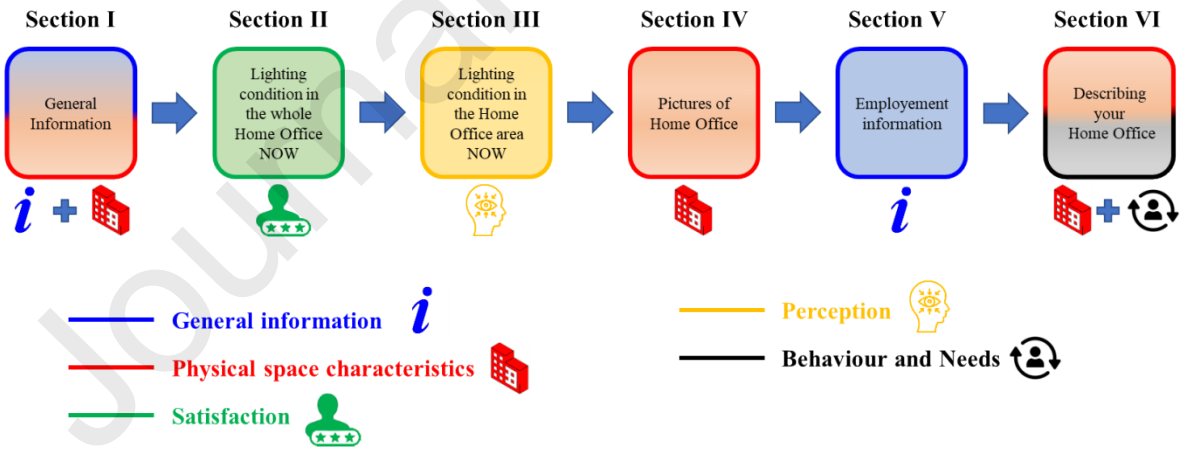

Figure 3 – Survey's structure and sections

In Section I, "General Information", the participants answered questions about their personal characteristics – gender, sex, age group, city of residence, profession, job tasks, and employment

nature. This section had also a question about the location of the home office space in the house/apartment.

Section II, "Lighting Condition in the whole Home Office room now" contained four questions related to satisfaction with daylighting and electric lighting during the survey period.

1. Satisfaction with daylight? (if no window, do not answer this question)
[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

2. Satisfaction with external view from window? (if no window, do not answer this question)
[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

3. Satisfaction with electrical lighting? (if no electric light, you mark no relevant
[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

4. Satisfaction with the general light level in the room?
[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

Section III, "Lighting condition in the home office area now", contained six questions for assessing the perception of the visual environment in terms of lighting levels and distribution, presence of glare, shadows and reflections, rendering, and colour appearance. An excerpt from section III is presented in Figure 4.

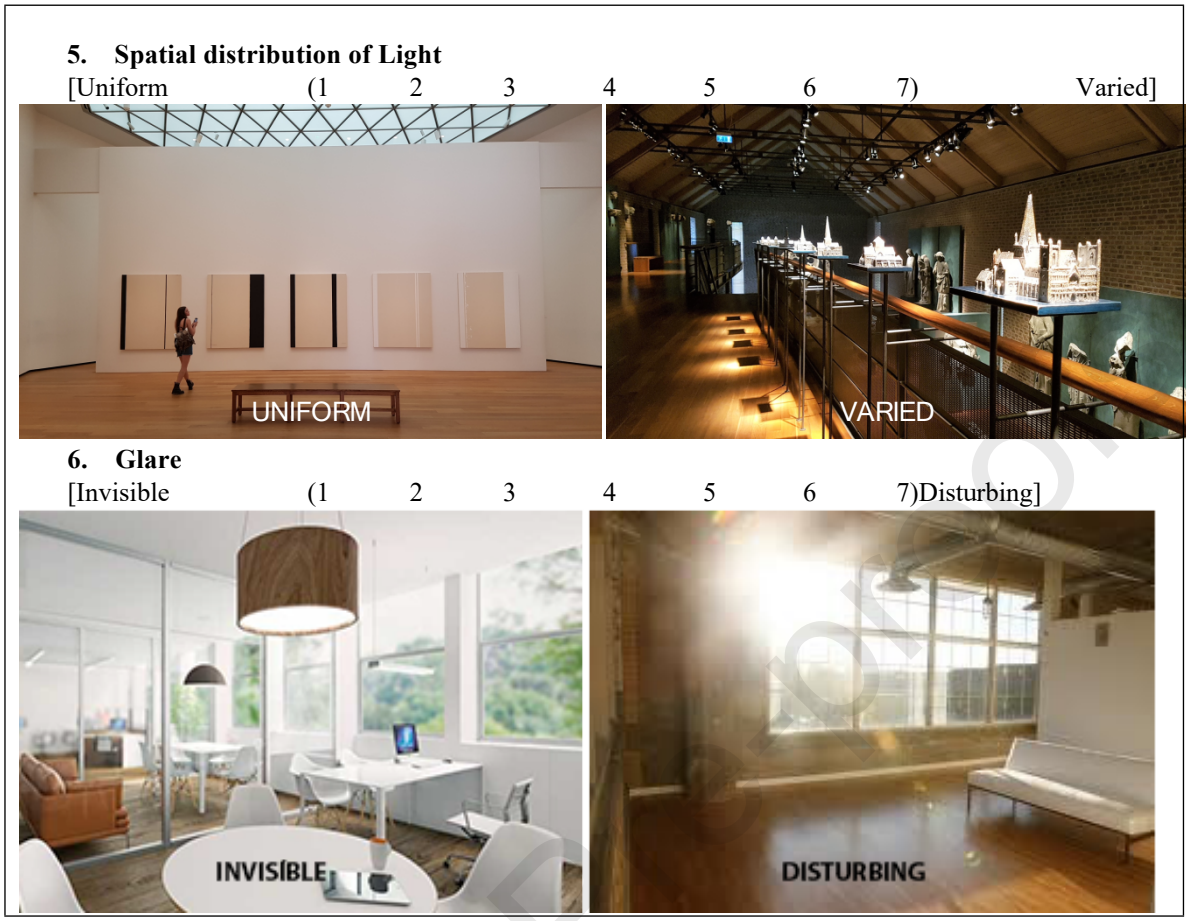

Figure 4- Images from Section 3 of the survey

Those lighting quality descriptors were proposed initially by Liljefors [34] and developed further into PERCIFAL (*Perceptual Analysis of Colour and Light*), a method of visual evaluation of space and light by Klaren et al. [35], and are in good agreement with the lighting quality descriptors found in the light-technical literature and summarised by van Bommel [36]. For those questions, semantic differential scales were used. Each question had images illustrating the evaluated aspect to ensure the participants' understanding of these concepts. Satisfaction assessments in Sections II and III were made through 7-point Likert scales representing "ratings" where higher numbers represent higher satisfaction.

Section IV, "Pictures of Home Office", included two pictures (photos) of the home office taken by each participant using a mobile phone camera at the time of the survey. The primary motivation for adding participant photography to the research method was the expectation of obtaining more information. Findings in recent literature show that adding participant-produced photographs or videos to the research studies has multiple benefits in knowledge production, from

both the researcher and participant perspectives [37–39]. The photos may considerably enrich the data by showing details and features of the environment that otherwise have to be omitted as the length of the survey has to be restricted to avoid bothering participants too much, and to avoid participation rejection. The participants were requested to take two pictures with their cell phone, without HDR mode, following these instructions (Figure 5), as follows:

- Picture 1: Take a photo from your typical sitting working position towards the window;
- Picture 2: Please, stand up and take one big step backwards (you will be about one metre from the worktable), then take a photo of your home office.

For this article, the window external view quality is evaluated using picture 1, while picture 2 showed any problems in the visual environment of the home office.

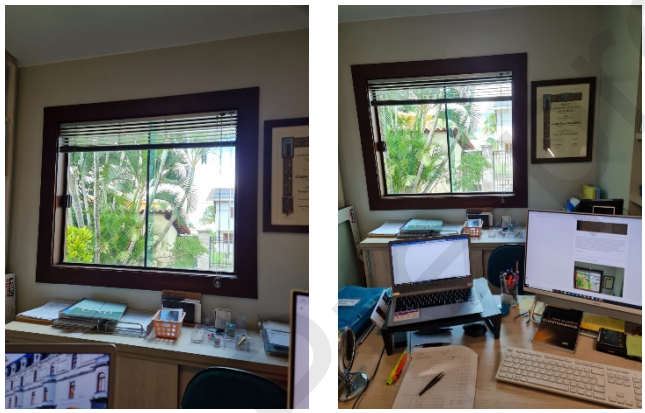

Figure 5 – Example of picture 1 (left) and picture 2 (right)

Section V, "Job and Education Information", includes additional information on the length of employment or studying time. Finally, in Section VI – "Description of the Home Office" – the participants were asked to describe their home office routine. The section contained 13 multiple-choice questions about the home office activities and duration and the features of the room, such as lighting fixtures and window shading devices. The last open-ended question inquired about the possible improvements of the visual environment if the respondents were to continue to use the home office. This section provided inputs about the occupants' behaviours and needs/wants. In this study, we approached the occupants' behaviour as the standard actions, especially regarding electric lighting and the occupants' needs as what they would like to do to improve the visual environment.

2.3. Data analysis

This section describes the methods, procedures and tools used in the data analysis, presented in Table 2 and described in detail in the next sections.

Table 2. Methods, procedures and tools for Data Analysis

DATA ANALYSIS			
METHODS	PROCEDURES	TOOLS	REFERENCES
Content analyses: descriptive statistics	Histograms with cumulative values (%); Median and IQR	Tableau Desktop software	Vaismoradi, M. et al. (2013) [40]
Thematic analysis (open-ended question)	1. Pre-analysis, 2. Exploration of the material, 3. Treatment and interpretation	Nvivo software	Pecheux (1997) [41] Oliveira et al, [42] Bardin (1977) [43] Braun, V. & Clarke, V. (2006) [44]
Inspection of photos	Visual inspection: Picture 1 - window external view quality (layers, sky visibility), Picture 2 - problems of visual environment (internal dark areas, contrasts, glare)	Image visualisation software	EN 17037 [45], Lighting handbooks [19,46][39], [48], [49], architecture manuals [47]

2.3.1. Content Analyses (descriptive statistics)

The majority of the survey was designed to collect data about home offices, with the questions designed based on the previous knowledge in the field of lighting including user needs/wants and behaviour in relation to lighting. Here, we followed the principles of data-driven content analysis (CA) [40]. For the questions in sections I, II, III and V, the participants' answers were organised into Excel spreadsheets. Histograms with a cumulative count of participants and answers (in the case multiple-choice questions) and mediaan and IQR (for summarising answers of light descriptors) are presented in order to report i) participants' characteristics and home office routine; ii) features of the home office area; iii) participants' satisfaction, preferences and behaviour. Results are reported by continent and split into the two main occupational profiles of the participants (students and professionals). Descriptive statistics such as median and IQR were obtained using R [47].Tableau Desktop software [48] was used for data graphical exploration.

2.3.2. Thematic Analysis (open-ended question)

Needs or wants are identified with the open-ended question. For this single question, we performed a thematic analysis (TA) [44]. Thematic analysis is a method used to identify, analyse and report patterns (themes) in the data. It minimally organises and describes the dataset in detail. However, it often goes beyond this and interprets various aspects of the research topic [49]. The thematic analysis involves searching a set of data to find repeated patterns of meaning, enumerating the occurrence of the same linguistic sign (word) that is repeated frequently, aiming to verify "the

pure existence of such or such linguistic material" [41]. Therefore, the main themes and sub-themes found in the open answer of the questionnaire were identified through keywords with the same meaning.

Nvivo software was used to analyse unstructured and qualitative open-question data about what people would like to improve in the visual environment if they continued in the home office layout. The main functions of the Nvivo software that were used were:

- Organisation and classification of data;
- Encoding;
- Link ideas, themes and information;
- Visualisation of patterns and connections through the creation of graphics, frequencies and distributions of words in word clouds.

The thematic analysis was divided into three parts as suggested by Bardin [43]: (1) pre-analysis, (2) exploration of the material, and (3) treatment and interpretation.

In the pre-analysis, the open answers were selected and inserted by defined groups, by countries and by occupation (students and professionals). A first hypothesis of themes was launched, still not based on the software. The themes must follow the requirements as suggested by Bardin [43]: they must be comprehensive – allowing all material to be classified; homogeneous – attending to a principle; exclusionary – belong to only one theme; relevant –related to the topic under study; productive – allowing inferences; and objective – ensuring that the same result can be achieved by different people.

The second part – exploration- consisted of exploring the material, selecting the counting rules and defining more precisely the themes. The software is pre-set to display the 1000 most frequent words. However, this analysis was set to display the 35 most frequent words, based on the number of significant responses from the different groups. The Japanese response group had the smallest amount, so the cutoff number was determined based on the number of responses found and applied to all others. The original language of the survey was English as it was the working language of the Task 61 project. The survey was then translated into the native language of each participating country. The procedure was that a lighting expert translated from English to her/his native language, and this translation was double-checked. The responses of the open-ended questions were translated again, from the native language to English, by the same lighting experts, always referring to the terms agreed during the survey elaboration. The procedures were carefully designed and discussed during the results processing to ensure the best results. After translation, the sample representativeness and the significant responses were verified to delimit the number of words displayed in the software. The

cut-off threshold of words with a minimum number of four letters was applied to the same language (English) so that connective words can be disregarded. Finally, a grouping that includes words with the exact origin was made (such as "talk" and "talking") [43]. The third part consisted of treatment and interpretation. At this stage, the results of the most frequent words were analysed and the final Themes and Sub-themes defined. The more times the word appears in the texts, the greater its size, and the more frequent it is. The purpose of this step was to illustrate the distribution, making it easier to visualise and interpretate the data. The result is a summary table with the words and their count and weighted percentages (Appendix 3 and 4), generating Themes and Sub-themes. There is also a word cloud to illustrate this result. The themes and sub-themes allowed us to identify needs or wants of respondents.

2.3.3. Inspection of photos

Analysis of the window external view quality

Analysis of the window external view quality is done with the inspection of photos. EN 17037 [45] presents a method for assessing the quality of the external view from a window based on the width of view (window width), the outside distance of view, the composition of the view (i.e., number of layers as the sky, cityscape/landscape and ground) and the quality of the environmental information of the view. This article has presented the window view picture quality (Picture 1) based on the layer composition and sky visibility. The photos, as explained above, were taken by the respondents, and the observation (inspection) of the photos was performed by the lighting experts of Task 61. For the analysis of the window view quality, we used Picture 1, and the inspection allowed us to identify how many layers are visible from the occupant's sitting position and if the sky is visible. The analysis was only performed on those photos with visible outdoors (i.e., pictures in which it was possible to distinguish those features).

Identifying problems in the visual environment of the home office

Simultaneous use of answers and photos makes it possible to better identify the lighting conditions, which is the first objective of the article. In the scope of this work, Picture 2 was used as a supporting information source concerning the survey answers for identifying problems that may occur in the visual environment of the home office. The identified problems of the visual environment (dark areas, contrasts, glare and so on) were referenced against practical solutions found in design

handbooks such as Architects' Data by Neufert [50], lighting handbooks [19,51] and Code for Lighting [52] (Table 2).

Due to the Japanese General Data Protection Regulation (GDPR), students from this country did not provide photo information. Therefore, the picture analysis was only performed for South America and Europe.

3. Results and Discussions

In this section, results and discussions are presented, organised according with the survey's structure and the research questions.

3.1 General Information: Home office routine

The **home office routine** was described according to the number of days/week working or studying from home, the duration of the workday (part-time day, shorter, longer or the same as before) and the typical working time (typical working hours, starting earlier, finishing later than before). The routine was noticeably different between the groups of professionals and students. Most professionals worked five days/week: 51.4% in Europe and 59.3% in S. America. Many students reported working between 5 and 7 days/week: 77.1% in East Asia, 86.7% in Europe, 89.9% in S. America (Figure 6, Q24).

Reinforcing this idea, most East Asian students mentioned that **they were studying more than before** (91.8%), as with South American students (68.5%). While European students seemed to have a more balanced studying day: 41.2% mentioned studying more than before. Most South American professionals also reported that they **worked more than before** (53.1%), while most Europeans reported they had a full working day, as before (59.5%) (Figure 6, Q25).

As for the working time, many European and South American professionals worked the same, typical working hours as before the pandemic (47.3% and 38.9%, respectively). A similar percentage of professionals worked late in the evening (40.5% in Europe and 38.3% in South America). Most students (more than 50%) were studying late in the evening, while some of them kept the typical studying hours – mainly East Asian students (38.3%) (Figure 6, Q26). The time extension for studying during the night can lead to more use of electric light than before the pandemic.

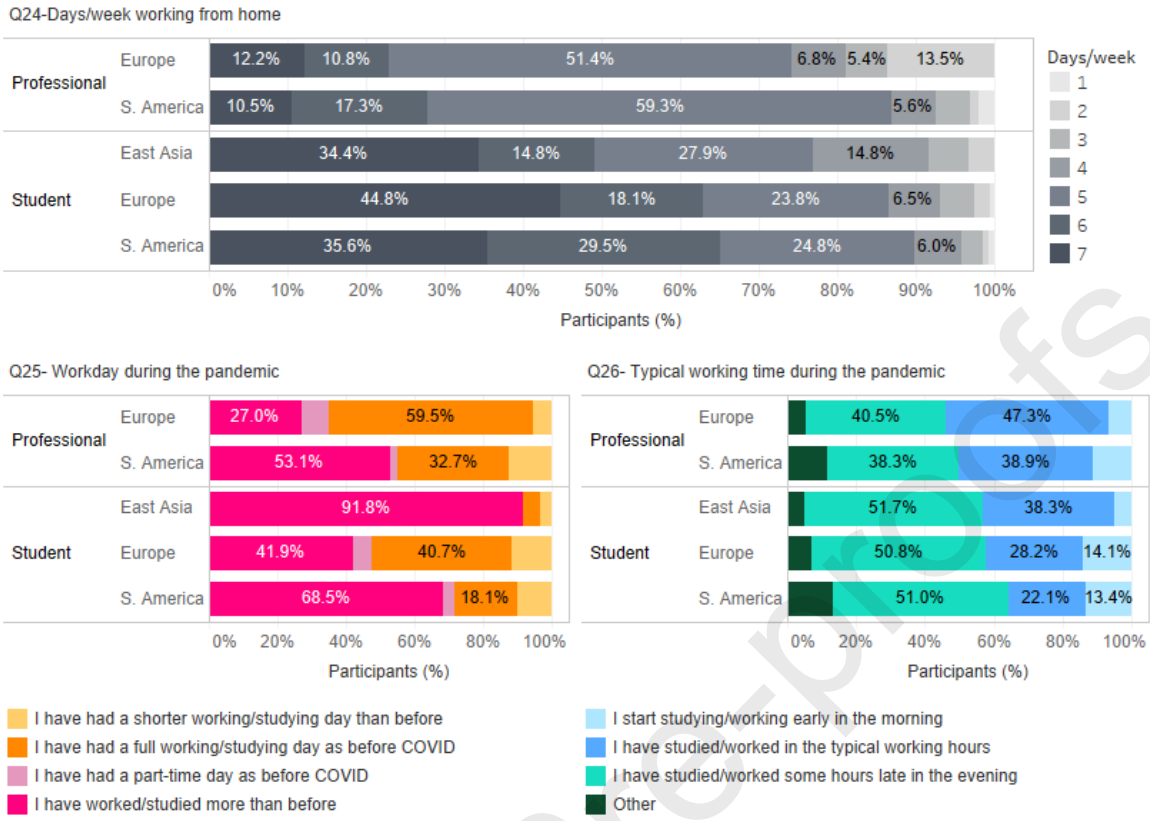

Figure 6 – Home office routine

It was hypothesised that the home office's main possible tasks would be reading and writing (on digital media, paper or both), virtual meetings or online classes, video recording and talking on the phone. Overall, both students and professionals reported a similar variety of tasks (Figure 7). Reading and writing on digital media was the most common visual task (average 29.7%), followed by participation in digital meetings/classes (average 28.2%). Professionals were not engaged in as many paper-based reading and writing tasks (11.4% for Europeans and 13.3% for South Americans) as students (23.8% for South Americans and 34.6% for Europeans).

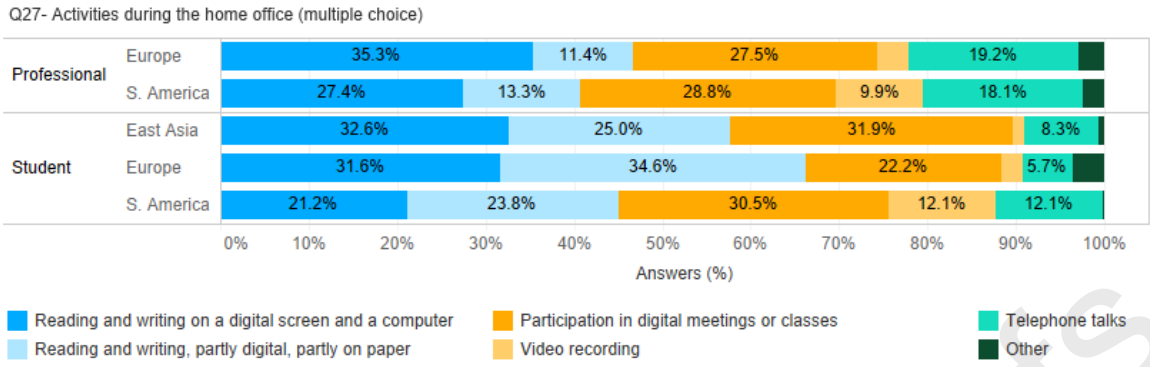

Figure 7 – Activities carried out in the home office

3.2 Physical space characteristics: Features of the home office

Participants were asked where in the dwelling the home office activities were carried out. Three possible scenarios were given: having an entire room for the home office, using one of the rooms that was usually intended for other activities (dining, living or bedroom, for instance) or sharing a table/desk with others in one of those non-exclusive rooms – which was the worst condition given (Figure 8, Q10). Room-sharing could affect the degree of independence and privacy, which could influence satisfaction. Few participants were working or studying under the last described scenario.

In contrast to the students, most of the professionals had a whole room for the home office (51.85% of South Americans and 42.59% of Europeans), while a slightly higher number of European professionals (50%) were using a non-exclusive room. For the students, the more common situation was to use a room designed for other activities (70.49% East Asian, 59.27% Europe and 72.48% SA). Only 32.7% of the European students had an entire room for studying at home, which is a slightly better situation compared to the 14.77% of South American students who needed to use a shared table.

For characterising the **window's orientation** in the home office room, the three main orientations were: North, South and West. Intermediate orientations such as Northeast and Northwest were grouped into the North orientation. The same grouping was done in the South orientation, which included Southeast and Southwest (Figure 8, Q29).

The predominant window orientations were South/Southeast/Southwest (average 31.2%) and North/Northeast/Northwest (average 30.5%). Fewer participants had windows facing the East (average 19%) and the West (average 18.4%). Most professionals in Europe and South America had their home offices with North/Northeast/Northwest oriented façades (37.8% and 30.2%, respectively). Most students from East Asia and Europe had the home office window towards the South/Southeast/Southwest orientation (39.3% and 35.1%, respectively), while slightly more South

American students had North/Northeast/Northwest-oriented windows (30.2%). Indoor working environments with North- and South-oriented façades made it easier to control the internal solar radiation . In this regard, most students in those latitudes seemed to have better conditions than the professionals. On the other hand, the lower latitudes of Colombian cities and cities in Northern Brazil has a small effect on the daylight availability through the year, and the need for controlling glare and thermal gains are lower in those orientations as compared to East and West façades.

The participants were asked about the distance between the home office desk/table and the window (Figure 8, Q31). Overall, most participants (98.7%) were less than 3 m away from the window, only 7.8% were more than 3 m away, and 1.3% did not have a window in the space where they were working or studying. The most common distance range among both professionals and students was between 1 m to 2 m (43.4%). While around 30% of European and South American participants were very close to the window (less than 1 m). The same proportion of East Asian students were located between 2 m to 3 m away from it. Since habitable rooms of Japanese apartments commonly had a balcony with a large double sliding window, a desk or a table was usually placed away from the window.

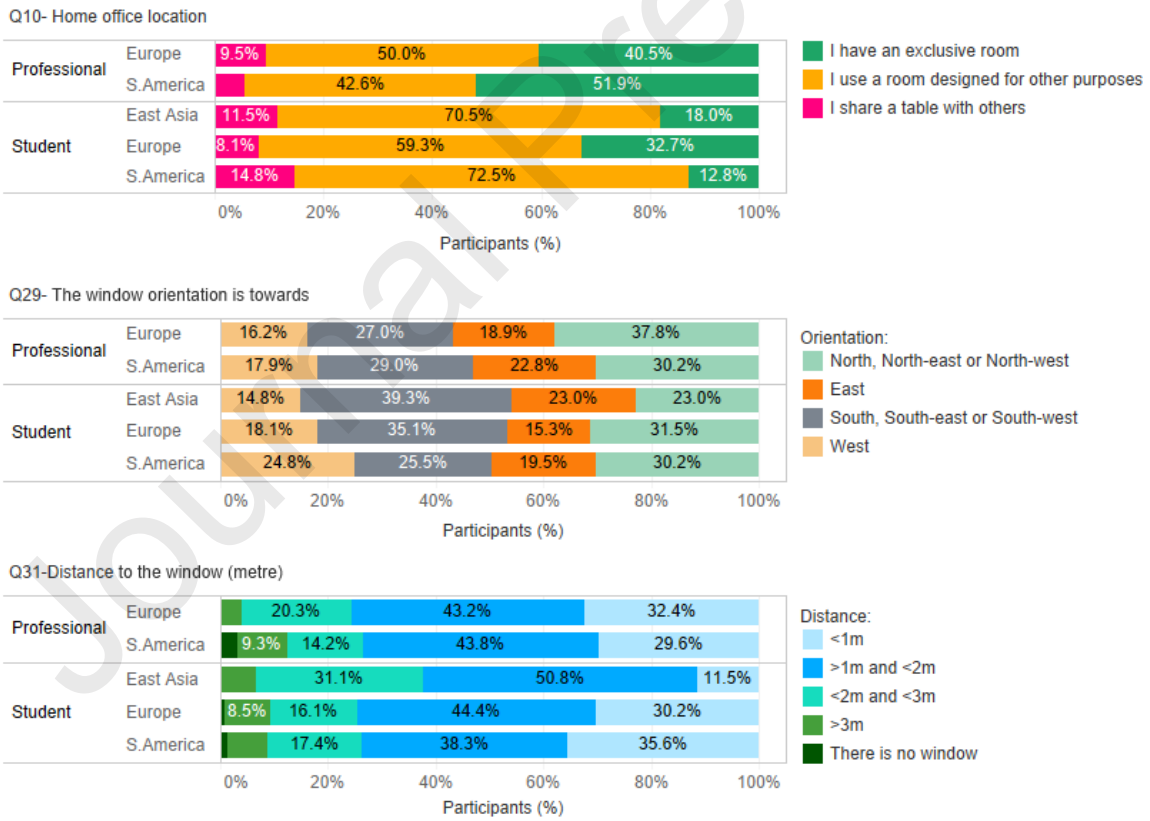

Figure 8 – Features of the home office room

Sun shading control and electric lighting features were multiple-choice questions that allowed participants to select as many options to provide the closest description of those aspects. Four options of internal shading (internal blinds and three different curtain types) and external devices were presented. Some participants informed that they had a different type of shading device and some did not have any sun shading. For describing the electric lighting, five types of light fixtures were presented: ceiling lamp, wall-mounted lamp, floor lamp, desk lamp, and specific lighting for video recording. The option was also given to describe the electric lighting if different from the given options. Most participants (80.3%) had only one type of shading device in the home office window, and only 18.7% had at least two sun shading solutions available. As for electric lighting, 51.4% of participants had one type of solution, and 42.1% had two different options (Figure 9).

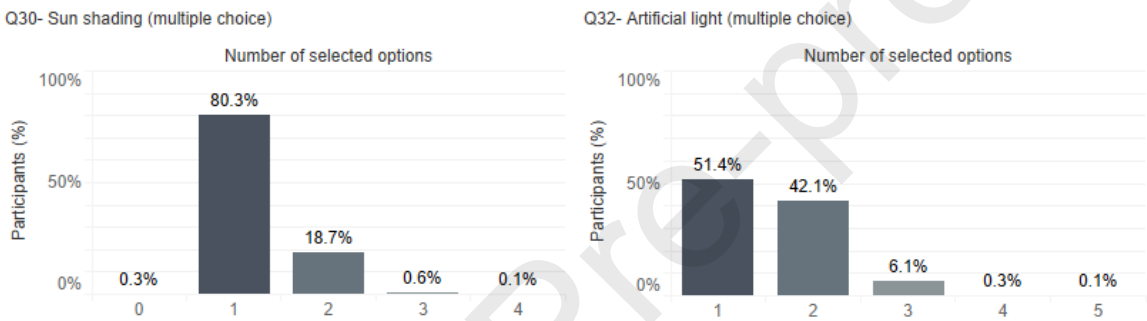

Figure 9 – Sun shading and electric light multiple answer: number of options chosen by participants

Internal shading devices seemed to be a universal solution. For the East Asian students, thick curtains blocking the external view were the most common (44.6%), followed by combined thick and thin curtains that allowed the external view (31.1%). European professionals more often used internal blinds (25.88%) and thin curtains (23.53%), while 26.3% of South American professionals did not have any solar protection, and only 15.6% had external sun shading. Similarly, around 20% of European and South American students had external solar protection (Figure 10, Q30).

Although ceiling lamps were the most widespread electric lighting solution in all countries, the number of European participants with this kind of solution was lower (42.3% for professionals and 51% for students) than for the participants in East Asia and S. America (around 60% each). Instead, the professionals and students in Europe more often had wall mounted (7% and 9.8%, respectively) and floor (9.9% and 7.1%, respectively) lamps than their peers from other continents. The second type of lighting fixture often used was supplementary sources, such as desk or table lamps.

Around 30% to 34% of European and East Asian participants had a desk lamp, while only 20–26% of South Americans had one (Figure 10, Q32).

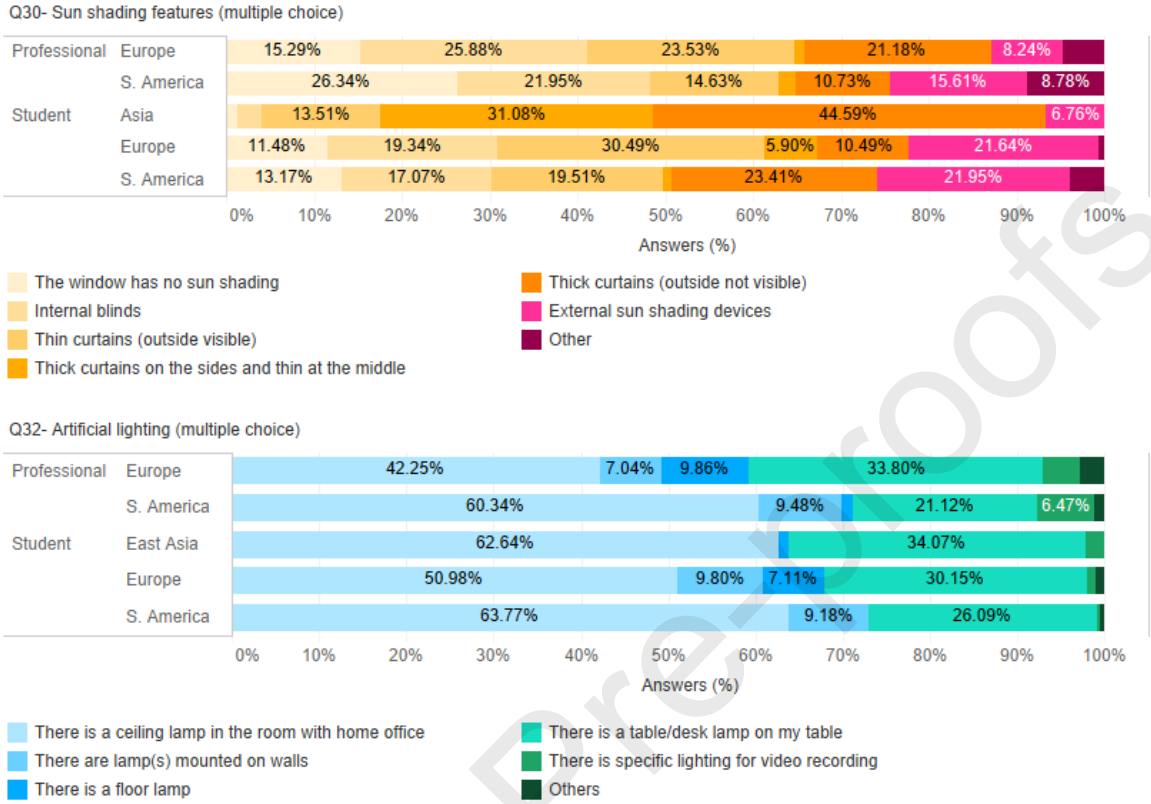

Figure 10 – Characterisation of sun shading and electric lighting features

3.2.1. Window external view quality

The participants sent a total of 1231 photos (604 as Picture 1 and 627 as Picture 2). Regarding the window view (Picture 1), 143 photos were taken with curtains/blinds shut or when daylight was unavailable. These pictures were disregarded from the analysis since the external view was not available. A total of 453 photos (Picture 1, from window) were analysed: 211 from Europe and 203 from S. America (Denmark = 30; Italy = 79; Poland = 102; Brazil = 115; Colombia = 88).

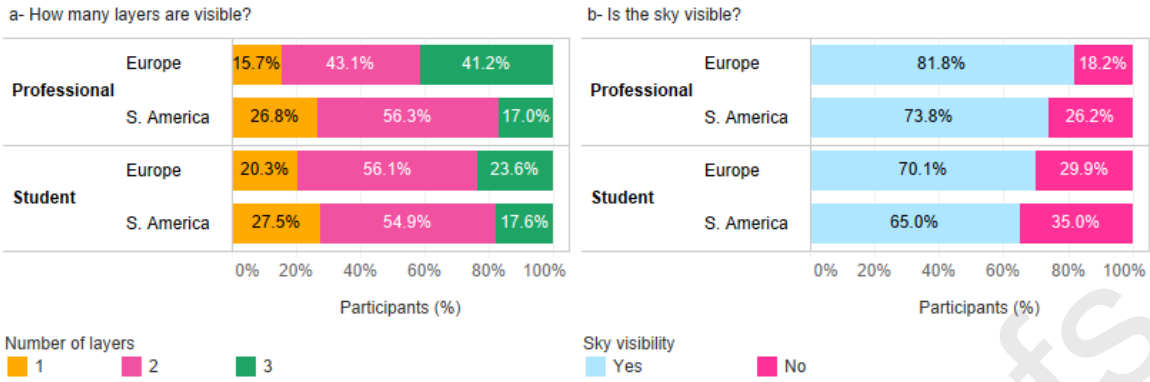

Figure 11a and 11b – Window view description based on Picture 1

Most participants could see at least two layers, indicating some distance between the window and the external elements. Professionals in Europe seemed to have a better window view quality since a large number had a three-layer view (41.2%) and only 15.7% had only a one-layer view. Only 17% of South American professionals could see three layers, and 26.8% only saw one layer. The frequency of students with one, two or three visible layers was very similar with South American professionals (Figure 11a). Additionally, most participants had sky visibility, which, aside from impacting the view quality, was also a good indicator of daylight availability in the home office area. Overall, most professionals (80.3% for Europeans and 73.8% for South Americans) and European students (70.1%) could see the sky while 35% of South American students could not (Figure 11b).

3.2.2. Perception of light descriptors

Results of light perception are summarised in Table 3 (median and IQR) and Figure 12 for the seven light descriptors. Though most participants perceived the room as somewhat "Bright", most of the South American students and professionals seemed to have brighter rooms compared to the European students, which could be explained by the season (summertime in S.America). Light distribution was perceived as being neither uniform nor varied, but most East Asian students perceived the light distribution in the room as somewhat uniform, more than others. Glare was not perceived by the students or professionals. Shadows tended to be soft, and diffused, light-coloured reflections were perceived as neutral by both the students and professionals. Overall, the colour of the surfaces appeared to be somewhat natural for all participants. The light colour and surface colour perception could be partially explained by the time of the survey, taken mostly during the daytime.

As stated by [53], when scales are translated across languages two forms of discrepancies may occur: there may be semantic bias during the translation process and some descriptors may lose

their original meaning; and there may be not a direct word linking the original descriptors to the second language. Even if we included images illustrating each light descriptor, these problems may have occurred, especially regarding East Asian (Japanese) results.

Table 3 - Statistics of the seven light descriptors used to assess light perception

	Professional		Students	
	Median	IQR	Median	IQR
Q15 – Light level (Dark – Bright)	6	1	5	2
Q16 – Light distribution (Uniform – Varied)	4	3	3	3
Q17 – Glare (Invisible – Disturbing)	3	3	2	3
Q18 – Shadows (Soft – Hard)	2	3	2	2
Q19 – Reflections (Diffuse – Strong)	2	2	2	2
Q20 – Light colour (Warm – Cold)	4	1	4	1
Q21 – Surfaces colour (Distorted – Natural)	6	2	5	2

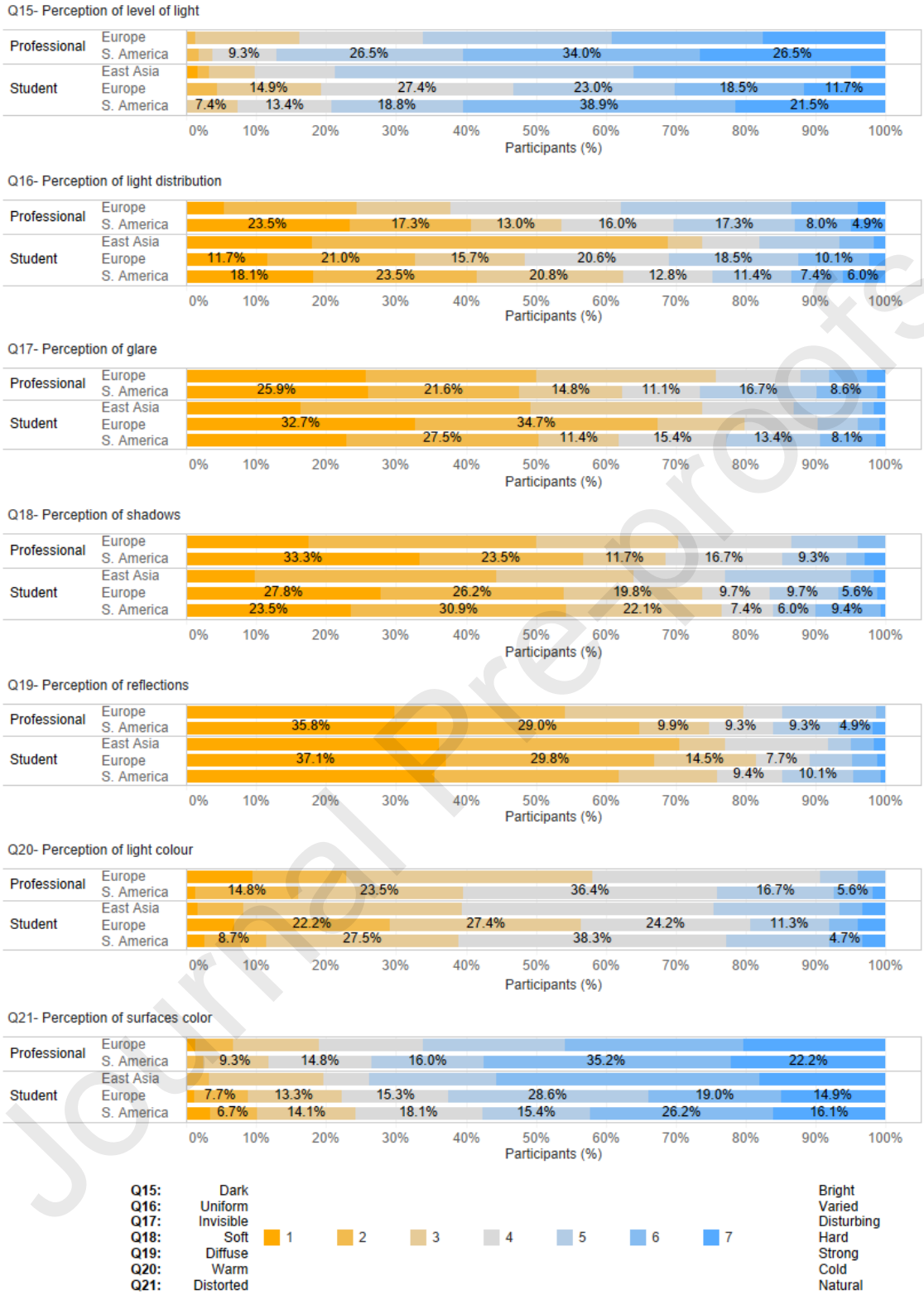

Figure 12 – Perception of the seven light descriptors

3.2.3. Satisfaction with lighting and Preferences

The results of the answers from Section II, "Lighting condition in the whole home office area now" (Figures 13 and 14) and two answers from Section VI "Describing your home office" (Figure 15) demonstrate what influences the overall satisfaction with lighting, the preferences and also the users' intention to continue in-home office activities.

In general, 47.62% of all occupants were satisfied or very satisfied with their **access to daylight** (rated 6 and 7). South American professionals were more satisfied with their daylight (64.38%) than Europeans (45.94%). Also, the South American students (55.86%), as compared to the Europeans (37.5%) and East Asians (34.43%), were more satisfied with their daylight. This could be partially explained by the survey period: wintertime in Europe and East Asia, and summertime in S. America, even if in the case of Colombia and upper parts of Brazil, seasonal differences are less perceptible.

The **external view** from the window was satisfactory (rated 6 and 7) for 34.94%. A higher percentage of South American professionals (56.96%) was satisfied with their external views, compared with the Europeans (36.48%). Between the students, a higher percentage of South Americans (40.14%) were satisfied, followed by Europeans (27.93%) and East Asians (13.13%). For the East Asian students, this was a point of dissatisfaction.

Regarding **electric lighting**, in general, 41.1% of all occupants were satisfied or very satisfied (rated 6 and 7). The South American professionals were more satisfied (45.8%) than the Europeans (38.86%). The East Asian students were much more satisfied with their electric lighting (49.18%) than the Europeans (37.9%) and South Americans (34.26%).

About the **general lighting level**, 51.53% of all occupants were satisfied or very satisfied (rated 6 and 7). The South American professionals were more satisfied (61.72%) than the Europeans (39.19%). Among the students, East Asia had the highest percentage of satisfaction (62.29%), followed by South America (55.71%) and Europe (38.71%).

Considering the "Yes" and "Rather Yes" answers, most occupants (75.7%) were satisfied with the **visual environment** (Figure 15). The South American professionals (84.57%) and European professionals (79.73%) were satisfied with the visual environment. Between the students, the East Asians indicated a higher percentage of satisfied users (73.77%), followed by the South Americans (68.45%) and Europeans (67.74%) – with very similar percentages.

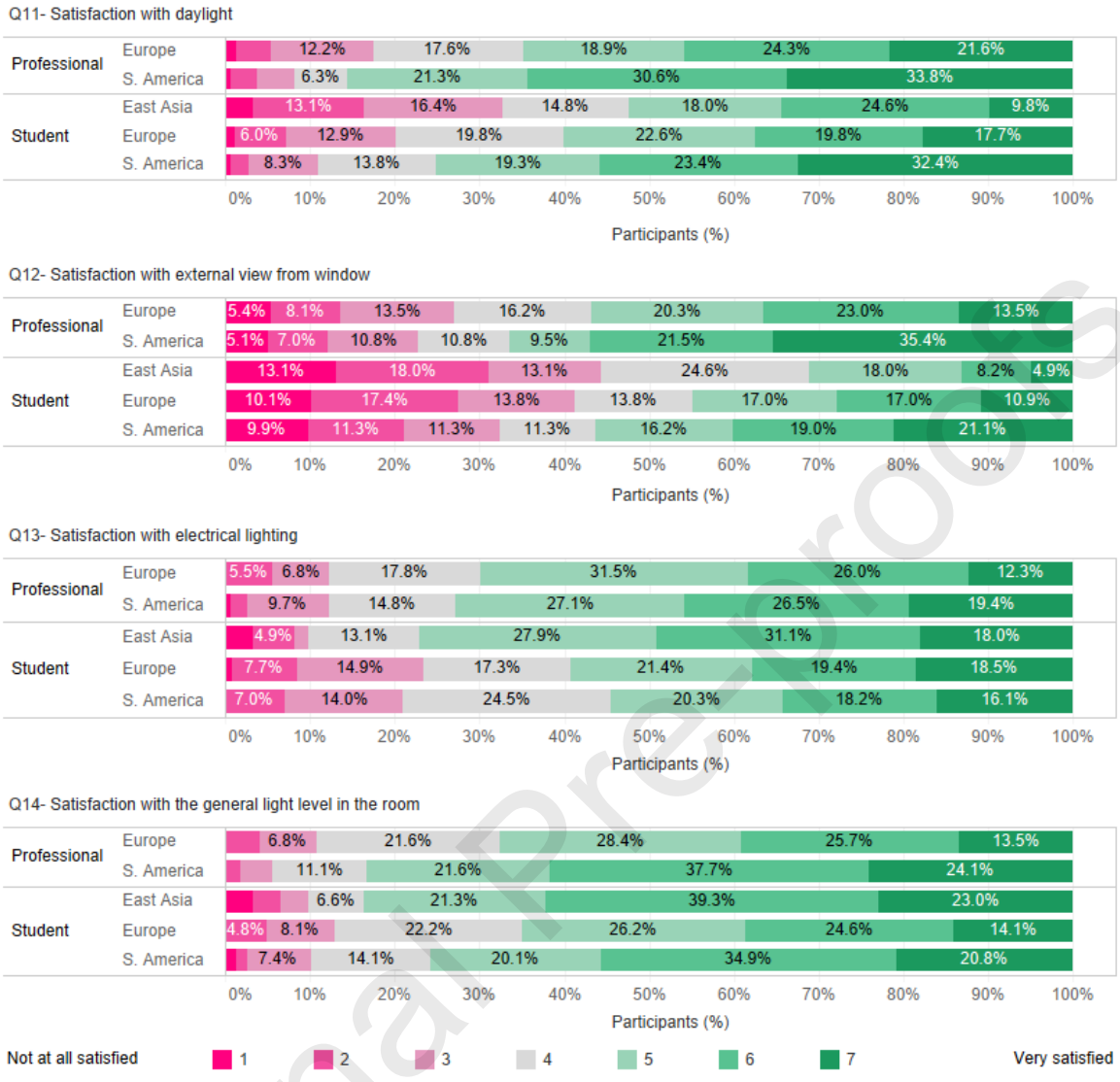

Figure 13 – Satisfaction ratings with daylight, external view, electric lighting and general light level

Regarding preferences of lighting type, 47.6% of occupants declared to appreciate daylight as the illumination of the room. However, the preferences for reading or writing were almost the same for daylight (20.3%) as for daylight and electric light (20.2%), indicating the need for electric light to complement this visual task (Figure 14).

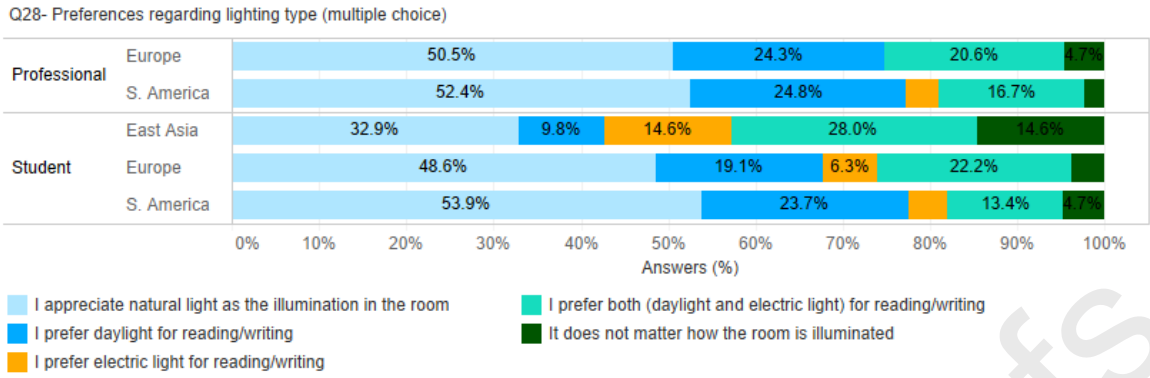

Figure 14 –Preferences regarding lighting type

Most participants **wanted to continue to work in their home offices** after the pandemic period (an average of 68.2% selected the answers "Yes" or "Rather yes"). This was more emphasised by South American professionals (84.57%) and East Asian students (73.62%).

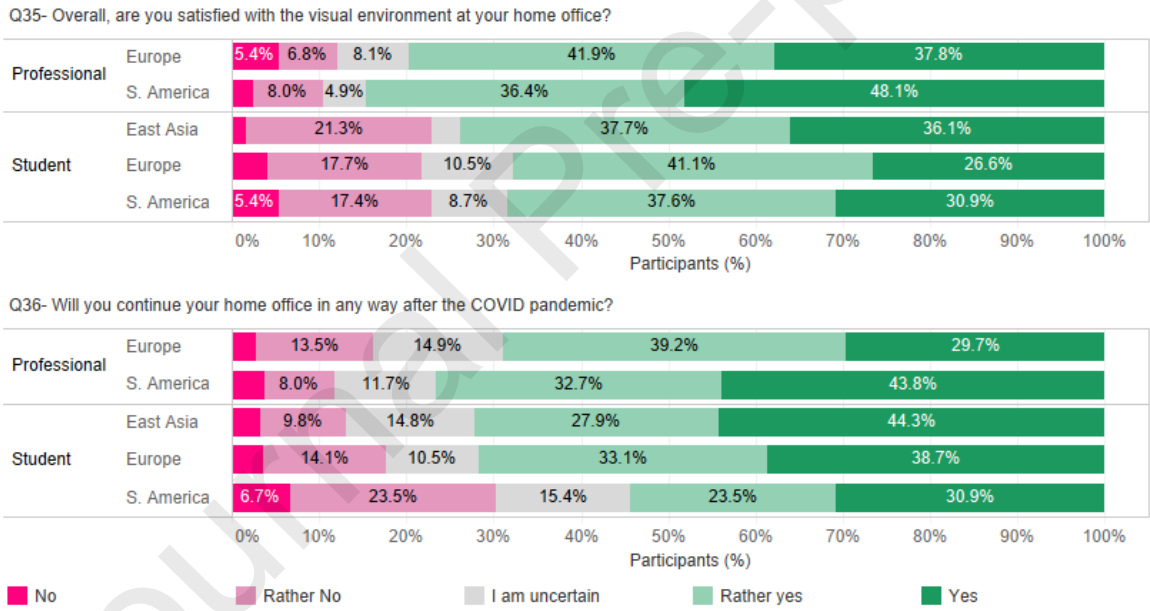

Figure 15 – Satisfaction with the visual environment in the home office

It is possible to conclude that the higher percentage of satisfaction was for the visual environment. A similar percentage of occupants wanted to continue their in-home office after the pandemic, indicating a relationship between these aspects. Nearly half of the occupants were satisfied with the general light level and daylight. East Asian students, on the contrary, were more satisfied with electric light. The lower percentage of satisfaction in this group was for the external view from

the window. South Americans were the most satisfied with general light level and daylight, explained by the season (summertime).

3.2.4. Behaviour

This part presents the standard actions in the in-home office, especially regarding electric lighting, with answers from Section VI.

In daylight, most participants did not use any lamp (electric lighting). This was true for most South American (60.67%) and European (51.11%) professionals, but also for South American (73.33%) and European (60.15%) students. The East Asian students were the exception: 37.68% mentioned that the ceiling lamp must be switched on, and for 30.43% a table or desk lamp had to be switched on (Figure 16).

In the **absence of daylight**, the most used electric light fixtures were ceiling lights, followed by desk or table lamps. The South American (63.13%) and European (45.76%) professionals used ceiling lamps and table or desk lamps. Between the students, the most common were ceiling lamps (SA 65.45%, EU 47.81% and East Asia 58.24%), followed by table or desk lamps. Wall lamps were less often used, but in South America, they appear more frequently (Figure 16).

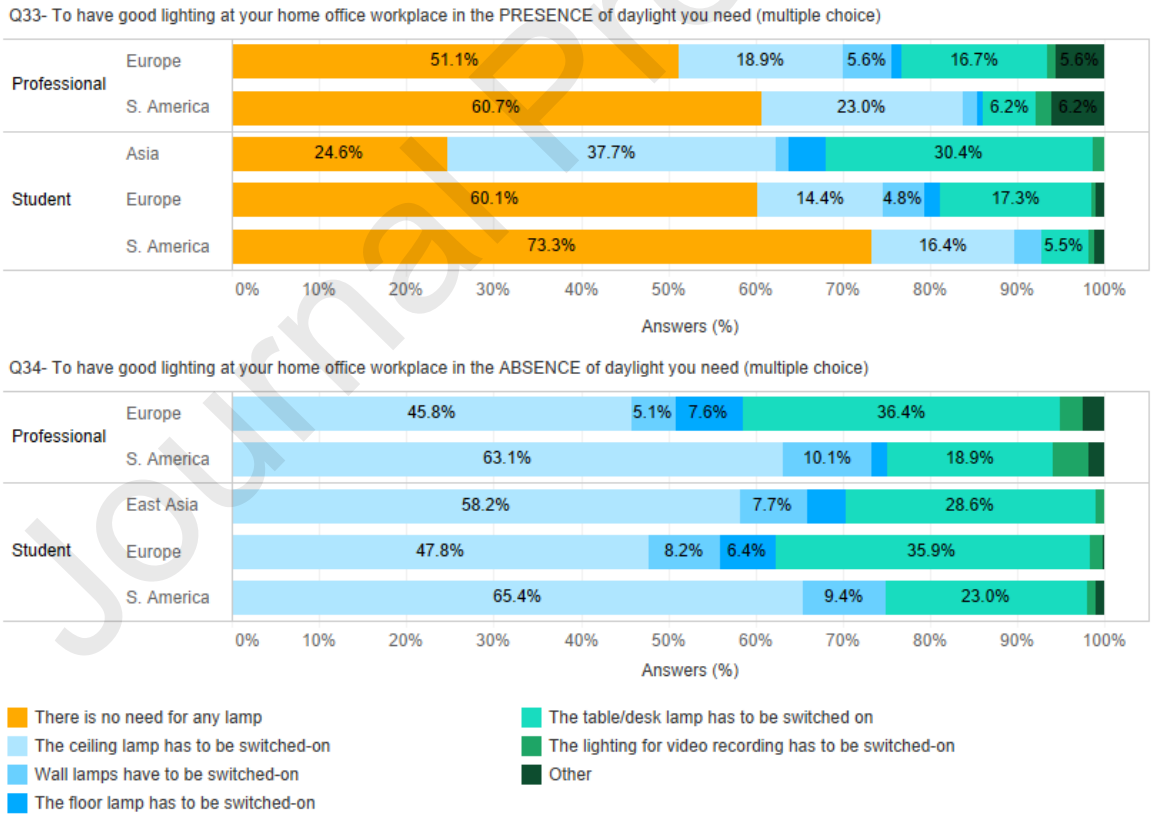

Figure 16 – Use of electric lighting fixtures in the presence and absence of daylight

The most frequent combination of electric light fixtures happened in the absence of daylight: 23.9% used ceiling + table/desk lamp. In the presence of daylight, only 3.3% used this combination (Figures 17 and 18).

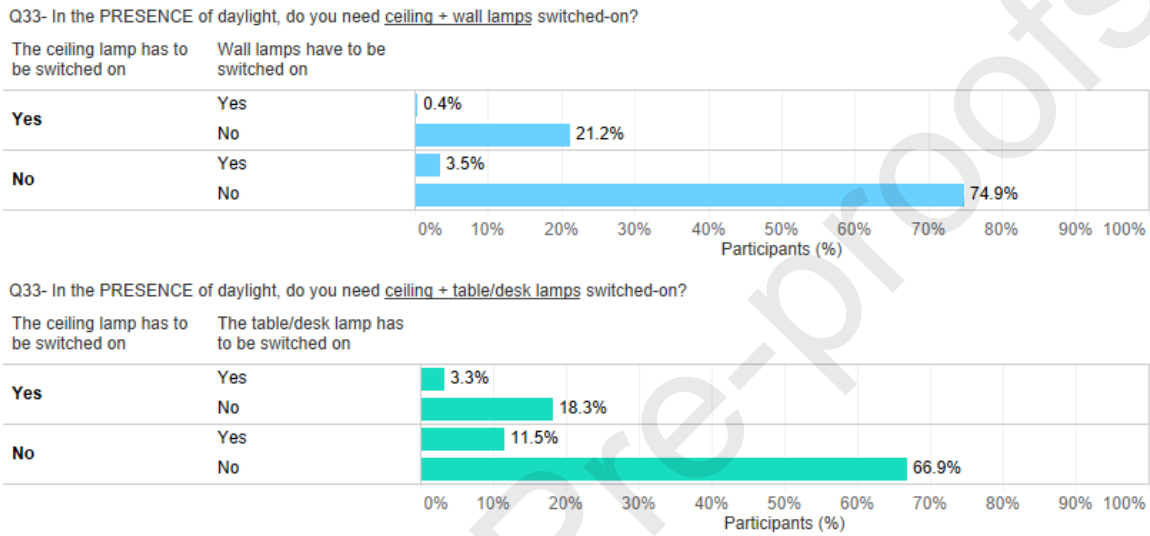

Figure 17 – Use of combined electric lighting fixtures in the presence of daylight

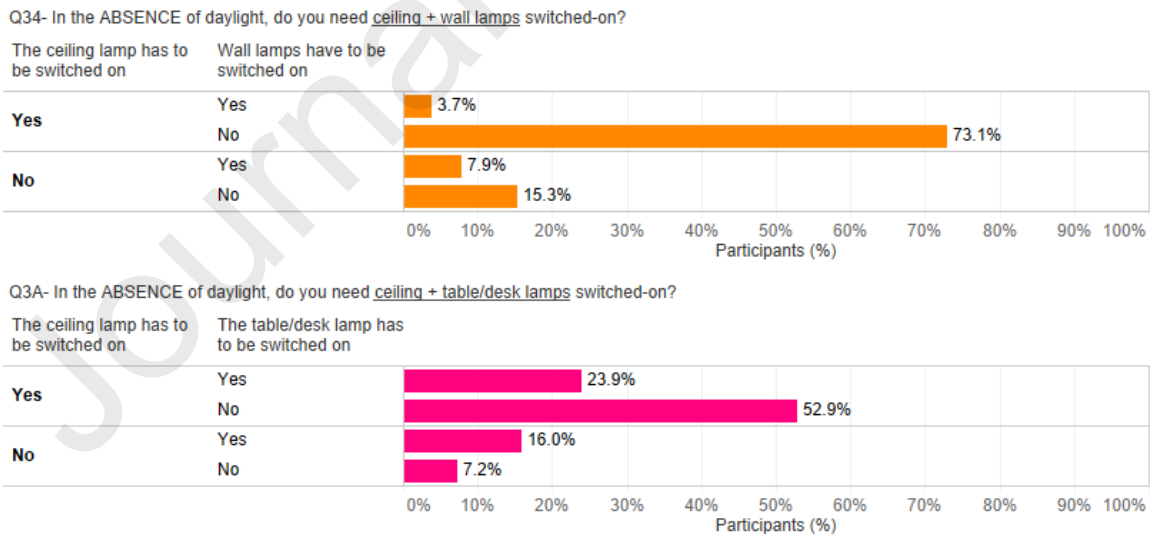

Figure 18 – Use of combined electric lighting fixtures in the absence of daylight

3.2.5. Needs or Wants

Through the open-ended question ("What would you like to improve in the visual environment in the case you must use the home office?"), the following most recurrent themes were identified: daylighting; electric lighting; and ergonomics. From two of the three main themes, subthemes were identified, being the most frequent words related to the themes:

- Theme 1: Daylighting – Subthemes: Quantity, Distribution, Sun shading, External view, Position
- Theme 2: Electric lighting – Subthemes: Quantity, Colour temperature
- Theme 3: Ergonomics

Tables A, B, C, and D (Appendix 3) show the frequencies of the words identified in the main themes and subthemes by categories – professional/student and continents. In addition, examples of respondents' answers to specific themes and subthemes were identified. Table E details the participants who would not like to change their environments.

Figure 19 illustrates the most recurrent words in the responses of the professionals and students in general. Appendix 4 shows the same information across the three continents.

Figure 19 – Word cloud with the most common needs of improvement in HO in general

The need to change the electric lighting was the most commonly mentioned answer in general terms and specifically about the colour temperature and quantity. The need to change the daylighting was most often mentioned concerning the position of the table to the window. Many students, especially in Europe, indicated the need to change the desk position to be near the window to improve the daylight and view. Solar protection was needed in all continents, especially for South Americans. The need to have a better external view from the window was also mentioned. The need to change the electric light was declared especially regarding the colour temperature, but also the quantity. Finally, the need to change other aspects such as furniture was mentioned. Even though the word

"light" frequently appears, it was not considered a theme, because it didn't follow the necessary requirements suggested by Bardin [43], as it is not "exclusionary".

The South American professionals and students would also like to make more daylighting-related changes than the Europeans and East Asians. Those from South America expressed the need to adjust the electric lighting more often than the Europeans. When it comes to daylight, those in South America would like to adjust the solar protection and control the daylight through shades and blinds to avoid glare and to have more evenly distributed light. The Europeans only suggested changing the position of their worktable to a place where the light conditions were more suitable, mainly next to the window. Again, this could be explained by the fact that the survey was taken in the summertime by South Americans, and in a tropical region, sunlight could be a problem.

Most of the European students had simple needs to obtain better conditions in their home office, such as changing the position of their work area to a place where the lighting condition was more suitable. In comparison, those from other continents responded with more complex interventions.

The responses of the European students that they were the most satisfied with the lighting in their home offices indicated that they did not want to make many changes. The few changes they indicated were related to a furniture ergonomics or changing the position of the work area.

3.3. Recommendations

Overall, we can identify many challenges within the home office lighting environment for both professionals and students from all continents. Table 4 summarises the problems identified through the survey results and by inspection of the photos, and offers recommendations for possible improvements towards obtaining a more resilient visual environment.

Table 4. Problems that may occur in the visual environment of the home office and suggestions for improvement

Identified problem	**Possible improvements**
No window	Insist on moving to a room with a window. This is needed for health, wellbeing, and many more reasons.
Unsatisfactory daylighting	Move the desk closer to the window.
Unsatisfactory amount of view	Move the desk closer to the window, reconsider the type and usage pattern of sun shading.
Window very high in the wall/roof and the view only of the sky	Adjust the height of the desk and the chair to move the eyes higher up, consider building a mezzanine floor and positioning the desk on it.
Problems with high luminance contrast in the visual field, daytime	Orient the desk preferably with the side to the window to avoid the main view direction facing towards the

	outdoors while keeping the possibility of seeing the view. Consider the colour of the desk; avoid a white desk if you have a black computer, and avoid glossy surfaces, e.g. of the desk.
Dark areas and corners in the proximity of the home office desk, daytime	Try different orientations of the desk and chair, and consider also using a lamp to illuminate the dark areas, choose a narrow light distribution.
Solar glare	Apply a sun shade that is reasonable for the climate and orientation, consider products that maximise the amount of view.
Not enough light on the desk in the absence of daylight	Add a lamp, preferably a desk lamp. A wall or a floor lamp may also function well, depending on the interior design. Choose a light source with a high colour rendering. In the case of dark walls, consider repainting the walls with lighter colours. Follow the colour harmony rules.

Conclusions

The results provide important information about lighting conditions in home offices for professionals and students in South America, Europe and East Asia (Japan). It is essential to mention that the survey was distributed during the summer season in South America and the winter season in Europe and East Asia, which may have influenced the answers.

For the analysed sample, the home office conditions were generally relatively good for most occupants, and daylight was one of the most appreciated features. Lighting descriptors indicate the dominant perception of a bright environment, with few disturbing glare occurrences, light distribution neither uniform nor varied, soft shadows, diffuse reflections, and natural colours. The natural colours can be explained by the fact that almost all of the occupants answered the survey during the daytime. The seasonal difference may also explain why the South Americans (summertime) perceived the room to be brighter than the others. The external view from the window was not so much appreciated by one third of the responders, which may be a consequence of the type of solar protection in some cases– – thick curtains, overhangs, louvers, sidefins and internal blinds can obstruct the view when closed or partially closed. The results also reveal a high percentage of occupants satisfied with the visual environment and a similar percentage of occupants who wanted to continue in-home office work after the pandemic, indicating a possible relationship between these aspects.

Cultural differences in styles of residential buildings in different continents could be identified. There were differences in the position of the desk related to the window and the customs of using lighting fittings. The South American occupants were more satisfied with the daylight than

the Europeans and East Asians (Japanese), which could be explained by the season when the survey was undertaken. The South American professionals worked more than before the pandemic, while the Europeans kept the same working rhythms. The East Asians were more satisfied with their electric lighting than others. Also, The South American occupants were more satisfied both with their daylight and external views compared with the others, which may be explained by the season of the survey (summertime), except for lower latitudes in Brazil and in Colombia. The photos demonstrate huge differences regarding the quality of the view out, from a view towards a wall or a fence located just a few metres away to a distance view towards a well-kept garden or a panoramic view of the city. It is influenced by the locational conditions of the housing and determines the satisfaction with the external view.

Some differences were also found between the student and professional categories. For example, 90% of all occupants shared their room or a table in a room with others, but most students did not have a separate room for their home office, having arranged a desk in a room designed for another purpose. This condition can partly explain some other results, as it can affect the degree of independence and privacy, which might influence the satisfaction. More than half of the students mentioned that they were studying more than before, especially late in the evening. About 40% of the students also use the home office seven days a week. One-third of the students were not satisfied with the lighting conditions in their home office. The number of students who did not intend to use their home office or were uncertain was higher (34%). These facts indicate a worse home office condition for these students, possibly impacting the learning process and increasing the use of electric light and energy consumption. Care should be taken to improve the visual conditions for students as they work many hours a day, and many of them the whole week, in isolation. At least the visual conditions should not be an unnecessary burden.

It is important to mention that carrying out surveys across language barriers raises several problems related to translation and reliability of results. This is specially truth regarding East Asian (Japanese) results, as discussed before. As suggested by Fotios [53], future studies should report the survey in both the original and translated languages, allowing checking this accuracy.

The results presented in this paper are limited to the description of the data. Despite the diversity of the research group, the reported outcomes might be biased due to subjective interpretation. The study faced some of the problems noted by Uttley [54]. For instance, although power analysis for establishing the sample size was not performed, an initial target of 200 participants per country (100 professionals and 100 students) was defined. Getting that number of participants was challenging, and it was necessary lowering such a target to 100 participants per country (50 for

each category)- even in some countries, it was not possible to have answers from both professionals and students. Another factor that could impact the data was the timing of the answers. Some participants filled in the online survey during the day, others during the night, according to their working/studying routine at home.

Future studies using this method for collecting data would benefit from analysing such differences. Additionally, further research in this field is necessary in order to deeper understand home office lighting conditions and establish correlations between different factors. Some points can be highlighted as suggestions for future works:

- Determining lighting conditions that might affect users' preferences and lighting performance in home offices;
- Determining the most significant lighting descriptors that mainly contribute to users' satisfaction in home offices;
- Analysing further pictures, in order to identify the visual environment conditions in more detail and possible improvements;
- Further investigating people's reasons for not working from home during the pandemic among those who had a choice and preferred to go to their regular workplace.

Acknowledgements

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APPENDIX 1

COVID-19 lockdown situation in countries participating the survey

Country	Main national safety anti-COVID-19 measures for students and professionals
Brazil	Schools and universities were closed from March 2020, but the situation differed depending on region, school and university. and were reopened at different times after 10 months or more. Home office work (teleworking) was recommended for the general public sector from March 2020. Public offices reopened physically (partially) from July 2021.
Colombia	Schools and Universities were closed from 16th of March 2020. Schools were reopened slowly at different times after 15th of February 2021 and Universities were partially reopened from July 2021. Home office was recommended for the general public from 25-03-2020 to 31-08-2020 and was extended to December 2020. Employees in private companies could stay working from home some days per week.
Italy	Following the Coronavirus (COVID-19) emergency, from 5th March 2020, face-to-face educational activities relating to the 2019/2020 school year had been suspended throughout the national territory. Starting from 3rd November 2020 and until 26th April 2021, the offices were encouraging the adoption of home-office work (teleworking) for most of their employees too; however, the teleworking was strongly adopted for big government offices until 23rd September 2021.
Japan	Schools and universities were closed in March 2020, but the situation differed depending on region, school and university. The new school year starts in April in Japan, and online education was provided from April 2020. Home office work (teleworking) was recommended for the general public at the same time. Although the conditions differed in degrees depending on the time and prefectures, behavioural restrictions were required during the school year of 2020 (April 2020 to March 2021).
Denmark	Universities were closed from 16th March 2020 until 3th July 2020 Home office work (teleworking) was recommended for the general public from from 13th March 2020 14th June 2020. Partial home office work was introduced from 2020-06-15 until 2020-12-15 and from 2021-05-21 until 2021-07-31.
Poland	Schools and universities were closed from the 12th of March 2020 until 25th of May 2020. Universities reopened on 1st of October 2020 for regular and hybrid (partly online) teaching. Home office work (teleworking) was recommended for the general public from the 8th of March 2020 until – (depends but the order to stay at home was from 24th of March until 19th of April). Teleworking was partly abandoned in June 2020.

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APPENDIX 2

ONLINE SURVEY

The visual environment in home offices

Dear reader, we would like to invite you to participate in this online survey. Please read the short description below before you decide to participate. Thank you.
This survey is a part of the research within the framework of International Energy Agency (IEA) Solar Heating and Cooling (SHC) Task 61 Integrated Solutions for Daylighting & Electric Lighting https://task61.iea-shc.org/
In Subtask A User perspective and requirements, we are working with registration of the visual environment conditions at workplaces in public buildings, trying to better understand people's needs. The results will be used to propose new requirements for the visual environment in international reports (IEA) and standards.
In the time of the pandemic, a large portion of employees and students worldwide has been advised to work at home. We must be prepared that the home office may became a long-lasting form (full- or part-time) for many of us.

- What is included in this survey?
1. Basic information about participants (anonymised, non-sensitive data for statistical analysis).
2. Questions about the visual conditions in your home office including access to the window, electric lighting and some general questions about the character of your work and employment.
3.You will be asked to take two photos of your home office and upload them during the work on the survey. Please, do not show people on the photos. The photos will be used for better understanding of the visual conditions, like light distribution on the desk, potential sources of glare, daylight access and view content.
- Why have I been chosen?
All people (independent of any form of background) who work at home are welcome to participate.
- Do I have to take part?
No, the participation is voluntary. If you do decide to take part in the survey, you can easily exit at any time with no penalties for either the researcher or yourself.
- What will happen to me if I take part?
If you decide to take part, it will take up to 7 minutes to fill out the survey.
- What are the possible disadvantages/risks and benefit of taking part?
There are no disadvantages/risks of taking part and there are no immediate benefits of taking part.
- What if something goes wrong?
This online survey is designed to have no risks involved. If you do have any concerns, please contact: XXXX
- What will happen to the results of the research project?
The results will be statistically analysed for the research purpose in the framework of IEA SHC Task 61.
- Confidentiality
The survey is completely anonymous, and no data can be traced back to the participant, meaning full confidentiality.
Thank you for reading this.

The home office is here defined as a workplace in your apartment, a place that you use repetitively for work-related tasks, for example a table with a laptop.
The questionnaire should be filled out during the working time typical for you.

Subtask A participants and Barbara Szybinska Matusiak, the Subtask A leader, IEA/SHC Task 6

Please tick the box to continue if you agree to proceed and use your images for analysis. Thank you so much for your willingness to participate.

- Yes, I have read the text above, agree to participate, and agree to my photos being used for analysis

Your home office
Please choose one of the alternatives:

- I am a professional
- I am a student

(For professionals) – For students, questions 6 and 7 were eliminated

General Information

1. Name and Nationality (optional):

2. Age*:

- 10–20
- 20–30
- 30–40
- 40–50
- 50–60
- Over 60

3. Gender*:
   - Female
   - Male
   - I prefer not to inform
   - Other

4. City/Country of residence*

5. Nature of your company or organisation*:
   - Public sector
   - Private sector
   - Self-employed

6. Your work is mainly related to*:
   - Office tasks
   - Education
   - Health
   - Sales
   - Industry
   - Arts
   - Other, please explain below

7. Inform your profession, activity or role in the company:

8. Date*:

9. Time NOW*:

10. Where do you have the space for the home office?*

- I use one of the rooms in my apartment/house for the home office purposes only
- My home office is mainly a table in one of the rooms (living room, bedroom, etc.)
- The table that I use for home office purposes is also used by others for other purposes

Lighting conditions in the whole home office room NOW:

Please, evaluate the lighting conditions at your home office NOW:

11. Satisfaction with daylight? (if no window, do not answer this question)

[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

12. Satisfaction with external view from window? (if no window, do not answer this question)

[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

13. Satisfaction with electrical lighting? (if no electric light, mark not relevant

[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

14. Satisfaction with the general light level in the room?

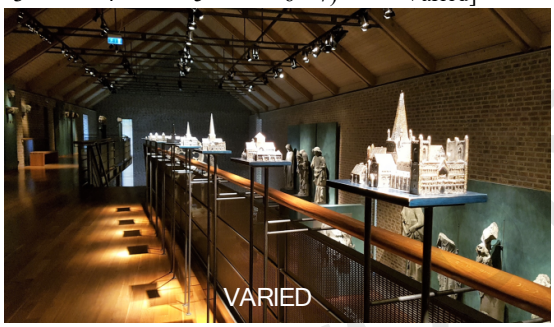
[Not at all satisfied (1 2 3 4 5 6 7) Very satisfied]

Lighting conditions in the home office area NOW:

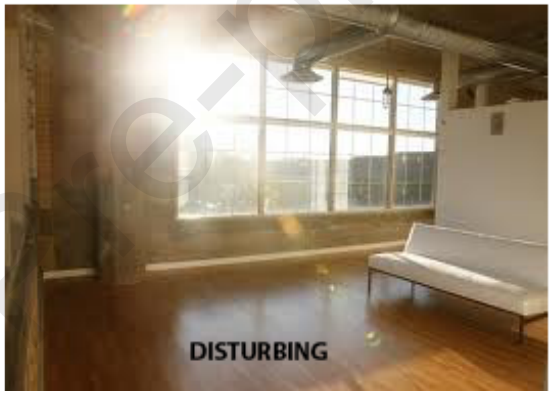
The following questions are about the home office, which may be only a part of the room. Evaluate the lighting condition NOW.

15. Level of Light
[Dark (1 2 3 4 5 6 7) Bright]

16. Spatial distribution of Light
[Uniform (1 2 3 4 5 6 7) Varied]



17. Glare
[Invisible (1 2 3 4 5 6 7) Disturbing]



18. Shadows
[Soft (1 2 3 4 5 6 7) Hard]

19. Reflections
[Diffuse (1 2 3 4 5 6 7) Strong]

20. Colour tones of Light
[Warm (1 2 3 4 5 6 7) Cold]

21. Colour of the surfaces
[Distorted (1 2 3 4 5 6 7) Natural]

Pictures of your home office

Before you fill out the next page, please, take two pictures with your smartphone. If there is no window in the room, please skip this section. Please, do not show people in the photos.

- Picture 1: A photo from your typical working position towards the window. Check that the **HDR** function is switched **off** on your photo camera/smartphone. If you have to choose between good visibility of the outdoors and indoors, make sure that the **outdoors** is well visible. If there is a computer, please leave it on with a **white** screen background
- Picture 2: Stand up and take one big step back (you are about one metre from the worktable), then take a photo of your home office. The **HDR** should also be switched **off**. The picture must contain your home office area and the window. If you have to choose between good visibility of the outdoors and indoors, make sure the **indoors** is well visible. If there is a computer, please leave it on with a **white screen** background.

Employment information

22. For how long have you been working at your present company?

- 0 to 1 year
- 1 to 5 years
- 5 to 10 years
- 10 to 15 years
- 15 to 20 years
- more than 20 years

23. Is your position permanent?

- Yes
- No

Describing your home office

24. How many days per week are you working from home?

- 1 day/week
- 2 days/week

- 3 days/week
- 4 days/week
- 5 days/ week
- 6 days/week
- 7 days/week

25. Have you been working full working days in your home office during the COVID-19 pandemic?
- I have had full working day as before COVID
- I have had shorter working days than before
- I have worked more than before
- I have had part-time days, as before COVID

26. How is a typical working time in the home office for you?
- I have worked in the typical working hours
- I have worked some hours late in the evening
- I start working early in the morning
- Other, please explain below

27. Select the option(s) that best describe your activities during the home office:
- Reading and writing on a digital screen and a computer
- Reading and writing, partly digital, partly on paper
- Participation in digital meetings
- Telephone talks
- Video recording
- Other, please explain below

28. Select the option(s) that best describe your preference(s) regarding the light in your home office:
- I appreciate natural light as the illumination in the room
- It does not matter how the room is illuminated
- I prefer daylight for reading/writing
- I prefer electric light for reading/writing
- I prefer both, daylight and electric light for reading/writing

29. The window orientation is facing:
- To the north or north-east or north-west
- To the east
- To the south or south-east or south-west
- To the west

30. Sun shading (it is possible to select more than one option)
- The window has no sun shading
- Thin curtains (it is possible to see the outdoors through the curtains)
- Thick curtains (not possible to see the outdoors)
- Thick curtains on the sides and thin in the middle
- Internal blinds
- External sun shading devices (overhang, louvres, sidefins)
- Other, please explain below

31. Distance to the window (from your eyes when you are working, to the middle of the window):
- <1.0m

- 1.0–2.0m
- 2.0–3.0m
- > 3.0m
- There is no window

32. Select the option(s) that best describe the artificial light in your home office:

- There is a ceiling lamp in the room with home office
- There are lamp(s) mounted on walls
- There is a floor lamp
- There is a table/desk lamp on my table
- There is specific lighting for video recording
- There is no window

33. To have good lighting at your home office workplace in the PRESENCE of daylight, you need (you can select more than one option):

- The ceiling lamp has to be switched on
- Wall lamps have to be switched on
- The floor lamp has to be switched on
- The table/desk lamp has to be switched on
- The specific lighting for video recording has to be switched on
- There is no need for any lamp
- Other(s), please explain below

34. To have good lighting at your home office workplace in the ABSENCE of daylight, you need (you can select more than one option):

- The ceiling lamp has to be switched on
- Wall lamps have to be switched on
- The floor lamp has to be switched on
- The table/desk lamp has to be switched on
- The specific lighting for video recording has to be switched on
- Other(s), please explain below

35. Overall, are you satisfied with the visual environment at your home office?

- Yes
- Rather yes
- I am uncertain
- Rather no
- No

36. Will you continue your home office in any way after the COVID pandemic?

- Yes
- Rather yes
- I am uncertain
- Rather no
- No

37. What would you like to improve in the visual environment in the case if you must use the home office?

Thank you very much for your participation. We wish you successful work in good lighting conditions.

APPENDIX 3

SUMMARY TABLES FROM OPEN-ENDED QUESTION

Table A– Theme 1 - Daylight – Generated from the frequency of words identified in the open question

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N (%) for continent		Weighted scores (%)	Sample quotes for continents
Daylight (natural light)	Professional	South America = 12 (1.02%) Europe = 2 (0.48%)	0.94%	South America: "I would like the lighting to be only natural" Europe: "More natural light. From the view of the windows, you can see buildings that restrict access to natural light"
	Student	South America = 22 (1.37%) Europe = 12 (1.16%) East Asia = 4 (2.76%)	1.45%	South America: "More natural light without increasing indoor temperature" Europe: "I want to use daylight more effectively by rethinking the usage of electric lights in the room according to daylight" East Asia: No answer
Subtheme: Solar protection (protection, blinds, curtains)	Professional	South America = 10 (0.96%) Europe = 2 (0.63%)	0.91%	South America: "Use glass protection as the sun shines straight onto the computer" Europe: "Better sun protection in the form of thin curtains"
	Student	South America = 9 (0.63%) Europe = 4 (0.36%) East Asia = 1 (0.69%)	0.56%	South America: "On mornings of direct sunlight (because it is an east façade) I would like to not need to close the blinds, as I like to work looking out the window" Europe: "Shading system – new blinds" East Asia: "Reduce the effects of shadows"
Subtheme: Quantity (intensity)	Professional	South America = 1 (0.11%) Europe = 0 (0.00%)	0.11%	South America: "Decrease the effect of natural light a little, particularly in certain times that come with high intensity" Europe: No answer
	Student	South America = 1 (0.10%) Europe = 0 (0.00%) East Asia = 0 (0.00%)	0.10%	South America: Given the orientation of the windows during the early morning, the light irradiation is very powerful. Europe: No answer East Asia: No answer
Subtheme: External view (view, visual, external)	Professional	South America = 3 (0.15%) Europe = 4 (0.55%)	0.38%	South America: "[…] be able to permanently enjoy the visual" Europe: "Outside view"
	Student	South America = 13 (0.50%) Europe = 1 (0.10%) East Asia = 0 (0.00%)	0.47%	South America: "My room has a view of another building, while the next room has a view of the hills and mountain ranges" Europe: "View out the window" East Asia: No answer

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N (%) for continent		Weighted scores (%)	Sample quotes for continents
Subtheme: Distribution	Professional	South America =0 (0.00%) Europe = 1 (0.41%)	0.41%	South America: No answer Europe: "Improve the daylight distribution"
	Student	South America = 0 (0.00%) Europe = 2 (0.29%) East Asia = 0 (0.00%)	0.29%	South America: No answer Europe: "Improve the daylight distribution" East Asia: No answer
Subtheme: Position for daylight and view (position)	Professional	South America = 3 (0.44%) Europe = 4 (1.11%)	0.82%	South America: "I would like to improve the distance between the window (natural light source) and the work table to reduce the use of the lamp" Europe: "Changing the position of the desk with its side to the window"
	Student	South America = 9 (0.70%) Europe = 26 (2.51%) East Asia = 1 (0.69%)	2.01%	South America: "The lighting, and the position of the table, but in the room I have no other option" Europe: "To move the desk closer to the window" East Asia: "Position of the desk"

Table B – Theme 2 – Electric light – Generated from the frequency of words identified in the open question

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N(%) for continent		Weighted scores (%)	Sample quotes for continents
Electric light	Professional	South America = 20 (2.46%) Europe = 11 (2.18%)	2.36%	South America: "Improve electric lighting for night work or on days with low sunlight" Europe: "Maybe a slightly better lamp on my right side, so both sides of my table are well illuminated"
	Student	South America = 57 (3.88%) Europe =44 (2.99%) East Asia = 8 (4.23%)	3.55%	South America: "Improve electric lighting, because to change the problems I have with the natural light, I would either have to change the orientation of the building, or change the façade to put a brise soleil or something like that" Europe: "I would add a desk lamp due to the need for spot lighting" East Asia: "I want a desk lamp"
Subtheme: Quantity (intensity)	Professional	South America = 1 (0.09%) Europe = 1 (0.31%)	0.20%	South America: "Invest in lighting with variation in luminous flux and colour temperature" Europe: "I would add the ability to control the intensity of lighting"

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N(%) for continent		Weighted scores (%)	Sample quotes for continents
	Student	South America = 2 (0.16%) Europe = 0 (0.00%) East Asia = 1 (0.78%)	0.37%	South America: "Increase the intensity of the light when there is absence of natural light" Europe: No answer East Asia: "Lighting intensity"
Subtheme: Colour temperature	Professional	South America = 2 (0.12%) Europe = 5 (0.87%)	0.66%	South America: "Invest in lighting with variation in luminous flux and colour temperature" Europe: "Increase the electric light levels, change light colour to cool/blue light, improve the light distribution"
	Student	South America = 2 (0.11%) Europe = 8 (0.46%) East Asia = 0 (0.00%)	0.39%	South America: "Change the colour of the bulb in the case of the electric light for a white one (it is currently yellow)" Europe: "Improve the lighting, I believe that the colour of the light should be cooler than the warmer bedroom light when working […]" East Asia: No answer
Subtheme: Distribution	Professional	South America = 1 (0.15%) Europe = 1 (0.41%)	0.28%	South America: "The spatial distribution […]" Europe: "[…] improve light distribution"
	Student	South America = 1 (0.09%) Europe = 0 (0.00%) East Asia = 0 (0.00%)	0.09%	South America: "Ceiling lights to distribute the electric light better" Europe: No answers available East Asia: No answer

Table C – Theme 3 - Ergonomics – Generated from the frequency of words identified in the open question

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N(%) for continent		Weighted scores (%)	Sample quotes for continents
Ergonomics (furniture, table, desk, chair)	Professional	South America = 31 (1.84%) Europe = 19 (2.84%)	2.22%	South America: "Regarding lighting, I understand that it is adequate. There is only a need to adapt the chair for long-term use" Europe: "A more ergonomic desk and a more comfortable place to sit"
	Student	South America = 43 (1.82%) Europe = 60 (3.03%) East Asia = 0 (0.00%)	2.52%	South America: "The space, the ergonomics of the chair and the desk, the natural light" Europe:" Arranging a desk for work instead of a dining table, buying a desk lamp" East Asia: No answer

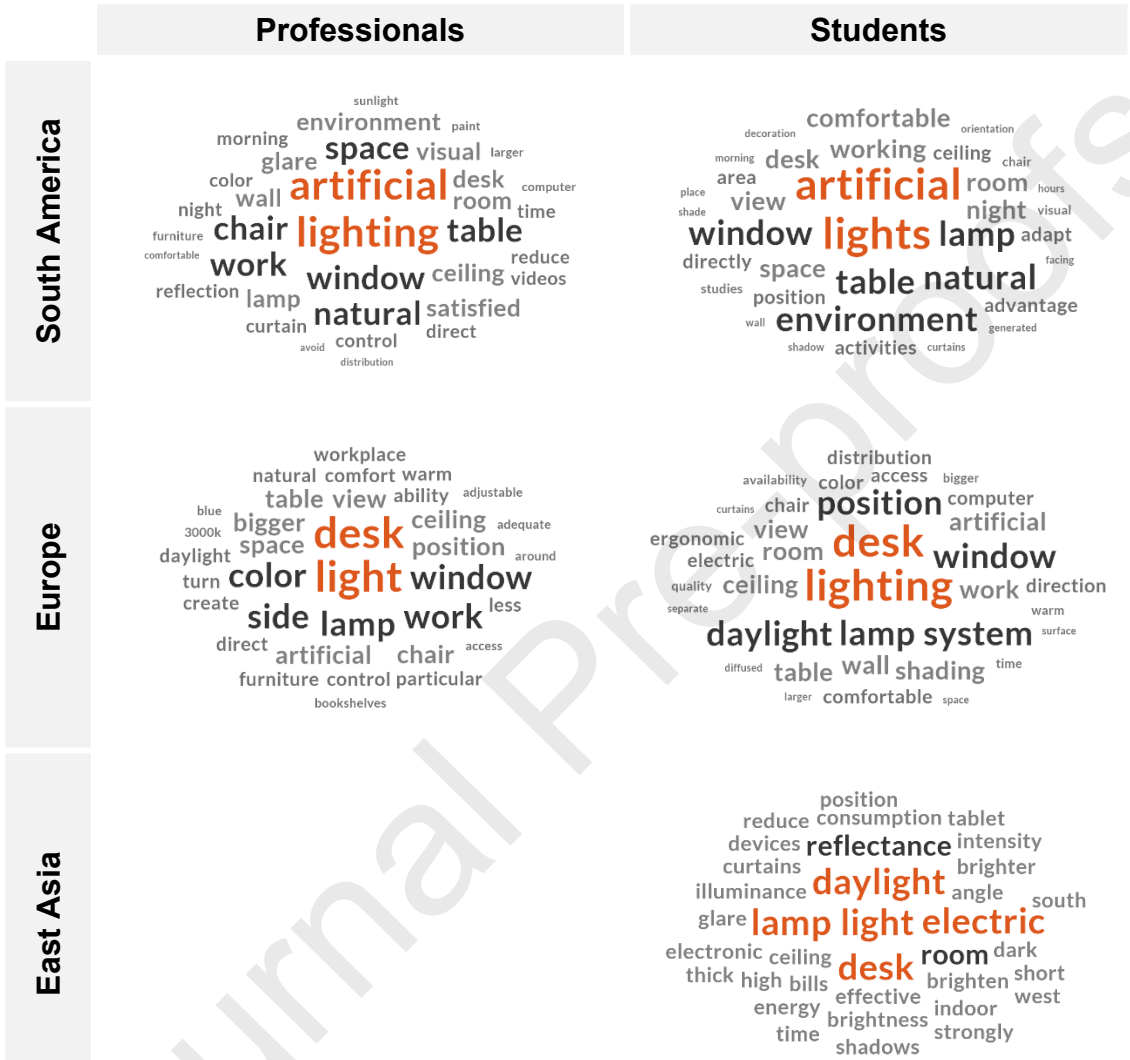
Table D – Participants who indicated satisfaction in the open question

Open-ended question				
Themes	What would you like to improve in the visual environment of your home office?			
Subthemes	N(%) for continent		Weighted scores (%)	Sample quotes for continents
Nothing (NA)	Professional	South America = 22 (1.89%) Europe = 17 (4.11%)	2.86%	South America: "Nothing" Europe: "Nothing"
	Student	South America = 11 (0.69%) Europe = 60 (5.08%) East Asia = 0 (0.00%)	4.40%	South America: "Nothing at the moment" Europe: "Rather nothing" East Asia: No answer

APPENDIX 4

WORD CLOUDS FROM OPEN-ENDED QUESTION

Figure A4.1 – Word clouds with the most common needs of improvement in Home Offices



HIGHLIGHTS

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- Most occupants had good lighting conditions at the home office
- Students have poorer home office conditions compared to professionals

- Occupants satisfied with visual environment intend to continue home office
- Cultural and seasonal differences due to continents led to different lighting uses
- Most participants appreciate daylight as the primary light source