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User-Centred Design: A Palm-Sized Light as a Part of Home Living

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Abstract

Nowadays, Hong Kong is facing serious housing problems. It is identified that insufficient light source is associated with small living space. In view of the generalization of poor living standard, we are inspired to design a user-centred product to alleviate people's troubles in life. Light is the source of life, affects our psychological well-being and brings hope in spiritual meaning (Chris, 2021). Thus, we design a light to brighten up users' daily activities. Its form is a cube plus a pad. The key features are (i) compatible: users are able to transfer the light from one place to another through attaching the cube to multiple pads; (ii)portable: which enable users to grab the light with few efforts; (iii) efficient: users can adjust the brightness and warmness of the light by clicking a few buttons. This paper first examines the social problem and users' difficulties. After problem identification, it explains our design concept and goal. To make a user-centred design, it is crucial to collect first handed research, descriptive research is used in this study. In the first experiment, participants are asked to grab 3 cubes in 8x8x8(cm), 9x9x9(cm) and 10x10x10(cm) one by one. Observational research method helps to understand users' behaviour and actual view. It also guided us to validate our design assumption: (1) There is a relationship between palm size and preferred light size. People with larger palm size like larger light, vice versa. (2) There is a relationship between hand gesture in holding the light and their preferred light size. Furthermore, there is also unexpected finding in the first experiment, which the choice of cube size reveals masculine traits behaviour. In the second experiment, participants are given a card and asked to place the buttons in their own way. Interview is carried out afterwards to better understanding users' preferences and concerns. The above research contributes to a great improvement in our final design. It is more human-centred and inclusive.

Keywords: Home living, light source, small living space, light, descriptive research, observational research method, interview, user-centred design, product design

1 Introduction

Housing affordability has deteriorated materially in recent decades, which has been a principal factor in an internationally observed reduction in middle-income standards of living (Cox, 2021). Hong Kong (20.7) is one of the least affordable housing markets among all. Young people can hardly afford high housing price, they live in small flat with very limited space in Hong Kong.

MAJOR MARKET HOUSING AFFORDABILITY RATINGS BY NATION						
Nation	Affordable (3.0 & Under)	Moderately Unaffordable (3.1-4.0)	Seriously Unaffordable (4.1-5.0)	Severely Unaffordable (5.1 & Over)	Total	Median Market
Australia	0	0	0	5	5	7.7
Canada	0	1	1	4	6	5.4
China: Hong Kong only	0	0	0	1	1	20.7
Ireland	0	0	0	1	1	5.4
New Zealand	0	0	0	1	1	10.0
Singapore	0	0	1	0	1	4.7
United Kingdom	0	3	9	9	21	4.8
United States	4	20	17	15	56	4.2
TOTAL	4	24	28	36	92	4.6

Figure 1. The housing markets by housing affordability ratings by nation, 2021, *Newgeography,* Copyright 2022 by New Geography. (http://demographia.com/dhi.pdf)

In recent years, Hong Kong has produced approximately 15,000 public rental flats per year. Comparatively, public rental flats have a smaller internal floor area than their private counterparts, and the percentage share of small apartments under 40 square meters has increased over years. In 2012, percentage share of small apartments was around 95%, and by 2015, 100% of all apartment completions fell under 40 square metres (Lau & Wei, 2018). It proves that area of flats in Hong Kong gradually decreased.

	Less than 40 sq.m.	Percentage share	40–69.9 sq.m.	Percentage share	Total
1990	25171	76.54%	7714	23.46%	32885
2000	19889	58.95%	13852	41.05%	33741
2012	9308	94.73%	518	5.27%	9826
2013	20760	97.79%	470	2.21%	21230
2014	5636	97.61%	138	2.39%	5774
2015	10147	100.00%	0	0.00%	10147
2016	21755	100.00%	0	0.00%	21755

Source: Census and Statistics Department, CSD, 1991, CSD, 2001, CSD, 2018.

Figure 2. Completions of public rental flats, by floor area, by Lau & Wei, 2018, *Land use policy.* Copyright 2018 Elservier Ltd.

Due to the small living space, most youths who live in public housing or small flats do not have their own room. They usually share rooms with their siblings or family members. Worse still, they only have a small desk to study or study in bed. Turning on light at night disturbs the sleep of their family members, resulting in a lack of private time and space for teenagers. In such poor living condition, they often feel frustrated with their lives.

Our ambition is designing a light to enlighten their lives and make their lives better. According to The Psychology of Color (LEDs and the psychology of light and color, 2020), lower temperatures (2,700-3,000K) like yellow and orange are classified as “warm” colors. They are lighting during sunrise and sunset, deliver a relaxing and dreamy feeling to people. While higher temperatures (5,000K or more) such as blue and green are classified as “cool” colors. Lighting increases in temperature toward midday, in accordance with our body’s circadian rhythm, higher color temperatures increase our concentration and make us feel more alert. In our design, both warm-toned and cold-toned lighting are included. Customized functions are designed to suit everyone’s life, regardless of the environment, pace of life, and needs. Our goal is “one light is enough to accompany users’ daily activities at home”. More importantly, conserves the environment by “buying less lights, reduce less waste”.

This paper studies the values and needs of youths. Descriptive research is used as a methodology to deduce the relationship between palm size and product size, and investigate the placement of buttons for good user experience.

2 Our design concepts

2.1 What is user-centred design

User-Centred Design (UCD) can be defined as the process of designing an interface that put users' usability goals, characteristics, environment, tasks, and workflow at the centre. UCD follows a series of well-defined methods and techniques for analysis, design, and evaluation of mainstream hardware, software, and web interfaces to create an interface that focuses on these factors. As part of UCD, evaluation and design steps are incorporated into projects at different stages from their inception through their execution (Shawn, 2007).

2.2 How user-centred design help solve the social problem we observed

There are three social problems that we address on, which are small living space, insufficient light sources and lack of space. Each of these will be explained in the following.

- Small living space

In the limited living area, the design should be flexible and compatible. We designed the product to be flexible for using anywhere. It can be placed on tables, sticked on the walls, and clipped to the side of table or column. In addition, compatibility of the light is considered. It is free to move, users can take the light out for independent uses. It can also be attached to multiple panels. When it is placed to a panel, light mode can be shifted accordingly. To fit room environment, brightness and colour of the light can be adjusted. In this context, light size is very essential for users to hold the light comfortably. To make our design human centred, testing is used to collect data and analyse the relationships between palm size and light size.

- Insufficient light sources

Rooms in small flats usually consist of one main light or one window only. As a result, insufficient light source is commonly observed. Our product has different lighting modes, which suit for different environments, including workplaces and bedrooms. To meet the needs of users, customized functions are part of our design. The goal of UCD is to produce highly usable products (Rubin, 1984). Custom functions can improve the practicality and effectiveness of user-centred design.

- Lack of own space

Adjustable lighting meets the needs of users without affecting their family's sleep. As a user-centric design, the location of the light button is a key element. It determines the convenience of users. Therefore, we decided to conduct a short interview with users to know their preferred position for buttons. In addition, we pay attention to the ease of learning, user reviews of the product are collected.

2.3 Features of our product

We consider our product can connect to the pad panel by electromagnetism. When it connects to the panel, it lights up. There are three customized functions in our lights: (1) Brightness, (2) Light adjustment, and (3) Timer. Users can choose the appropriate brightness according to the environment. When they want to work at night, they can make it dimmer. When they use it in the afternoon, they can make it brighter. For light adjustment, users can choose the colour temperature (from Cool White to Warm White), it creates the perfect atmosphere or mood for the desired area. For instance, warm white is suitable for resting and cool white is suitable for work or study. Timer can be set to turn off the light automatically after 15 minutes, 30 minutes, 45 minutes, or 60 minutes. Our light promotes convenience living for users. For example, some users prefer turning on the light while falling asleep. With a timer, they do not have to wake up to turn off the light when they are almost asleep. These functions are crucial to enlighten users' days and nights.

2.4 Idea development: sketches

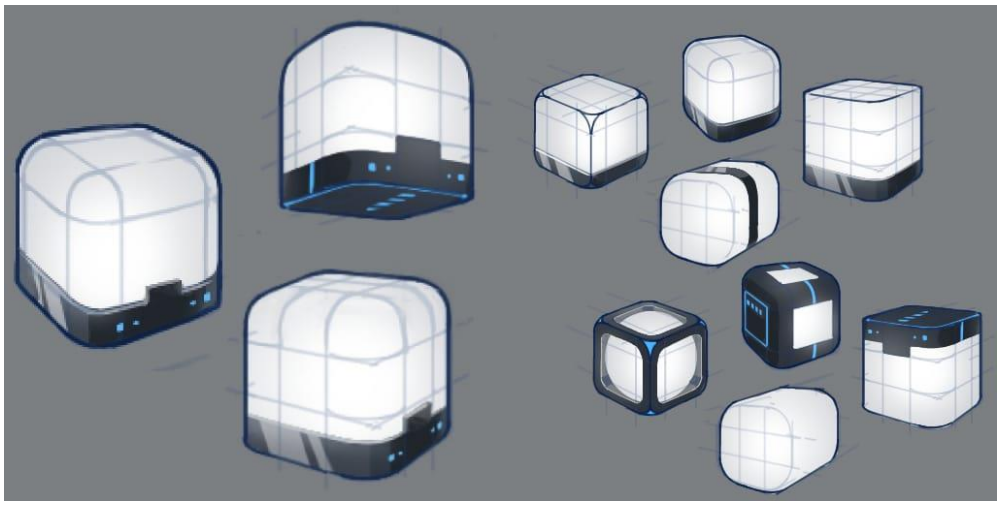

Figure 3. Concept sketches

- Form

It is geometric. According to O'Connor (2020), "shapes with straight lines and angles usually symbolise structure and order", which enhances the reliability. Users feel safe when the light is attached the pad and stacked in a corner. While circle or sphere has a free sense of movement, fails to represent stability (O'Connor, 2020). Among all shapes, cube is most ideal for (i) portability. It is easy to hold by hand for all our users, including men, women, children, adults, and even the elderly. It also outstands sphere in terms of the stability in grabbing. In emotional design, cube is more neutral, objective and unique than sphere or round shapes lights (Fussell, 2021). Therefore, in the appearance and usage of the light, the cube form is more suitable for any user. which is more suitable for use in Hong Kong rooms with small spaces.

- Lighting directions

Lighting in all directions is more beneficial than lighting in one direction. As mentioned, our key objective is “one light is enough”. When whole cube lights up, it is bright enough to support users’ activities. An additional advantage is that users are not confused with its orientation.

- Buttons

Buttons are located at the pad panel. To enhance user experience, function bar is designed for customization. Black and blue colors are used to create a calm, effective and reliable feeling.

3 Methodology

In our research, we collect primary data through descriptive research method. Primary data means the collection of first-hand information, it allows flexibility and small sampling; Descriptive research is data collection in study subject without intervening, it provides homogenous settings and accessibility (McCombes, 2021). Through the process, we amended the research approach for better outcomes: figure 4 is the photo taken in the beginning of research. It is found that participants were confused with the instruction. To improve our research approach, we sticked the 3 cubes on the board (figure 5). With fixed positions, they demonstrate their ways in grabbing and pulling the lights. We used descriptive research and short interview in both experiments.

Figure 4. 1st approach: prototype on desk

Figure 5. 2nd approach: prototypes on wall

3.1 Research for best light size

We first draw 7 cubes on a A4 paper, which are 6x6(cm), 7x7(cm), 8x8(cm), 9x9(cm), 10x10(cm), 11x11(cm), 12x12(cm). After collecting the opinions, we decided to take 8x8x8(cm), 9x9x9(cm), 10x10x10(cm) for testing the light dimension. For the sample group, we divided by the palm size. With reference to average palm size, we set it to be participants with palm size 15.0-15.9(cm), 16.0-16.9(cm), 17.0-17.9(cm), 18.0-18.9(cm) and 19.0(cm) or above. Descriptive research method is used, followed by short interview. To ensure representativeness of our research, we set sample size as 30, both male and female, left-hand and right-hand users are in sampling.
We set two hypotheses: (1) There is a relationship between palm size and preferred light size. People with larger palm size like larger light, vice versa. (2) There is a relationship between hand gesture in holding the light and their preferred light size.

3.2 Research for placement of buttons

Interviewees are given a card with all buttons we designed for the light (figure 18). They are required to place every button in their own way. Descriptive research method is used, followed

by short interview. A total of 8 users participated in the test. We aim to understand their preference through studying the patterns.

4 Data analysis

4.1 Research for best light size

4.1.1 preference of light size

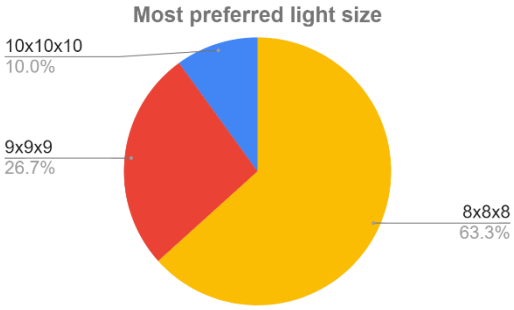

Figure 6. Most preferred light size

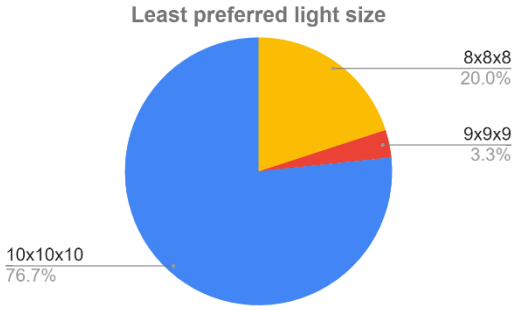

Figure 7. Least preferred light size

Over half of the participants (63.3%) choose 8x8x8(cm) cube as the most preferred option (figure 6). Over three-fourth of the participants (76.7%) choose 10x10x10(cm) cube as the least preferred option (figure 7). Two results are positively related, it shows people prefer smaller light size.
10x10x10(cm) cube is more viewed as the least preferred option than 8x8x8(cm) cube as most preferred option, with a difference of 14.4%. Participants reflect that it is too big to grab. Thus, 10x10x10(cm) cube can be opted out in our choice.

As 20% of the participants choose 8x8x8(cm) to be the least preferred light size. We further examined the distribution in groups:

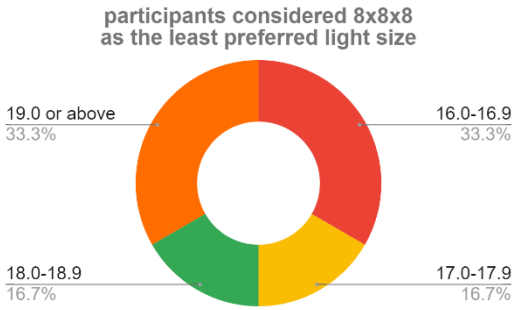

Figure 8. Distribution of voting 8x8x8

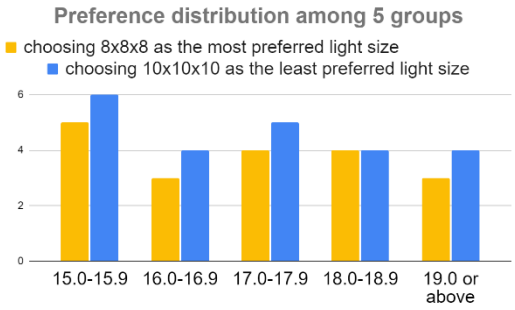

Figure 9. Least preferred light size

It is seen that the distribution of participants disfavouring 8x8x8(cm) cube is evenly distributed. Thus, it has an insignificant relationship between the palm size and their choice in this result (figure 8).

8x8x8(cm) cube is most favoured to participants with palm size 15.0-15.9(cm). It shows that the light size fits their palm size the best.

It is more favoured to participants with palm size 17.0-17.9(cm) and 18.0-18.9(cm) than 16.0-16.9(cm). This phenomenon can be explained as: participants who have larger palms enjoy

covering larger parts of the lights, thus 8x8x8(cm) cube is better than 9x9x9(cm) cube (figure 9). Therefore, the form of 8x8x8(cm) is applied to our design.

4.1.2 Types of hand gesture identified

Similar pattern in hand gesture is identified in the test. There are three most common hand gestures (figure 10, 11, 12). Among all, the most common hand gestures are gesture c (figure 14).

Figure 10. Gesture a

Figure 11. Gesture b

Figure 12. Gesture c

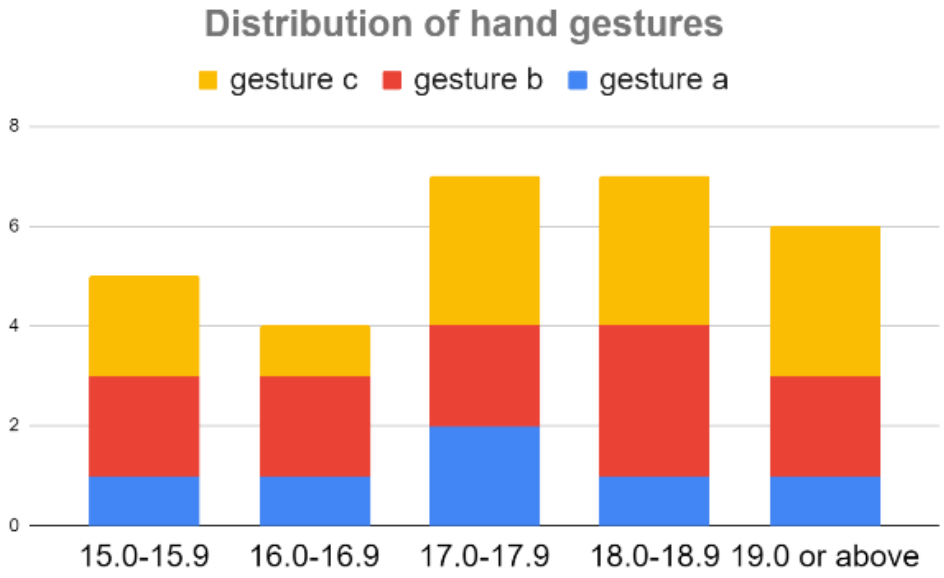

Figure 13. Hand gestures in different age groups

From figure 13, different hand gestures are found in all groups. There is no significant relationship between hand gesture and preferred light size. Hypothesis (2) is not observed.

Surprisingly, we observed that there are no big changes in hand gestures when holding the light regardless light size among most individuals (figure 14, 15). Some participants show small changes in hand gestures, while still insignificant (figure 15). It reflected that when the light size is too big for the participants, they change their hand gesture gently to for better comfortability.

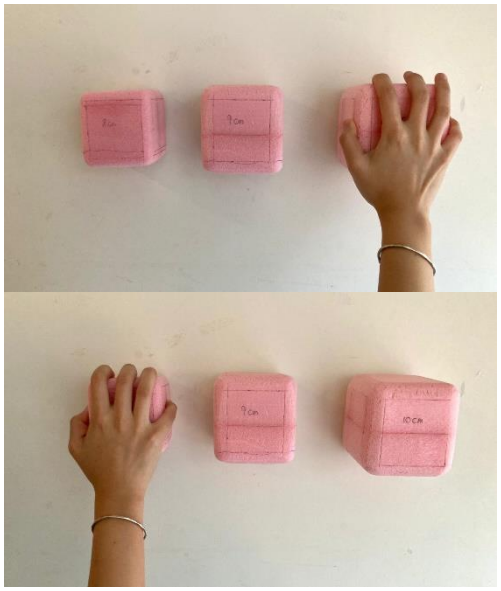

Figure 14. Palm size 15.0-15.9(cm)

Figure 15. Palm size 16.0-16.9(cm)

4.2 Placement of the light button

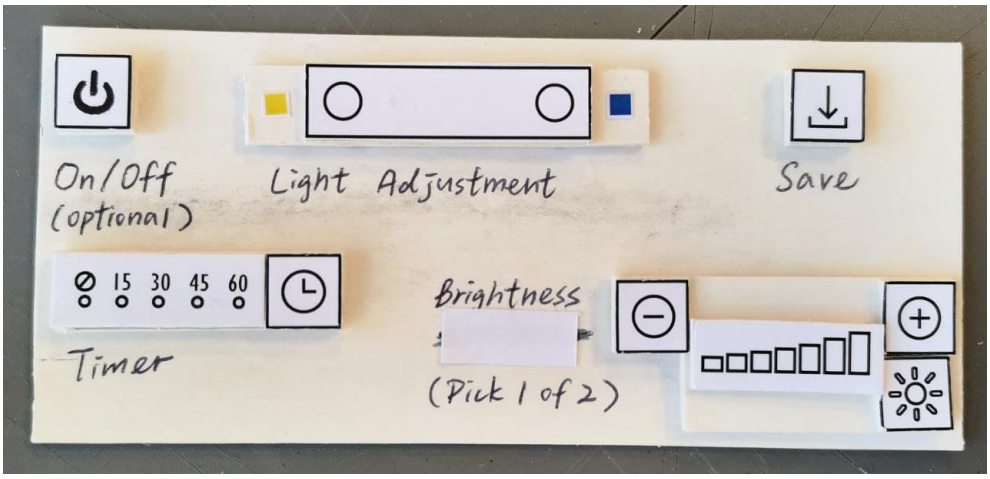

Figure 16. Buttons on a card

4.2.1 observation

Overall, participants tend to put buttons on the front view. They place the button according to their order of using the button. At the same time, 5 out of 8 users prefer no buttons on the back of the light (figure 16). Most participants put the timer button on the back, or on the right for left-handed user. This shows that participants perceive timer button as the least chance to use. For the save button on the charging panel, most of the participants place it on the right-hand side, including both the right-handed and the left-handed. One specific difference between right-handed users and left-handed users is the placement of on-off button. Right-hand users placed it on the front-right corner, while left-handed users placed it on the front-left corner.

Figure 17. How users place the buttons

4.2.2 comment from interviewees

Interviewees are asked to explain their choices and comment on the buttons: (1) On-off button and the brightness button can be combined as one. In other words, the light turns off when user presses the minus button in minimum brightness level. (2) +/- brightness button is preferable than only one brightness button. It is suggested that +/- button is easier to control the brightness (Figure 19). (3) Light adjustment button can be converted into one button if the light consists of two modes only, which are warm and cold light. (4) Gesture button can be added such that whole experience in light setting becomes smoother. (5) One right-handed user considered the direction of the light source when she was placing the buttons. Suppose light comes from left, if the light hangs on the wall, buttons for setting up, like +/- brightness button and light adjustment button, should be placed on the right-hand side for frequent changes (Figure 18). (6) Save button on charging panel provides a function to save the first setting only, users may be confused with how to rewrite the setting. It is worried that once the light attaches to the panel, it may change to the saved setting automatically.

Figure 18. How users place the buttons

Figure 19. How users place the buttons

5 Final design

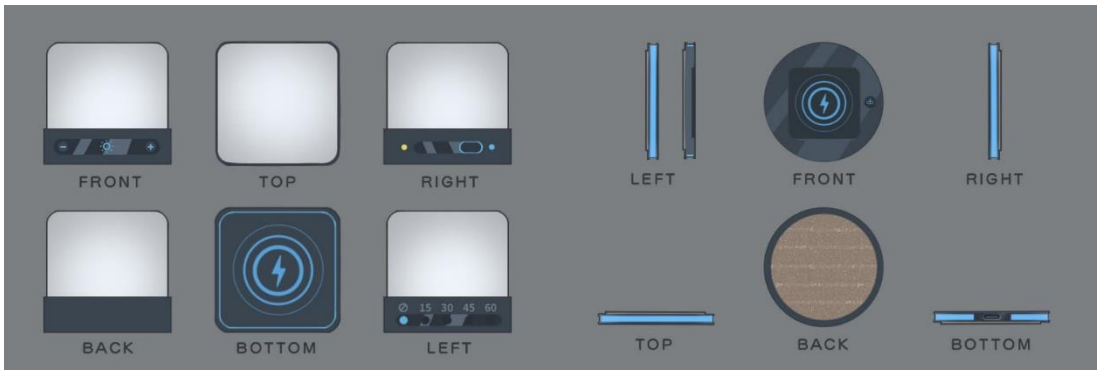

Figure 20. Final sketches

After all considerations, size and interface are further considered. Its size is smaller than traditional table lamps and with a lighter weight, regarding an adding of charging pad (figure 21). To make it more user-friendly and attain high efficiency, it is with fewer buttons. To achieve high compatibility, users can customize the brightness and light colour. It is also charged automatically once the cube is attached to the pad (figure 22). Regarding the material, polypropylene is selected. It is light, durable and uneasy to damage.

				
Brand	GRUNO	IKEA	Philips	Our Design
Size(cm)	18.8x15x15	21x13x13	40x40.1x18.5	8x8x8 & 1.2x13x13
Weight(g)	703	830	1313	650~750
Material	Glass	Glass, PU	Aluminium	Polypropylene

Figure 21. Weight and Dimension

Figure 22. User scenario

6 Conclusion

Throughout the whole research, we used the process of UCD for improving the living quality of target users. The data is representative as it includes both genders, right, and left-handed users. This led our design to be more inclusive. This palm-sized light is with high compatibility and efficiency for people who live in small living rooms, or people who need their own space. Overall, it provides our users with a better living environment.

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