Extended Essay:

How do Internet of Things based smart lighting products impact the lives of adolescents (15-18 year-olds) and adults (35-55 year-olds)?

Group 3: Information Technology in a Global Society

Word Count: 3989

PIN Code: fjy477

Abstract

I had the opportunity to intern at Philips Lighting during the summer of 2016. My internship allowed me to acquire experience on how a smart lighting product was conceived and built, and learn about the applications that a smart lighting product could generate. The combination of this internship and my interest in IoT led to my investigation on how IoT-based smart lighting products impact people's lives.

My research question is *"How do Internet of Things based smart lighting products impact the lives of adolescents (15-18 year-olds) and adults (35-55 year-olds)?"*

One of my primary sources is a survey of 42 adolescents and 40 adults who answered 10 questions on the environmental, economic and social implications of smart lighting products in their lives. I also interviewed two Philips Lighting senior executives to receive greater insights on the IoT smart lighting market and products. Furthermore, reliable websites on the Internet are used for my secondary research.

IoT-based smart lighting products impact adolescents and adults in many different ways. Both adolescents and adults recognize the benefits of energy-saving IoT smart lighting products while the solution is to increase the awareness of such benefits to adolescents and to create energy-saving standards for smart lighting products. Also, since adolescents and adults have different levels of price sensitivity toward smart lighting products, it would be best to segment the market and create different levels of applications and functionalities for adolescents and adults to overcome the high price challenge of smart lighting products. Moreover, there is a significant impact of smarting lighting in improving people's studying and working efficiency, as well as their social interaction. Thus, I have proposed to create more adult-oriented applications to overcome the challenge of how the impact that such products have on people's social interactions is relatively low.

Word Count: 298

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Introduction

With the ever-increasing amount of new technologies that are introduced to us everyday, it is important to consider the environmental, economic, and social implications of the impact that new technology has on us. Internet of Things (IoT), a hot topic emerging in recent years, has the potential to largely impact the way we live and work. In the past, IoT technologies focused on industrial application the most, but now, there are more and more human-centric IoT technologies that help humans connect smart devices to receive a better user experience.[1]

The new IoT technologies emphasize on generating new applications by creating unique user experiences. Because of this, IoT in the lighting industry has become a trend. IoT enables the integration of sensors, wireless connectivity modules, and lighting devices such as luminaires and lamps. By connecting to Internet, new kinds of applications and services emerge. For instance, light bulbs and luminaires that are connected via Internet do not only interact with each other, but also with human beings. Through smartphone apps, users can control the light remotely or let the light automatically adapt to the environment to meet their needs.[2]

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[1] Wilson, James H. "How People Are Actually Using the Internet of Things." Harvard Business Review, Harvard Business School Publishing, 28 Oct. 2015, https://hbr.org/2015/10/how-people-are-actually-using-the-internet-of-things.

[2] Control4. "Smart Lighting." Control Systems, Control4, 2016, https://www.control4.com/solutions/smart-lighting.

As IoT technologies make lighting products smart and they bring brilliant applications to users, I want to investigate how they affect our lives. I am greatly interested in Internet of Things. I had the opportunity to intern in Philips Lighting, the world leading lighting company in the summer of 2016. During my internship, I had the opportunity to be a part of IoT smart lighting development team that allowed me to acquire some experience on how a smart lighting product was conceived and built as well as the new applications that a smart lighting product could generate.[3] The combination of this internship and my interest of IoT led to my research question, "How do Internet of Things based smart lighting product impact the lives of adolescents (15-18 years old) and adults (35-50 years old)?" I am questioning the environmental, economic, and social implications of IoT smart lighting products in their lives in both positive and negative ways. In this essay, 'adolescents' refers to 15-18 year-olds who are engaged in education, and 'adults' refers to 35-50 year-olds who is in employment.

I am interested in investigating IoT in the field of lighting, as light is an essential part of our life. I wonder if IoT smart lighting products conserve more energy than traditional lighting products. Moreover, in order for everyone to enjoy such products, lighting companies need to understand what price the users can accept, and thus the economic affordability of such products needs

to be considered. I am also keen to understanding how IoT smart lighting products can improve adolescents' and adults' quality of life by increasing their studying efficiency or working efficiency, changing their lifestyles. In addition, I am curious to find out whether IoT smart lighting products can improve adolescents and adults' social connections or not.

For the research component of my essay, I have done both primary and secondary research. I have surveyed 42 school students, aged between 15-18, and 40 adults from two companies, aged between 30-55, in Shanghai, China. In addition, during the summer of 2016, I interned at Philips Lighting Research Center for a month, where I participated in a group project for IoT smart desk light's UI development. This internship allowed me to acquire some concrete experience on how Philips Lighting develops user cases for IoT smart desk light to maximize the benefits for users from the perspectives of energy saving, competitive price, and new applications to improve user experience. During this internship, I interacted with the colleagues of my project team. Moreover, I also had the chance to contact and interview Olivia Qiu, the Chief Innovation Officer of Philips Lighting[4], and Hakan Yuce, the Vice President and Head of Ventures of Philips Lighting[5], which helped me gain great insights on the implications of Philips Lighting IoT smart lighting products on people's lives,

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[4] Appendix A: Interview with Olivia Qiu

[5] Appendix B: Interview with Hakan Yuce

which is associated with my research question. Furthermore, I have also used reliable websites on the Internet for my secondary research.

The essay will conduct an analysis and comparison of the environmental, economic and social implications of IoT smart lighting products in the lives of adolescents and adults. As I research about both the benefits and challenges of using such products, I also proposed solutions to overcome the challenges.

Chapter 1 What is IoT based smart lighting?

Hundreds of millions of computers in the world are connected, and every computer has a small storage that can gain access to information. As we receive and send all sorts of information, we are capable of learning much faster through the efficient exchange of information. This, the Internet, has shaped the way we live today. The next generation of Internet — Internet of Things, is not only about getting people connected, but also about getting things connected via the Internet. Widely credited to Kevin Ashton, this term refers to devices sensing the real world using sensors and acting accordingly based on the sensed data.[6] In this way, information is consumed and processed by machines to improve the qualities of our lives.

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[6] Duncan, Geoff. "You Can't Avoid the 'Internet of Things' Hype, so You Might as Well Understand It." Digital Trends, Digital Trends, 24 July 2014, http://www.digitaltrends.com/home/heck-internet-things-dont-yet/.

IoT mainly works through radio frequency identification technology (RFID). The devices contain small RFID chips, and they use radio waves to send information as RFID readers. The IoT also uses smartphones and sensors embedded in the devices to communicate with each other.[7] Each device is given an ID, or an IP address, and they are given sensors that act like a human's five senses. The sensors will then capture information, and through a network, connect to the Internet. For instance, a light sensor detects environmental light and may even capture both visible light and depth data. Subsequently, the device can save information on the ID, and through the Internet, the information can be saved on a cloud, which has unlimited space. Essentially, smart devices communicate with each other to create a giant network of interconnection. Ideally, users can use a central hub that serves as a control point for many different devices, no matter where they are.[8]

IoT based smart lighting product can be defined as lighting product that embeds sensors to allow data exchange and connectivity module to connect to Internet are defined as IoT smart lighting products. The IoT smart lighting products are connected over Internet. They can be controlled remotely by a remote controller or a smart phone and also interact between them as well as

[7] CNN. "Explainer: What Is the 'Internet of Things?'" CNN, Cable News Network, 4 June 2013, http://www.edition.cnn.com/2012/12/04/business/leweb-parallax-internet-things/index.html.

[8] Coldewey, Devin. "New Samsung Sensor Captures Both Light And Depth&Nbsp;Data." TechCrunch, AOL, 29 Feb. 2012, https://techcrunch.com/2012/02/29/new-samsung-sensor-captures-both-light-and-depth-data/.

with human being to provide the new applications that can't be done by traditional lighting products.

## Chapter 2 IoT smart lighting applications

IoT has many applications in the field of lighting. For example, with motion sensors, the light can turn on when a person walks in a room, and vice versa; with light sensors, the light would adjust accordingly to the natural light for eye care, and users can control and adjust their light via the Internet through computers or smartphones, or televisions.[9] When you put a smart lamp beside your bed, your light can detect the environment and know the time; therefore it will turn on dimly to avoid hurting your eyes. One can also change a group of lights' color dramatically, including different 'scenes' that could fit your mood, and the brightness of the lights would also be adjustable to the user's liking. Lights could also send reminders by flashing urgent amber, or even help the user find his smartphone by detecting its Wi-Fi signature, which later signifies the user. In this way, the light augments your lifestyle, as it adds on to your health and happiness. Lighting can affect your mood, and it can also impact many other aspects of your life. Besides this, there are lights that have a "vacation mode", which will prevent burglars from targeting the house, as the

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[9] Kho, Jennifer. "The Next Wave in Lighting and the Internet of Things." Forbes, Forbes Magazine, 20 Oct. 2012, http://www.forbes.com/sites/jenniferkho/2012/10/20/the-next-wave-in-lighting-and-the-internet -of-things/.

house appears to have people living in it due to the lights. This implies that the user can control the lights anywhere, at any time. For entertaining purposes, room lights could also change accordingly to fit the atmosphere of the TV show or movie the user is watching. Currently, Philips is already selling its Hue smart wireless units that offer smart light bulb functionality.[10]

The following are some examples of Philips HUE home smart lighting mobile applications.[11] Philips HUE lighting bulbs or luminaires can generate up to 6 million colors for users to set all kinds of lighting scene (Image 1); the bulbs can also interact with music (Image 2); they can also be controlled by the smart phone through voice (Image 3). There are already more than 400 these types of applications that are created to service HUE's users.

Image 1: Lighting scene setting on Philips HUE via smart phone apps[11]
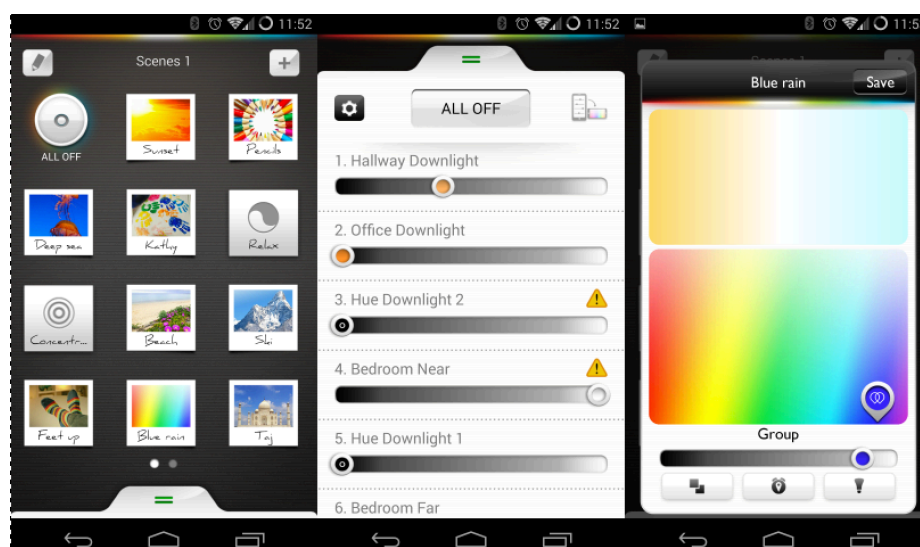
[10] Eaton, Kit. "The Internet Of Things Is People, Innovating." Fast Company, Fast Company, 23 Nov. 2012, https://www.fastcompany.com/3003336/internet-things-people-innovating.

[11] Albright , Dann. "8 Fabulous Apps for Philips Hue Lights." MakeUseOf, MakeUseOf, 20 Mar. 2015, http://www.makeuseof.com/tag/8-fabulous-apps-philips-hue-lights/.

Image 2: Light interacting with music on Philips HUE via mobile apps[11]
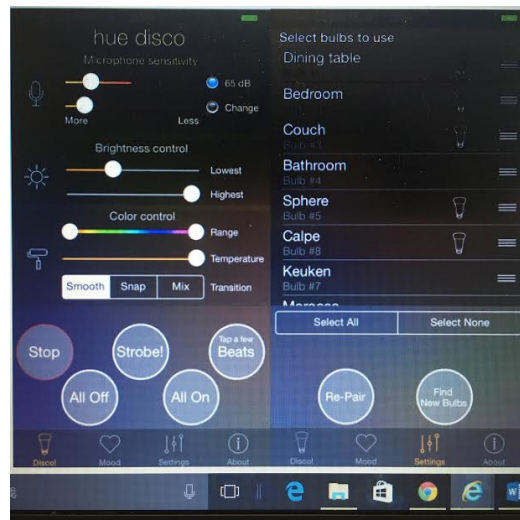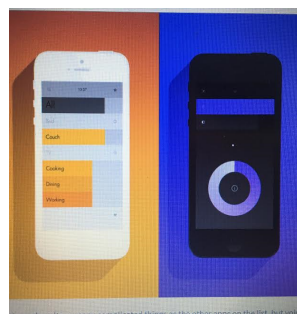

Image 3: Voice controlled light on Philips HUE via smart phone apps[12]

Chapter 3 Environmental implications of IoT smart lighting in people's lives

Our planet needs more energy. With the United Nations predicting world population growing from 6.7 billion in 2011 to 8.7 billion by 2035, the energy demand increases substantially over that period. With both the population growth and the increase of living standards for people in developing countries,

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[11] Albright , Dann. "8 Fabulous Apps for Philips Hue Lights." MakeUseOf, MakeUseOf, 20 Mar. 2015, http://www.makeuseof.com/tag/8-fabulous-apps-philips-hue-lights/.

[12] Albright , Dann. "8 Fabulous Apps for Philips Hue Lights." MakeUseOf, MakeUseOf, 20 Mar. 2015, http://www.makeuseof.com/tag/8-fabulous-apps-philips-hue-lights/.

the world will face the challenge of the shortage of energy supply. One of the most significant energy is electricity. It is estimated that electricity demand is increasing twice as fast as the overall energy use and is likely to rise by more than two-thirds from 2011 to 2035. In 2012, 42% of primary energy used was converted into electricity.[13] As Olivia Qiu said, "It is crucial that we build more and more energy-saving product to contribute to overcome the challenges of the increase of electricity demand, as lighting accounts for approximately 20% of total energy consumption".[14]

Although smart lighting has a lot of different kinds of functions available, it is mostly energy-efficient. Dan Utech mentioned that smart lighting system could save up to 70 percent of energy costs with dimmable LED street lighting.[15]

From a total of the 82 people whom I surveyed, 65 of them have the experience of using IoT smart lighting products. I excluded the 17 people who have no experience with smart lighting products. Out of these 65 people, 42, or

[13] World Nuclear Association. "World Energy Needs and Nuclear Power." World Energy Needs and Nuclear Power, World Nuclear Association, 13 Oct. 2016, http://www.world-nuclear.org/information-library/current-and-future-generation/world-energy-needs-and-nuclear-power.aspx.

[14] Appendix A: Interview with Olivia Qiu

[15] Utech, Dan. "Launching the Presidential Challenge for Advanced Outdoor Lighting." The White House, The White House, 23 Jan. 2015, https://www.whitehouse.gov/blog/2015/01/23/launching-presidential-challenge-advanced-outdoor-lighting.

65% of them, mentioned that smart lighting products had some impact on energy saving; 26% of them experienced great impact of smart lighting products on energy saving while only 9% of them noticed no impact.[16]
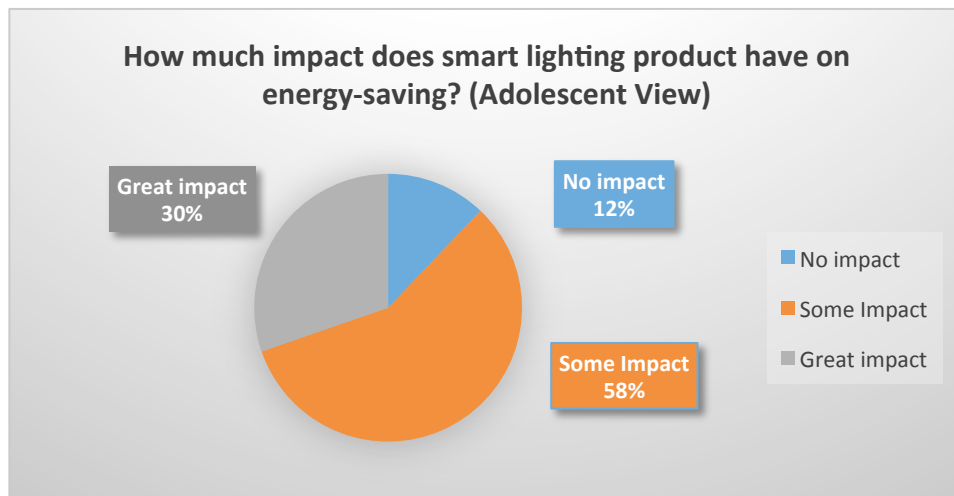
Figure 1. Impact of smart lighting on energy saving (Overview)
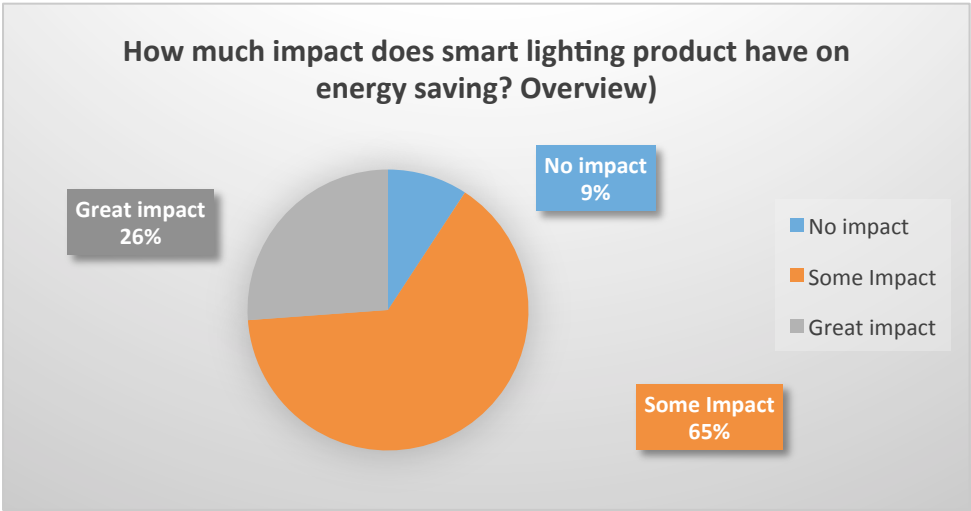
From the 42 adolescents whom I surveyed, 33 of them have the experience of using smart lighting products, out of 33, 88% of them mentioned that smart lighting products had some impact or great impact on energy saving, only 12% of them notices no impact.

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[16] Appendix C: Survey Results

Figure 2. Impact of smart lighting on energy saving (adolescents view)

How much impact does smart lighting product have on energy-saving? (Adolescent View)

- No impact 12%
- Some Impact 58%
- Great impact 30%

From the 40 adults whom I surveyed, 32 of them have the experience of using smart lighting products; out of those 32, a total of 94% of them mentioned that smart lighting products had some impact or great impact on energy saving, only 6% of them noticed no impact.

Figure 3. Impact of smart lighting on energy saving (Adults view)

How much impact does smart lighting product have on energy-saving? (Adult View)

- No impact 6%
- Some Impact 72%
- Great impact 22%
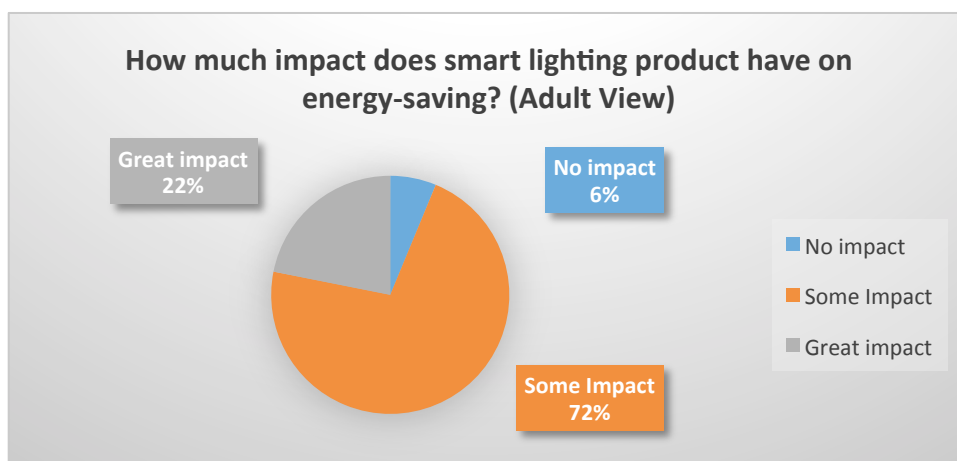
Results show that both adolescents and adults clearly experienced the impact of energy saving when using IoT smart lighting products, and overall, there are no significant difference on the total number of people in both groups who experienced energy saving (88% for adolescents vs. 94% for adults). It is interesting that 30% of adolescents mentioned that smart lighting brought great impact on energy saving while this number is lower with adults that is 22%.[17] This is because adolescents and adults have different levels of understanding and opinions about this topic.

Chapter 4   Economic implications of IoT smart lighting in people's lives

Smart light bulbs that are used at home, with prices like $60 for Philips Hue lights, are expensive for many. Before smart lighting became prevalent, in 2015, a small bulb entered the market with $19 as its selling price, contrasting the $50+ norm for the smart light bulb market. So, what is the price affordability for IoT smart lighting products?

The survey shows that overall, the majority (57%) of people surveyed voted for 10-30% price difference that is acceptable between smart lighting products and non-smart lighting products, followed by 20% who voted for 30-50% price difference. It is interesting that 14% of people mentioned that the

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[17] Appendix C: Survey Results

price difference between the 2 types of products should be smaller than 10%.

Figure 4: Price affordability of smart lighting products vs. non-smart lighting products (Overview)
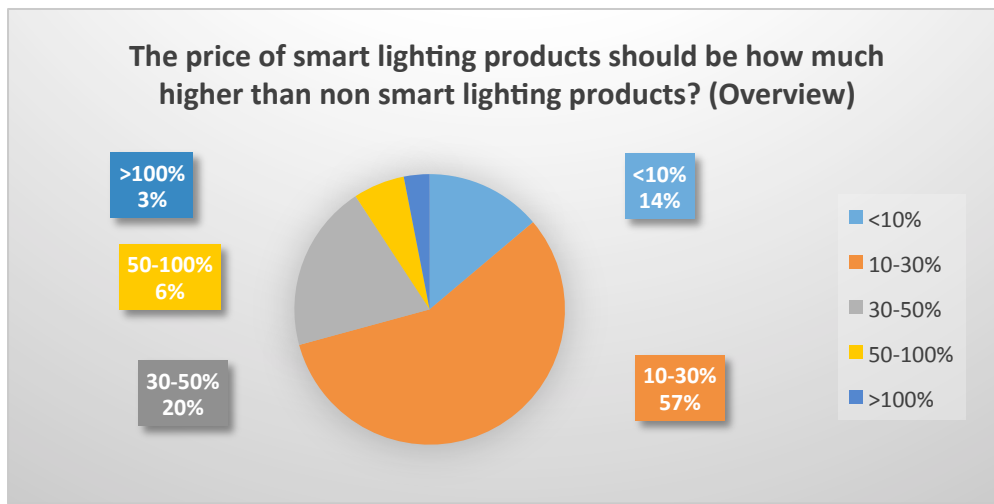
A large number of adults (62%) fell into the range of 10-30% price difference of the two types of products versus 52% for adolescents. There is a significant gap between the view of adolescents (27%) and adults (only 13%) in the range of 30-50%; 6% of adolescent voted for >100% price difference of the two types of products while 0% vote for adults. The percentage of the people who could accept the price difference between the two types of product to be smaller than 10% are 19% for adults and only 9% for adolescents. This

could be interpreted that adolescents might see more values of smart lighting

products than adults and thus are willing to pay higher price.[18]

Figure 5: Price affordability of smart lighting products vs. non-smart lighting products (Adolescent View)
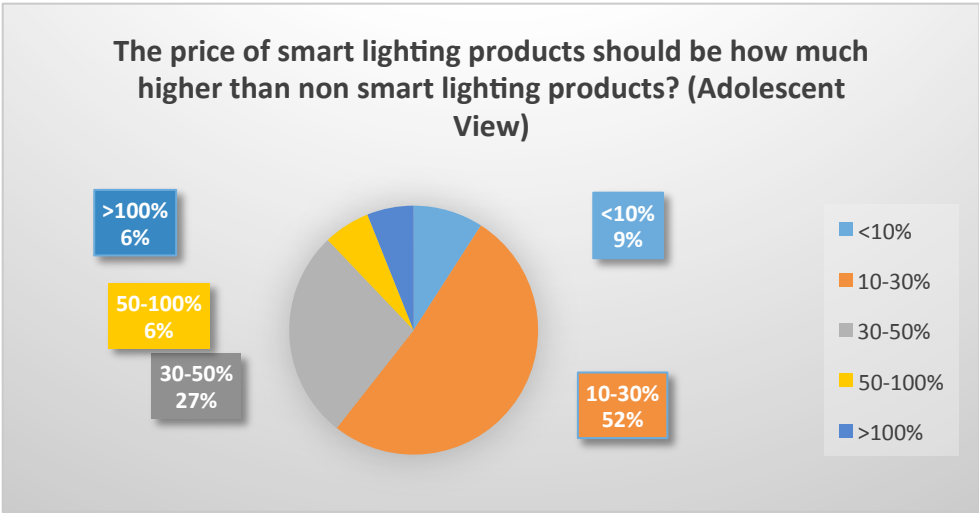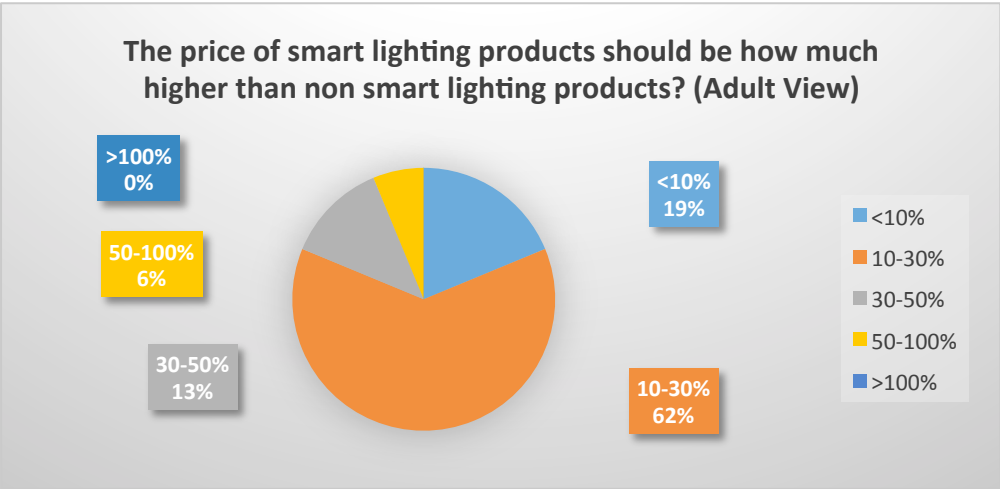
The price of smart lighting products should be how much higher than non smart lighting products? (Adolescent View)

>100% 6%
50-100% 6%
30-50% 27%
<10% 9%
10-30% 52%

- <10%
- 10-30%
- 30-50%
- 50-100%
- >100%

Figure 6: Price affordability of smart lighting products vs. non-smart lighting products (Adult View)[19]

The price of smart lighting products should be how much higher than non smart lighting products? (Adult View)

>100% 0%
50-100% 6%
30-50% 13%
<10% 19%
10-30% 62%

- <10%
- 10-30%
- 30-50%
- 50-100%
- >100%

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[18] Appendix C: Survey Results
[19] Appendix C: Survey Results

Chapter 5 Social implications of IoT smart lighting in people's lives

5.1 IoT smart lighting impact on people's studying and working efficiency

As the everyday lives of modern day people paces faster, there is a need for tools that will lead to higher efficiency for both adolescents and adults. When people become more efficient in their life, the quality of their life also improves. While adolescents may need to prepare for their future through tests and exams, adults need to work for a living. Hence, an efficient lifestyle is ideal for many, as more work can be done in less time.

Researchers of University of Toronto assert that humans perform better under different types of light during various hours in a day. For example, "a sunlight-like spectrum of cool white light increases productivity during the day, and a warmer incandescent light help increase melatonin production ensuring a calm, good night's sleep".[20] This means that lighting can influence a person's efficiency. In addition to making the user sense different types of light, there are companies who aim to protect the customers' eyes. For instance, the

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[20] Goldberg, Brianna. "Lighting Brighter: 6 Ways Smart Sustainable Lighting Transforms Cities, Health, Business and the Environment." University of Toronto, University of Toronto, 13 Aug. 2014, https://www.utoronto.ca/news/lighting-brighter-6-ways-smart-sustainable-lighting-transforms-cities-health-business-and-environmen.

Philips EyeCare Blade Desk Lamp is a lamp that protects the user's eyes. Using a light that is diffused and evenly distributed across the workspace, the customers' eyes will not feel tired, as uneven lighting or dazzles are reduced. The reduction in glare and eye strain ultimately leads to a comfortable workspace that supports optimal eye comfort. As this kind of lamp mainly targets students who work on desks over long periods of time, the lamp also has a concentration mode where the light would have a cool daylight color temperature of 5500K and up to 100 lux. This maintains the energy levels of the user with natural light levels.[21]

The researchers of the Fraunhofer Heinrich Hertz Institute have investigated on the impact of adjustable light on learning performance in schools. The classrooms have been illuminated with light at 12.000 Kelvin and 650 Lux in the morning to support the production of the hormone Cortisol which energizes the body, and a light with around 2.700 Kelvin and 300 Lux in the afternoon to support the production of the hormone Melatonin, which calms the students down. The results show that the students being experimented has made 45% less mistakes, increased reading speed by 30%, and reduced restlessness by 75% (Blankenberg).

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[21] Philips. "Eye Care Table Lamp." Philips, Koninklijke Philips N.V., http://www.mea.philips.com/c-p/674228716/eyecare-table-lamp.

The results of our survey show that overall 88% of people experiences the increase of their studying or working efficiency by using IoT smart lighting products. This percentage is very high in adolescents (94%) vs. 84% with adults. My survey seems to confirm that smart lighting could improve people's studying and working efficiency.

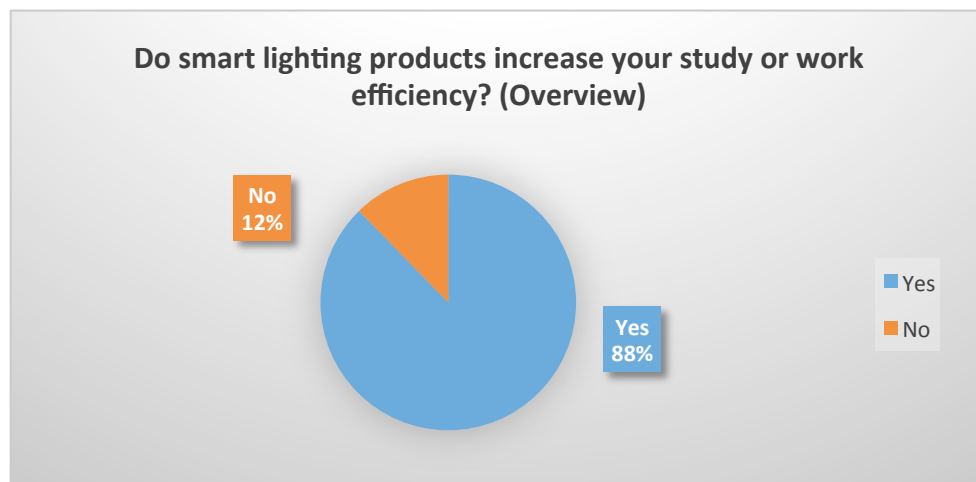**Figure 7: Impact of IoT smart lighting products on study and work efficiency (Overview)**

Figure 8: Impact of IoT smart lighting products on study and work efficiency (Adolescent View)

Do smart lighting products increase your study or work efficiency ? (Adolescent View)

No 6%

Yes 94%

Yes
No
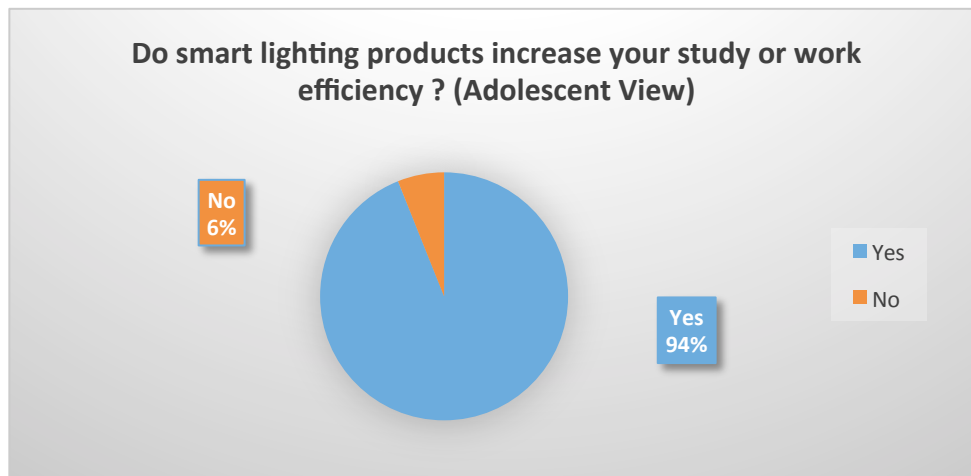
Figure 9: Impact of IoT smart lighting products on study and work efficiency (Adult View)

Do smart lighting products increase your study or work efficiency? (Adult View)

No 19%

Yes 81%

Yes
No
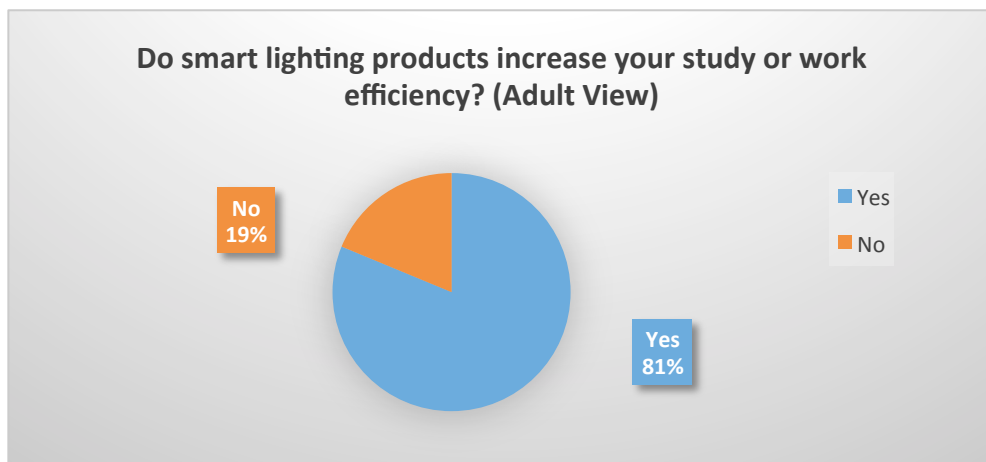
5.2 IoT smart lighting impact on adolescents and adults' social interaction

The survey shows that overall 65% of the people surveyed mentioned that smart lighting improved their social interaction with a much larger number of adolescents (76%) vs. adults that is 53%. Adolescents more actively using social media compared to adults could cause the results. The smart lighting could be treated as a social media for people to interact.

For example, Philips HUE bulbs, by partnering with Live Nation Entertainment, the world's leading live entertainment company, can connect music fans everywhere through intimate artistic performances and interactive smart lighting using Philips Hue. In a series of exclusive online videos of the Living Light Sessions, music lovers everywhere will be able to watch up-and-coming artists perform songs from living rooms outfitted with the Philips Hue smart lighting products.

Figure 10: impact of IoT smart lighting products on people's social interaction
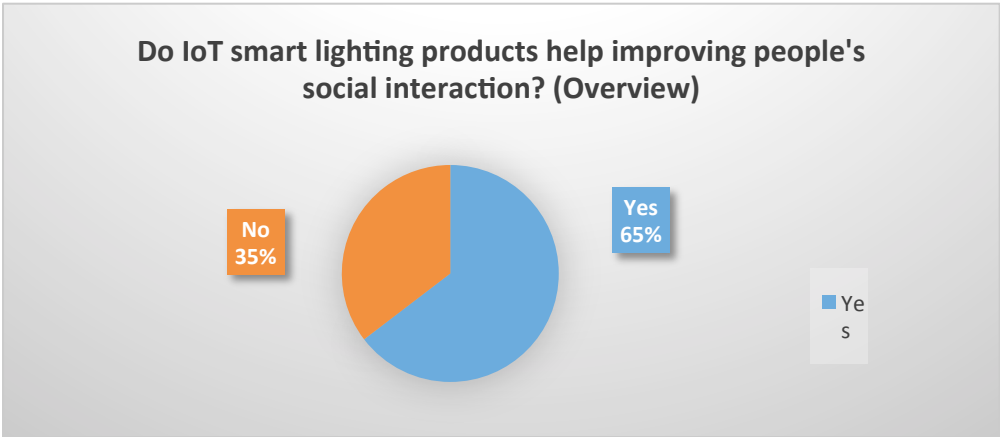
(Overview)

Figure 11: impact of IoT smart lighting products on people's social interaction
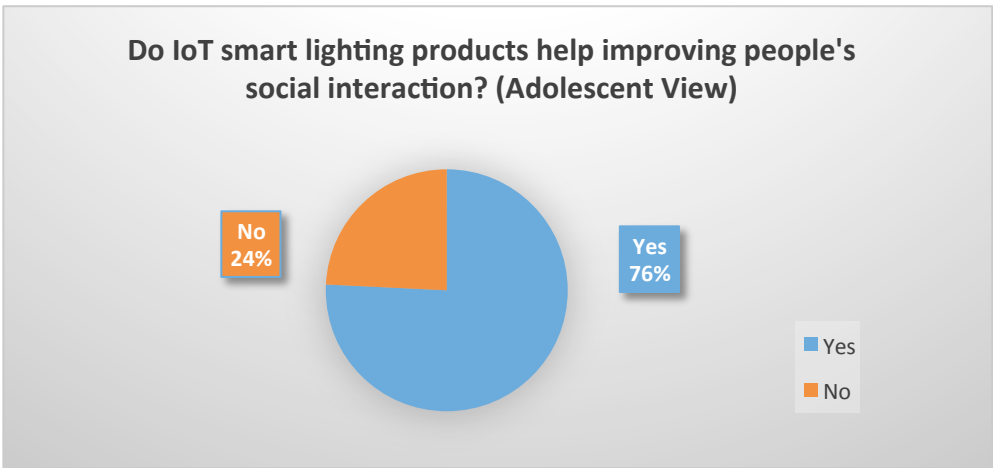
(Adolescent View)

Figure 12: impact of IoT smart lighting products on people's social

interaction (Adult View)
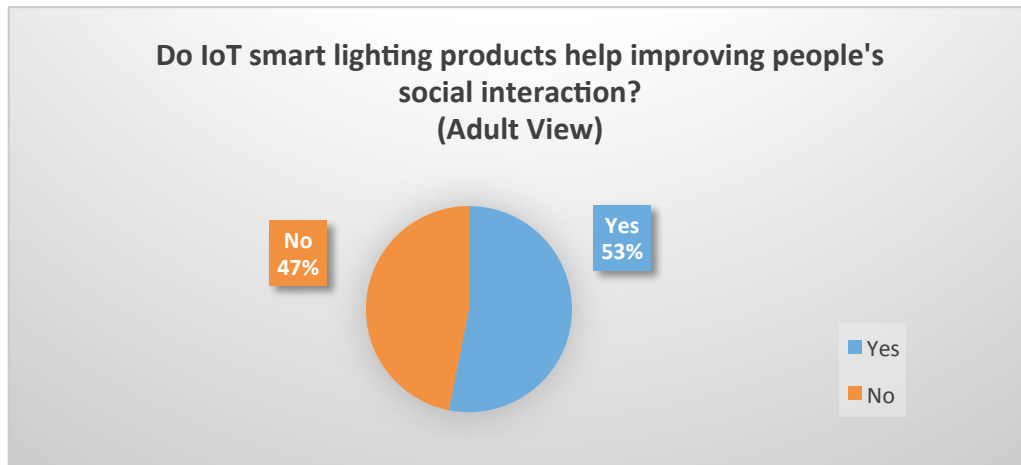
Chapter 6 Solutions

6.1 Proposal to overcome the environmental issues of IoT smart lighting:

Although the survey shows that the majority of people who used smart lighting products enjoyed the energy saving experiences, Olivia Qiu also confirmed during the interview that smart lighting products prove to save energy up to 80% compared to conventional lighting products.[22] Nonetheless, 9% of the people surveyed mentioned that smart lighting products have no impact on energy saving. This number is even higher with the adolescents

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[22] Appendix A: Interview with Olivia Qiu

(12%).[23] Therefore, I propose to take the following actions to overcome this challenge:

- In order to increase the awareness of significant energy saving benefits that are generated by smart lighting products, we should leverage social media such as Facebook, Twitter, and Wechat. This will make the adolescents who use such platforms on a daily basis become more aware of the energy saving benefits of IoT lighting products.

- Standards & Regulations organizations should set up energy saving standards in the lighting industry, so that all products that are qualified as smart lighting products have to reach a defined level of energy saving. In that case, energy saving will become a default feature of smart lighting product. Thus, when people choose to buy smart lighting products, they would know by default that energy saving benefits is guaranteed.

    It is important to encourage people to use as much smart lighting products as possible in order to help our planet save energy and protect our environment, as the shortage of energy sources is a serious issue.

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[23] Appendix C: Survey Results

6.2 Proposal to overcome the economic issues of IoT smart lighting

My survey shows that only 19% of the people surveyed accepted the price difference between smart and non-smart lighting products to be bigger than 50%; this demonstrates the big challenges that we are facing in promoting the smart lighting products. Today, the majority of smart lighting products are over 50% more expensive than non smart lighting products as indicated by Hakan Yuce during the interview.[24]

My proposal to overcome this challenge is to launch the different ranges of products with different level of features and functionalities. Given the current cost of smart lighting products, which is still high, I propose to launch simpler features and functionalities in smart lighting products for adults. In this way, the price would be more attractive for them, as the survey shows that adults are more sensitive to price. On the other hand, for adolescents, I propose to launch smart lighting products with more applications and features, to attract adolescents even if the price is high, as the survey shows that they are less price-sensitive than adults.

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[24] Appendix B: Interview with Hakan Yuce

6.3 Proposal to overcome the social issues of IoT smart lighting

My survey shows that a large majority of the people (88%) surveyed recognized that smart lighting products would improve their studying and working efficiency. The number is very high with adolescents (94%).

The challenges come more from the relative low recognition of the benefits of the smart lighting products bringing to the increase of social interaction, with only 65% of people surveyed recognizing the benefits.[25]

I propose that lighting companies should put more efforts in developing applications that will help adults to better interact socially. For example, in China, many retired people like to dance together in a public area. This is a very important social moment for them, I could imagine lighting companies to incorporate creative smart lighting products with their dancing and music by providing different smart lighting scenes. Another example could be controlling the meeting time. When a planned meeting time has passed, the light will flash to remind meeting attendees. And if an office requires a quiet environment, lighting companies could develop features to allow people to communicate with light, for example, by remotely turning a person's light red to signal a meeting.

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[25] Appendix C: Survey Results

Conclusion

IoT is changing the world; there are more and more devices that are connected via Internet to create new kinds of applications that impacts people's life dramatically. Lighting Industry is moving into the IoT world, as we see more and more IoT smart lighting products in the market.

To answer the research question, "How does Internet of Things based smart lighting product impact the lives of adolescents (15-18 years old) and adults (35-50 years old)?" with the result from my primary and secondary research, I have drawn the following conclusion:

- My research about how IoT based smart lighting products impact people's lives is conducted based on a survey with 42 adolescents and 40 middle aged adults, interviews with two senior executives from Philips Lighting, the number one lighting company in the world, as well as secondary research from websites on the Internet.

- My analysis shows that there are environmental implications of IoT smart lighting products in people's lives. The majority of the people whom I surveyed (excluding the ones who has no experience with smart lighting products) recognized the energy saving benefits of using smart lighting products. I also

proposed to increase the awareness of the energy saving benefits of smart lighting products, especially of adolescents. In addition, it is important to create energy-saving standards for smart lighting products.

- My analysis shows the economic implications of IoT smart lighting products on people's lives. The challenge we are facing today is the large price difference between smart and non-smart lighting products (price difference that is higher than 50%). This leads to the low acceptance of smart lighting products in the market. I proposed to segment the market, to create the different levels of applications and functionalities differently for adolescents and adults.

- My analysis shows that there is a significant impact of smarting lighting in regards to improving people's studying and working efficiency as well as their social interaction. However, there is a lower number of people who voted for the benefits of smart lighting product on their social interaction. I have proposed to create more adult-oriented applications to overcome this challenge.

However, I recognize the limitation of my research. The selected population of my survey has limitations. The population of the survey is limited in one city, Shanghai; the size of the surveyed population is relatively small (82

people in total); and the adolescents surveyed were from one school. Nonetheless, my internship in Philips Lighting Research Center and the interviews I conducted with the senior executives of Philips Lighting reinforced the reliability of my research, along with my secondary research.

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Appendix A: Interview with Olivia Qiu (Chief Innovation Officer of Philips Lighting)

1. How have you been involved with Internet of Things based lighting system?

Yes, in my role of chief innovation officer of Philips Lighting, i have been involved in all products design, development and launch to the market including IoT based lighting products and systems where Philips Lighting is clearly leading the Lighting industry.

However, before going there, I need to set innovation vision for the company as well as for innovation community. Philips Lighting wants to the leading lighting company for internet of things. Our innovation strategy is to extend our leading position in products and systems into internet of things, our internet of things strategy is to make our all lighting products connectable over the internet, with sensors embedded to interact with the environment to collect the data and we use the data to generate added value applications beyond illuminations for our customers.

2. What kind of lighting products does Philips Lighting sell that are IoT based?

The definition of Internet of things based lighting products is the products that fulfill the following 3 conditions:

- Products are connected to the internet and can be controlled remotely via a remote control, or a tablet or a smartphone
- There are sensors that are embedded into the products that collect the data and also make products automatically interact between them and with the environment including human as per their needs
- The data such as how consumers operate the light (when they turn on, off etc.) are stored in the cloud.

3. What are the benefits of people using IoT based lighting products? Are there any disadvantages?

People can benefit a lot from the IoT based smart lighting products, first, IoT based lighting products can generate up to 80% of electricity energy saving versus conventional lighting products without compromising the quality of light. Secondly, IoT based smart lighting products can bring a lot of applications that improve people's life for instance, with Philips HUE bulbs, you can turn on the light as you wish when you are away from home for holidays to

make your house appear occupied to reduce the risks of your home being robbed, another example in public space, we put gunshot sensor into our street lighting poles so that when there is a gunshot, the signal will be captured by the sensors that are installed in our lighting devices and sent to police center via smart lighting infrastructure, they are many these kind of applications.

Yes, there are challenges of IoT based smart lighting, first one is the cost of making those products are still significantly higher than non smart lighting products in some of the product ranges, this prevent those products to scale so less people could benefit, second challenge we are facing is the product security and customer data privacy protection. As IoT smart lighting products are connected over internet so we need to continuously reinforce our product security measurement alone with product development process and also after the product is launched to protect our customers and at the same time, we should strictly follow the data privacy policies that are defined in different countries to protect our customers' privacy as some of our customers related data are stored in lighting product manufacture's cloud.

4.   What is the IoT based lighting product most sold? At what price? To what kind of people?

Those are trade secrets that I cannot disclose for Philips lighting :-).

There are more than 50 types of smart lighting products and systems that we sell to the market in more 100 countries and the numbers are getting increasing everyday.

5.   What do you think is the future of IoT lighting?

We believe that lighting industry is moving into IoT world now, as world is increasingly connected over internet, by 2025, it is estimated that around 20 billion of the devices will be connected over internet, it is important for us to get ready for this industry transformation, and again, it is happening now, the world will be changed by IoT and lighting industry will be also transformed and enabled by IoT to unlock new values to our customers and provide millions of new applications beyond illuminations to our customers.

Appendix B: Interview with Hakan Yuce (Vice President, Head of Ventures of Philips Lighting)

1. Does the IoT smart lighting product come with any encryption built in? Can they be easily hacked?

All of our IoT smart lighting products are encrypted at different layers. We take encryption very seriously and work tirelessly to ensure that strict measurements are in place to protect our customers.

To address the second part of your question; we strongly believe that with our security measurements in place, the smart lighting products cannot be easily hacked. In addition, to ensure this, we continue to monitor, check and update the encryption software.

2. What do you think are the impacts on adolescents who use IoT-based lighting products, in both positive and negative aspects?

I believe that the younger generation, who are very tech savvy and forward looking, will see the benefits of our products.

3. What do you think are the impacts on adults who use IoT based lighting products, in both positive and negative aspects?

For adults, there are many factors that go into making purchase decisions. Money for value is a big consideration. However, I know that once anyone commits to trying our product, there will be no turning back. Though our product is at a higher cost than traditional lighting products, believe me when I say that its added value far exceeds the cost.

4. What environmental implications does smart lighting have on adolescents/ adults?

The IoT-based smart lighting products bring enormous benefits with regard to environmental conservation in the form of greatly reduced energy consumption. In this day and age, with the state of the environment in the forefront of everyone's minds, this is a serious concern for both adolescents as for adults. And, it is one that we are addressing head-on with our innovative product.

5. What social implications does smart lighting have on adolescents/ adults?

My personal view is that the social impact of using the IoT-based smart lighting product will be greater for adolescents than adults. As they are more active with social media, for example, Philips Lighting Hue home-connected products are integrally linked to social media outlets. I addition, there are more than 400 applications that have been developed around HUE. This has led to the creation of HUE fan communities who use those applications and we have noticed that most of those fans are adolescents or young adults.

6. What economic implications does smart lighting products have on adolescents/adults?

With regard to the price affordability for people who are considering using smart lighting products, our target is to create basic functionality-enabled smart lighting products with the price no more than 10% higher than non-smart lighting products. This way our goal is to entice more people into the IoT lighting world. Up to now, only a few of the smart lighting products have attained this goal.   For the majority of smart lighting products that we see on the market, their prices are still more than 50% higher than non-smart lighting product, Our company goal is that, by 2020, all our products will be connectable to provide smart functionalities according to our customer's' needs and the cost of smart lighting products would be much more competitive.

7. We understand the price difference between smart and non-smart lighting products.   As far as smart lighting products go, why is there a big price difference among the various smart lighting products? Are the energy-saving functions similar across the board on these products?

For smart lighting products, the energy saving functions are usually the same. The price differences come from other added features, other functionalities and other applications.

Appendix C: Survey Results

ITGS Extended Essay Survery

Participant #	Gender		Age		1. Do you have a smart phone?		2. Internet connection time per day (incl. via mobile)			3. How much more expensive should smart lighting products be compared with non-smart lighting products?				4. Do smart lighting products increase your study or working efficiency?		5. Do smart lighting products help improving people's social interaction?		6. How much impact can smart lighting product bring to energy saving ?			7. Did you know that if you control your smart lighting products through your smart phone, your user behavior as well as usage data will be recorded and stored in suppliers' cloud and that product maufactures and internet companies will analyse those data ?		8. your acceptance to the situation that referred in previous question?			9. How mature are smart lighting products?					10. When you use smart lighting products, how reliable do you think those products are?				
	Female	Male	20-55	15-18	Yes	No	<1 hour	1-3 hours	> 3 hours	<10%	10-30%	30-50%	50-100%	>100%	Yes	No	Yes	No	No impact	Some impact	Great impact	Yes	No	Not Acceptable	Acceptable	Need more information to decide	Not matured	Not very matured	Matured	Do not know	Not reliable	reliable	Very reliable	Have not used IoT smart Lighting products

ITGS Extended Essay Survery

Participant #	Gender		Age		1. Do you have a smart phone?		2. Internet connection time per day (incl. via mobile)			3. How much more expensive should smart lighting products be compared with non-smart lighting products?					4. Do smart lighting products increase your study or working efficiency?		5. Do smart lighting products help improving people's social interaction?		6. How much impact can smart lighting product bring to energy saving ?			7. Did you know that if you control your smart lighting products through your smart phone, your user behavior as well as usage data will be recorded and stored in suppliers' cloud and that product maiufactures and internet companies will analyse those data ?		8. your acceptance to the situation that refered in previous question?			9. How mature are smart lighting products?				10. When you use smart lighting products, how reliable do you think those products are?			
	Female	Male	15-18	20-55	Yes	No	< 1 hour	1-3 hours	> 3 hours	<10%	10-30%	30-50%	50-100%	>100%	Yes	No	Yes	No	No impact	Some impact	Great impact	Yes	No	Not Acceptable	Acceptable	Need more information to decide	Not matured	Not very matured	Matured	Do not know	Not reliable	reliable	Very reliable	Have not used IoT smart lighting products
Grand Total	31	34	33	32	65	0	2	27	35	9	37	13	4	2	57	8	42	23	6	42	17	43	22	5	26	34	11	41	1	12	2	43	20	0