The Research and the Manufacturing of a Multifunctional Sunrise Alarm Board

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Abstract
In recent years, people have become late sleepers. Many people even have insomnia and need to rely on medication. A sunrise alarm clock has been invented to help people have a better circadian rhythm and wake up with positive emotions. In this project, the sunrise alarm clock will be made into a decorative hanging board to save space and have decorative effects. The product is made based on Arduino and the previous related project. The product was evaluated through questionnaires and interviews for materials and functions. Furthermore, user feedback indicated its uniqueness and moderate performance in the awaking function. Overall, the sunrise alarm board is considered a successful product by the evaluation mentioned in the research based on participants' preferences, and we can see more possibilities for this product in the future.

Keywords
Arduin; Sunrise alarm; Sleep Inertia; Board

Introduction

There are many benefits to getting up early. Generally speaking, people are also used to waking up in the morning and prepare working or study. However, in recent years it has become increasingly difficult for people and even translates into a big problem in our health. According to the Sleep Research Association of China, more than three-quarters of interviewees claim their difficulties are falling asleep in terms of overall sleep status. More than one-third of people sleep after 1 a.m., which leads to some health problems. Due to the pandemic covid-19, people in China have a more significant amount of time to sleep. However, according to China Sleep Research Association, the overall time to fall asleep was delayed by two to three hours—the search volume about sleeping increased by 43 percent.

Technology is an essential productive force that promotes the development of our society. The alarm clock is a product of this background and penetrates our lives. Although it can be alert for people, it has many disadvantages, such as bringing anxiety, irritability, and other negative emotions. Therefore, people invented the wake-up light, the most famous of which is the product of Philips. According to the introduction page of a sunrise alarm on the website of Philips, the light intensity of the alarm gradually increases in 30 minutes to help users wake up and prepare for their new day.

Although wake-up light is already an increasingly popular product and has a complete

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and mature industrial chain, we can still find some of its shortcomings.

At present, the products on the market are all spherical or pie-shaped. I found that these shapes have become space-consuming. Typically, it needs half the size of a bedside table to place them. Consequently, I decided to do a project fixing the problem of space. Additionally, a new function including decoration too.

In this field study project, the literature review introduces the background knowledge about physiology and the relationship with light, electronic units such as LED and Arduino, and the product evaluation standard. The methodology indicates and explains the methods of design, materials choosing, testing, data collecting, and evaluation on both the board and the sunrise alarm. Furthermore, product testing uses questionnaires and interview methods. By the way, I did make a sunrise alarm decoration board due to my interest and need.

Literature Review

In terms of making a product, according to the research below, I summarized them into three principles: product principle, working principle, and design principle, which need to be considered. The product principles of this project include two main ideas--the concept of the sunrise alarm clock and the importance to the human physical body. The working principles cover and interpret theories of LED, Arduino, and some other related projects in specialized fields. The design principle involves rules and criteria for creating a brand-new product that is recognized by the public. This research lays the fundamental basis for making a sunrise alarm board while significantly influencing manufacturing.

Product Principle

Understanding the science behind the product is vital before making one.

Moreover, the significance of the product to human society will come to our minds. The previous research on the sunrise alarm clock goes back to the late 19th century. The sunrise alarm clock is more physically friendly than the typical mechanical alarm for the biological aspect.

Physiology

Waking is a crucial action at the beginning of a day. According to the research, it can influence our sleep, mood, health, and behaviours, all highly relative to our lives. Circadian physiology, sleep inertia, and hazards of the standard clock are three different factors that indicate and explain the impacts.

Circadian Rhythm

Due to the industrial revolution, people have to work from morning to night, which violates the circadian rhythm of humans affected by sunrise and sunset. Refers to an authoritative dictionary website Britannica, Circadian rhythm is a periodical 24-hour biological activity of humans. Usually, for most people, one-third of the time is sleeping, and the rest is awake. During the daytime, the retina detects light and sends signals to the brain through a series of processes. Then, the inhibition of melatonin occurs(Korf & Charlotte, 2013). In terms of the abstract of Melatonin on science direct, Melatonin is a that could regulate some physiological cycles and rhythms, and examples include sleep and wake cycle, seasonal rhythm, and circadian rhythm.

Moreover, it is helpful to people with difficulties falling asleep, according to recent research (Hardeland, 2006). Furthermore, another study also reveals that lightness and darkness can modify circadian rhythm in most mammals. The properties of light, such as intensity, wavelength, timing, and duration, have a considerable impact on the human biological clock (Duffy, Jeanne & Charles, 2009). In other words, light is a significant factor that affects our sleep and wakefulness. Both sunrise and artificial light can contribute to wakefulness.

Sleep Inertia

The transition process between sleeping and awakening is called Sleep Inertia. It can range from one minute to four hours depending on the condition. Nevertheless, sleep inertia usually does not last for more than 30 minutes if the sleep duration is enough (Tassi, Patricia & Muzet, 2000). The article ‘‘Waking up is the

hardest thing I do all day: Sleep inertia and sleep drunkenness" indicates that the main characteristic of sleep inertia is "performance impairments and sleepiness"(Trotti, 2017). Further research done by Bruck, D., and Pisani, D. L manifests the impact of sleep inertia on decision-making. They discovered that the performance of decision-making is reduced for at least half an hour (Bruck, Dorothy & Danielle, 1999).

Hazard of Noises

Alarm clocks are widely used in our daily life. Every morning, the alarm clock rings again and again, but is that good for us? Alarm clocks are harmful to the human body and are the potential cause of some illnesses, because a typical

alarm clock is at about 85 dB which is likely to damage hearing over time. For example, fast heart rate and high blood pressure. Simultaneously, the use of alarm clocks will bring distorted emotions and build up stress reacted by raising noradrenaline levels (Andrén, et al, 1983).

Sunrise Alarm Clock

The sunrise alarm clock is also called the daylight alarm and dawn simulation alarm. From a technical perspective, dawn simulation is an indispensable technology in this professional setting. The dawn simulation concept brings the idea of the sunrise alarm clock to people, using a healthier and older way to wake up in the morning. Furthermore, the daylight alarm's final entity came out in the late 20th century because of the invention of electronic units that are used. From the perspective of the purpose of the product, sunlight benefits our health and improves sleep and wakefulness. In the current stage, artificial light can imitate sunlight and even the state of sunrise or sunset.

The benefit of Dawn Simulation

Dawn simulation is a technology that has a positive impact on alleviating sleep inertia. A recent study shows the promotion of positive emotion, alertness, attention, and inhibition between the transition period of sleepiness and awakening(Zhu et al, 2020). In addition, dawn simulation is used in the treatment of SAD(Avery & David et al, 2001).

Benefit of Light

Most people just heard about the benefit of sunlight on human health from their parents. The fact is sunlight does bring many benefits to humans. Exposure to sunlight promotes releasing of serotonin (Nall, 2018). Serotonin is a biogenic amine that regulates depression and anxiety (Baldwin & Rudge, 1995). Studies reveal that the artificial sunlight emitted by LED promotes the release of melatonin, providing better visual comfort, and improving mood and well-being (Cajochen et al, 2019).

Working Principle

Learning the working principle of the materials and models is the first step in design and manufacturing. The working principle brings the ideas and lays the fundamental basis of every product. Without knowing it, the product will have some fatal systematic errors. The working principles of LED and sunlight simulation are introduced below.

LED

A Light emitting diode is an electric component, or semiconductor, that releases light as the electricity flows in the circuit. When current passes through, the electrons recombine with holes emitting light in the process.

Sunlight Simulation

The dawn simulation was proposed and patented. This is a technique invented to imitate sunlight by using artificial light. The entity of sunrise alarm clock was invented after the invention of its electronic units in 1973.

Arduino

Arduino is a simpler and more convenient electronic platform, that was made in Ivrea Interaction Design Institute, compares to Raspberry pi, It has its own libraries of hardware and software. In addition, its programming language is provided freely. Arduino is intelligent that is able to board works by receiving a set of instructions from the microcontroller on it.

Hardware

The statement indicating Arduino is a

microcontroller is not accurate. The Arduino board consists of many components. For connecting, a USB plug and external power supply are included. For input, reset buttons, pins of analogue, digital, and power are used. For output, a microcontroller and in-circuit programmer can work (Badamasi & Abdullahi, 2014).

Design Principle

The intention of the design is the most essential part of the first stage of the project. Designers or makers have to be clear about their goals and ways to achieve them. It helps to make decisions and increase efficiency.

MVP vs MMP vs MLP

MVP, MMP, and MLP are all different types of products that designers might aim to make. Minimum Viable Product, MVP, is a fast-designed product that is also cheap and built completely based on ideas. MVP only indicates the need, so it is considered not marketable. Minimal Marketable Product, MMP, is relatively cheap and marketable because it is designed to solve a practical problem in our lives. Minimum Lovable Product, MLP, is the most relevant product to the ideas that can also build an emotional connection with users (Svitlana, 2019).

Evaluation Method

According to the article "7 essential design principles for product managers" posted on the Medium website, users' experiences definitely occupy the largest section of evaluation (Latif, 2018). If a design is not easy for users to operate, then it might be considered a failure.

Methodology

In this section, the design separates into two different parts. One is the decoration board, the other one is the sunrise alarm clock. In each part, the design idea, materials used, method of testing, result, and evaluation are covered.

Board

Designing, Material choosing, a questionnaire, and evaluation are involved. I designed the board based on the functions needed and my personal preference. In terms of materials, the most common types of materials used for lamps or sunrise alarm clocks are compared from different aspects. The questionnaire is designed according to previous studies (Krosnick, 2018). I post my questionnaire on two different mainstream social networking sites in China powered by "wenjuan.com", a professional survey builder website. The survey is helpful to learn about market preference.

Design

Board is the carrier of the sunrise alarm. Also, it is required to be hangable. Therefore, as the main feature of the board, the ability to carry and even store things is important. More than that, the size of the board is designed to be relatively small. Apart from those two features introduced above, another essential idea is to bring a decoration function to the users. Thus, the material used should be considered both in designing and choosing. Finally, in order to show the function of decoration, extra space for decorating is essential.

Material

There are four main types of light shade in the market. They are pc, acrylic, glass, and fabric. In preparation for choosing materials, three features are necessary to consider: Temperature resistance, light transmittance, and appearance. More than these, density and firmness are also vital.

Method

Aim

Refers to the design principles, the decoration board should be user-friendly and highly relevant to the initial idea of this project. Therefore, a questionnaire is made to estimate the preference of the potential users.

Target group

The target group of users is females aged approximately 15-25. Therefore, I conduct the survey on two main social media in China, called Weibo and Douban. According to the"2020 Weibo User Development Report", Weibo has about 80 per cent of users were born between 1990 to 200925. The white paper posted indicates that 60 per cent of Weibo users are female26. For Douban, the proportion of

females and males is balanced. However, I conduct my questionnaire in two specific groups: the audience group of a male idol survival show and the makeup group, which have many more female users than male on average.

Questionnaire

The questionnaire was designed to be fair and simple. Because the purpose is to figure out the public preference for the light shade and for the board to evaluate my product.

This questionnaire mostly provides people to rank materials based on their background knowledge. This avoids the awkward situation that people cannot choose what they exactly want or their personal opinion is between two choices. Furthermore, I designed a question that repeat twice to avoid the ineffective answers used in my evaluation25. If I get two different answers I will consider it a failure.

For the choices I only give 5 different types of materials, because most people do not know about many materials deeply, controlling the number of answers could help them easily finish the questionnaire and the data would be more valid.

Result & Evaluation

There are 37 data collected. 32 are data effectively collected.

The result is shown in the diagram below

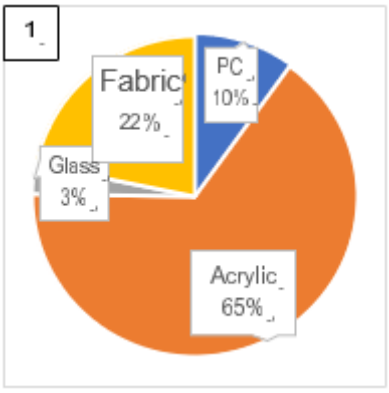

Figure 1. Percentage of people who choose materials for light shade

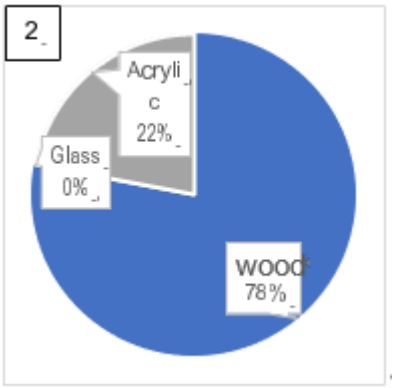

Figure 2. Percentage of people who choose materials for the board

The data collected for materials of the light shade is close to my hypothesis. Due to the consideration of light transmittance, firmness, temperature resistance, density, and appearance, glass is excluded in most cases. I also discovered that many people do not know what is pc, which is polycarbonate plastic. It has greater impact resistance than acrylic plastic, but it is less light translucent. It is quite surprising that fabric gains more votes than pc. But it is also reasonable, in terms of normal users, that the frequency of using fabric in light shade is more than polycarbonate as they cannot recognize the materials when it is polycarbonate.

Unexpectedly people prefer wood about 3.5 times more than acrylic. One of the factors might be the frequency of use of the materials in our daily life. Due to the experience accumulated, people tend to trust what they see and keep using the same material.

As result, the questionnaire shows the preference of my target group of potential users. I found it close to my hypothesis for the light shade but not the board. Due to the design principles, I evaluate my board based on the questionnaire and the actual properties of the materials. Here is my success criteria table (standard) made for the board.

Table 1. Success criterion of the material of the board.

Grade	Performance	Public preference
0-2	Poor performance in features that must be considered.	Only a few people choose the materials for either light shade and board.
3-4	Moderate performance in features that must be considered.	More than 30 percent of people choose the materials for either light shade and board.
5-6	Best performance in 1 feature that must be considered.	More than 50 percent of people choose the materials for either light shade and board.
7-8	Best performance in more than 1 feature that must be considered	More than 50 percent of people choose the materials for both light shade and board.

According to the standard table above, I would give acrylic which is the material that I chose for the board a 7 for the performance since it has a good light transmission and temperature resistance. Also, it can be used as a whiteboard, so it is more functional than others. For the public preference, I would give a 6 based on the data collected. Overall, the material I chose could get an average of 6.5 out of 8. It's at the upper middle level.

Sunrise Alarm

A sunrise alarm is a professional product that requires more background knowledge and experience than the board. Therefore, I made it based on different project posts online, in order to ensure safety and success. As I said, most of my design of the sunrise alarm is based on previous projects and patents. I evaluate many different projects and choose the advantages to combine. Materials are limited, except the Arduino board, LED, and ways to connect the power supply. The materials used could not make a lot of changes. For the programming, I also learned programs from others, but I wrote my own code to control the LED. The method I used for testing the sunrise alarm is inviting volunteers to experience and give their feedback.

Design

Due to the particularity of the sunrise alarm, I need it to be light and small, and long.

Therefore, I chose an LED strip as my material. In order to match the Arduino board, I used a 5v LED. Furthermore, two colours of LED are used to imitate the sunrise: white and natural light.

I select all other materials based on other projects because most of the projects used similar materials which indicates that to do this project those electronic units are the only or the best to function.

The main component included Arduino UNO, MOSFET N-channel, RTC, breadboard, wires and LED. Since I am doing a decoration board, the Arduino cannot connect to the laptop for the power supply. Therefore, a 9v battery is used for the external power supply. Moreover, strips are required to solder together, in order to connect the Arduino board. LED strips are soldering based on their colours.

Programming

I code the program on the official software Arduino. It contains plenty of libraries that provide users to manipulate and program the Arduino more conveniently. The library I included is RTC lib, which is for the clock of the LED. Except for the library included, we only need to set the time and control the time that the LED starts to light up.

Method

Aim

The sunrise alarm should be functional and user-friendly. All the content of the interview is based on the experience of the volunteers. The aim is to see to what extent users feel comfortable with the sunrise alarm that I made and get some feedback to improve.

Volunteers

Due to the size of the sunrise alarm board, I invited volunteers around me to test the product. 6 females and 1 male are included. 5 females aged between potential users 1525. 1 female and 1 male aged between 45-50 for testing the functions of the alarm and also comparing the difference in needs between two age groups of people.

Volunteers are separated into three groups. The separation is made based on their living. The first group is two females aged 15-25. The second group is a female and a male aged 45-50. The last group is three females aged 15-25.

Interview

For the first two groups, they have 2 days to

experience the product. The last group, they have four days to use the product. I did previous research about their wake-up times. I also ask them to sleep at the same time during the testing (about midnight). I redefined the wake-up time and time of light gradually turning bright set for different volunteer groups based on their habits.

After testing the product, I ask some regular questions to each group of volunteers.

Result & Evaluation

Terms of group 1, they are students currently studying at University in the UK.

However, in view of the fact that the pandemic is not fully under control, they chose to stay in China and have online classes at home. This leads to a different circadian rhythm compared to other people who live in China. This might be a crucial factor that makes them harder to fall asleep and wake up. As the result, the time they wake up is different every day.

With regard to their feedback, their wake-up-time range narrowed from three hours to an hour in 2 days, which means they might have a more regular time schedule. However, they think the light could be more intensive. Besides, adding audio with the gradual light might be helpful.

In terms of group 2, they have regular biological clocks. After using the product, they suggested the function of the sunrise alarm changes their wake-up time, but they feel more relaxed using the sunrise alarm clock.

In terms of group 3, they had a longer period of testing, they suggested that the product could be thinner and lighter for females to carry. In the respect of the sunrise alarm, they said they were more pleasant when waking with the LED light. Moreover, during the testing, all of them felt soberer more quickly than they used to be in the morning.

Apart from the function of the sunrise alarm, the board provided space for announcements and messages. According to the interview from group 2, they claimed that in the morning the one who goes to make breakfast or leaves home could just stick a sticky note to remind another one, instead of texting on the phone, which makes a ring that might wake people up. Other female volunteers suggested that they put the photo of themselves and their families on the board, and some photos of their favorite celebrities too.

Overall, the product is considered to be a user-friendly product. It has more functions and satisfies the needs of the users. However, it still has some shortcomings compared with a mature product made by a company. Materials used should test and evaluate more times.

Conclusion

In conclusion, the product of the sunrise alarm board is successfully created. It has two main functions: waking people up and decoration. In terms of the material of the board, according to the result of the questionnaire, most people prefer acrylic as what I used, and some people prefer fabric, such as silk, and cotton as the material of light shade, because of the light and shadow effect created.

Therefore, the choice made on the material is considered to be favorited by the potential users.

Refers to the feedback from the volunteers, the product is considered to be a usable and generally nice sunrise alarm. The combination of the alarm and the decoration board is mostly acclaimed by female volunteers aged between 15-25. Due to the target user of the product set, only one male volunteer is invited and he gave a moderate comment on the function. The suggestions from the volunteers indicate that the intensity of the LED light emitted should be higher, the testing duration needs to be longer, and the decoration board is too thick.

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