Posture Check – Creative Technological Approaches

By

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A thesis exhibition was presented to OCAD University in partial fulfilment of the requirements for the degree of Master of Design (MDes) in Digital Futures.

Toronto, Ontario, Canada, April 2022

ABSTRACT

“Posture Check: Creative Technological Approaches" explores new ways of giving individuals real-time visual feedback on changes in their posture to help them become more aware of their stance. This research follows to create various optical outputs transmitted by a sensor integrated with the wearable device that can regularly analyse an individual’s sitting posture and assist them in improving their sitting habits. The physical prototype is a posture awareness device that detects seating positions. When a person’s posture deteriorates, the device shares the data wirelessly to a nearby computer or phone and provides real-time feedback through digital visualisation prototypes, these visualisations present different methods of notifying people about their changing posture in an unobtrusive way. The prototype result is created through an iterative design and prototyping process, with a final version being examined for its influence on posture.

Keywords

Wearable technology, wearable devices, posture, sensing methods, real-time feedback, notifications systems, visualisation

ACKNOWLEDGEMENT

I want to express my sincere gratitude to my thesis supervisor Professor Kate Hartman, and secondary advisor Professor Nicholas Puckett for their patience, enthusiasm, cooperation, and suggestions that made me present this research work to produce in the present form. Their brilliant, skilful supervision enriched this study. I couldn't have asked for a better group of advisors. They both challenged and motivated me, and they went above and beyond to guide me on my journey, for which I am eternally grateful. Thank you for inspiring me and being awesome.

I want to thank my family for all the love and support they have given me throughout the course. Their unconditional support has given me massive amounts of power-ups. I would like to specially mention my regards to my Late Grandfather, who encouraged and pushed me to pursue my master's program and motivated me to be dedicated.

Next, I would like to thank the Digital Futures staff, faculty, and classmates. It was an enjoyable journey with them towards my learning and self-discovery. I could not have completed this thesis without the support of my friends – Candide Uyanze, Patricia Mwenda, Krishnokoli Roy Chakraborty and Abhishek Nishu, for being my constant support system and lifting my spirits through the process.Special thanks to my friends Prayag Ichangimath, Anantha Unnikrishnan Kalidas, who provided me with technical support throughout the prototyping process.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Human posture refers to how people sit, stand, or move while resisting gravity (May and Lomas 2010). During the day, people spend most of their time sitting, which averages roughly 13 hours each day (Levine n.d.). Therefore, maintaining proper body posture when sitting is critical to avoiding back strain. Poor posture, particularly slouching, has been associated with depressive illnesses (Canales et al. 2010) and a lack of confidence on the mental side. This, in turn, impacts how people see you, which may have significant implications for your work and personal life. High levels of stress are also linked to poor posture (Riskind and Gotay 1982).

In this context, it's vital to remember that posture isn't merely a passive indication of one's mental state; it may also influence one's mental state and behaviour (Riskind 1984). Two significant characteristics emerged from our early examination of the subject through casual talks with friends and colleagues. First, individuals pay relatively little attention to posture until they experience detrimental impacts. Second, people have a distorted notion of how good posture feels. As a result, it is believed that increasing awareness of one's posture throughout the day and providing information on when someone sits in an unhealthy posture is necessary.

Traditional methods of posture monitoring and evaluation, on the other hand, are time-consuming, costly, and challenging to apply (Dunne et al. 2008). Posture refers to how individuals hold themselves, including how they stand, sit, move, and carry out duties, and it has a significant impact on their health. The vertebrae of the spine can be aligned properly by maintaining appropriate posture. Poor posture has been related to both poor health and poor performance. The research found that slouching affected the transverse abdominal muscle. When a person maintains a slouched posture, the thickness of the transverse abdominal muscle is dramatically reduced (Reeve and Dilley 2009). transverse Moreover, another study showed that subjects who were asked to sit with a hunched posture reported more significant stress and thus lower performance (Reeve and Dilley 2009). Staying in the same position for a long time, even with a decent posture, is considered bad postural practice because the muscles in the spine might stop producing neurotransmitters/chemicals necessary for normal biological functions—field(Bey and Hamilton 2003). And keeping a good posture and changing one’s position from time to time is considered important, if not necessary, for maintaining good health.

There are several aspects of today's lifestyle that contribute to poor posture. Notably, the rising sedentary behaviour spent sitting must be addressed at this time. Even those who achieve or surpass the public health standards for physical activity spend a significant amount of time engaging in sedentary activities. Sensing technologies can assist users in becoming more aware of their posture and correcting it as needed, (Wang et al. 2015). A wearable device, which is location independent and enables continuous observations and real-time feedback, can be precious in this situation.

Compared to the others, the student is the most affected when sitting since they remain sat for 19-90 minutes throughout a 90-minute double lesson. On average, students sit in class for more than 60 minutes. Being seated in a static position for an extended time without being disturbed or moving might be uncomfortable.

The three sitting postures are upright, forward-leaning, and backwards-leaning. While students write or draw, they lean forward and backwards when working on their desktops. According to recent surveys, 57 per cent of pupils lean forward, while 43 per cent lean backward (Hojat and Mahdi 2011). Because poor posture impacts the spine’s condition, it is essential to maintain proper back posture. Students must maintain good back posture since their spines are still mild. Their spine may quickly adapt if their stance is not corrected over time. Sitting in a weak back posture for an extended period will influence the student's spine condition and other factors such as stress levels. Therefore, the target population for this project is university students (undergraduate, graduate, and doctoral).

Through my master's program, I developed an interest in wearable technology as a new platform for engaging user experiences. These technologies allow novel interaction options and more personal user experiences due to their intrinsic proximity to the user. Wearables can overcome the shortcomings of previous interfaces in terms of constant presence and intimacy, especially when it comes to behavioural changes. For these reasons, I determined early on that my final thesis would focus on creating life-enhancing and engaging wearable technologies.

A graduate elective class inspired the thesis project I took in the winter semester of 2021 at OCAD University called ‘Body Centric Technologies”, taught by my Primary Advisor, Professor Kate Hartman. The course evolved around different sensors and circuits used in wearable technologies. The project further expanded to exploring real-time visual feedback on p5.js, which I wanted to incorporate from my learnings in the “Creation and Computation” course that I completed in the fall semester of 2020, taught by my Primary advisors Kate Hartman and Nicholas Puckett. The course taught us different ways of connecting external sensors with JavaScript libraries for creative coding.

This project explores non-intrusive ways of giving users real-time visual feedback and making them more aware of their posture by detecting movement through a wearable device. This thesis aims to create a wearable device that regularly senses your body posture and provides non-intrusive feedback to assist users in changing their habits and becoming more aware of their normal sitting posture. The prototype is a wearable device with a microcontroller inside to sense the user's movement. As their posture deteriorates while sitting at their desk, it will notify the user in the most non-intrusive way and encourage them to sit straight.

1.2 RESEARCH QUESTION

The primary research question addressed by this thesis is:

What are effective but non-intrusive methods for using existing technologies and interfaces to share posture feedback with users to help them improve their posture awareness?

1.3 LIMITATIONS

During my research, I realised that there are limitations to this project that I will be able to cover. As the project started during the lockdown and the target audience mainly attended school from home, the first limitation faced was a lack of first-hand engagement with the intended users. Secondly, the nature of this project requires expert advice from health professionals like chiropractors and doctors, which could help me identify the exact placement where the product could be placed. Still, due to covid restrictions at the beginning of the project, I could not connect with any professional.

To keep the project in scope, I focused on standard sensors rather than more innovative approaches. The aspect of creating the interface and wireframes of an application for the desktop that is connected to the wearable device could not be explored.

CHAPTER TWO: LITERATURE REVIEW

This chapter gives an in-depth study and background to three main topics of this research study, i.e., Wearable technology, Posture and Notification Systems.

2.1 WEARABLE TECHNOLOGY

Electronic devices that may be worn on the body are known as wearables. Since the turn of the century, such devices have shrunk in size and cost while enhancing observation capabilities for various health-related metrics, resulting in a move toward commercialisation and integration into the everyday activities field (Wei 2014). Apple Watch, Oculus Rift headset, Fitbit activity tracker, Samsung Gear, Google Glass, Bluetooth earbuds, bright rings & jewellery, fitness & heart rate monitors, hearing aids, and so on are just a few examples. Their scope of the definition is now expanding to include the devices worn in or on the body in support of enterprise activities, i.e., to transform operations and performance, increase safety, convenience, and efficiency like exoskeletons (Poon et al. 2019) for use in heavy industries, rehabilitation, and military, bright clothing for helping athletes and patients in recovery and repair, etc. These wearable devices are not merely portrayed as something that can only be worn on the body or carried along, nor is the technology characterised as a 'wearable technology' simply because it is worn like the traditional wristwatches. These devices need to incorporate information technology and process the information while working autonomously and, on the go, making them 'smart'.

Wearable technologies pose one of the most promising trends in the human media interaction, (Montuschi et al. 2014). Utilised in a wide variety of application areas, their most general purpose is to enhance the quality of life. Due to their inherent closeness to the user, a whole range of new interaction possibilities is enabled. Thus, they have the potential to add value in terms of functionality and performance when compared to other technologies (Baurley 2004). Other definitions of wearables add that these technologies mediate their user and environment (Sogeti Labs 2013) and let the user access information anytime and anywhere (Spagnolli et al. 2014). In other words, a worn system capable of detecting and communicating with the wearer's and the environment's circumstances and stimuli is referred to as a wearable system. (Cho, Lee, and Cho 2009).

I have identified five dimensions that determine the user experience of any wearable device in previous work. These characteristics - application area, human factors, wearability, technology, and design process - provide a valuable framework for discussing the current position and planning the construction of our prototype. The topic of this thesis they are explained in the following paragraphs.

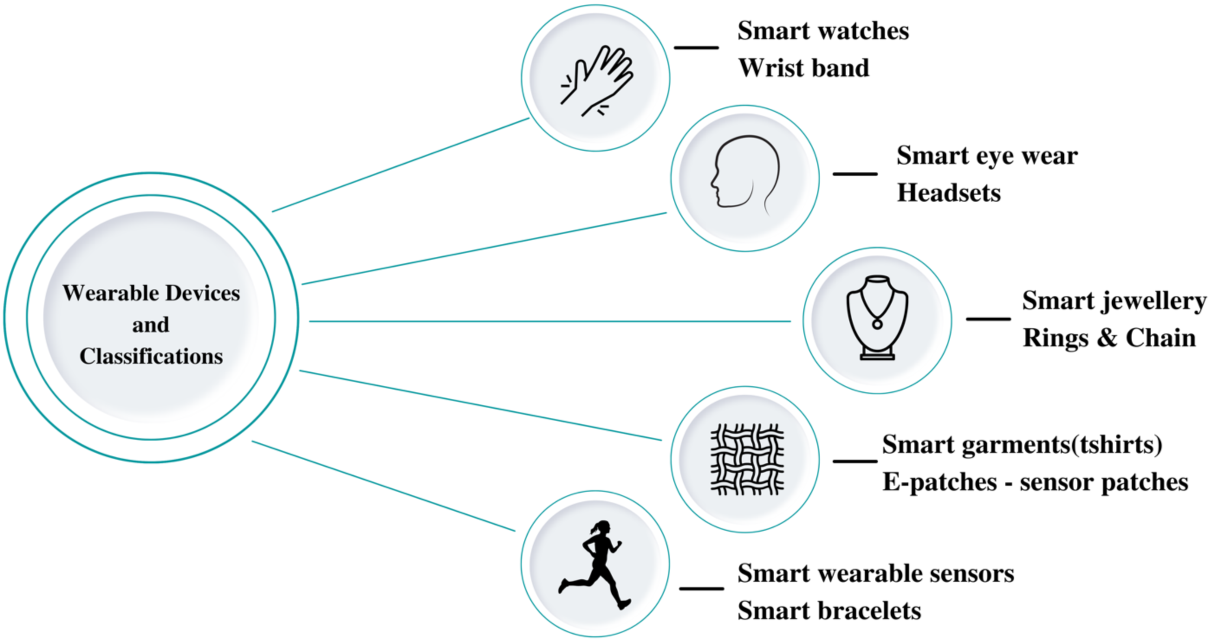

Figure 1 Wearable devices and classifications

Application areas

The application area is the first part of the wearable user experience. It sets the context of any wearable device, enhancing the user experience significantly. This applies to both human and technological factors. The application is likely to impact the device's design process. In the current scenario of a wearable device for posture correction, three major application areas may be addressed:

- In the sport/fitness industry, which promotes an active lifestyle, wearables may be used to monitor fitness, navigate outdoors, manage body temperature, and measure and optimise sports performance. When opposed to, for instance, wearables for wellness applications, one distinguishing feature of these devices is that they are used for specific activities rather than being worn all the time. By evaluating and getting feedback on their posture, athletes and sportspeople may maintain proper form. Two sports in which posture is essential are the rowing (King et al. 2009) and strength training, i.e., the weightlifting (WILSON, MURPHY, and WALSHE 1996).

- The medical industry encompasses applications related to professional medical and health care. Wearables can assist doctors in diagnosing illnesses and tracking treatment reactions. They're also supposed to make it easier for patients to walk around by getting rid of bulky gadgets like vital-sign monitors. Wearables must conform to medical equipment rules in these applications, which are not required for wellness products. A posture-improving wearable for the medical sector might help patients with physiological or psychological illnesses caused by poor postures, such as structural deformity of the spine or shoulder, back or neck discomfort (Wong and Wong 2008), or those in the rehabilitation (Wang et al. 2015). On the other hand, it could be helpful to medical personnel throughout the day.
- The wellness industry strives to encourage an overall healthy lifestyle and the wearer's overall well-being. Physiological tracking, weight and energy tracking, mood tracking, eye care, gait/posture correction, massage, and sleep tracking are all covered. Health and wellness wearables are commonly worn continuously throughout the day. Because posture has a significant influence on overall well-being (Tattersall and Walshaw 2003) and there are fewer limits than in the medical business, this market is mainly motivated to develop a wearable posture correction device.

The user's view of new technology impacts acceptance, and any wrong opinion of the gadget is a roadblock to adoption. The two most crucial cognitive attitudes that determine the acceptability of any technology, according to the Technology-Acceptance-Model, are perceived utility and perceived ease of use (Venkatesh and Davis 2000). As a result, a user must be able to observe how a wearable gadget helps them. In addition, usage must be seen as intuitive or, at the very least, simple to interact with the user. Other elements that impact a person's adoption of intelligent clothes include assumed anxieties - worries based on (false) assumptions - and perceived disadvantages.
Age and gender are the most relevant demographic traits when interacting with technology. While Buenaflor and Hee-Cheol (Buenaflor and Kim 2013) define technical expertise as a distinct factor in technology acceptability, it is suggested that demographic characteristics often influence specialised experience and may be included in this study. Devices used for monitoring that does not require extra user engagement beyond being worn may be ideal for elderly persons and those who are unfamiliar with technology.

2.2 POSTURE

2.2.1 Seated Posture

Correct posture is widely acknowledged among scientists as something that should be maintained, taught, and modelled (Hansraj 2014). However, when considering the different aspects of determining what constitutes "proper" posture, the idea can become confusing as a user may not know the correct sitting posture. Poor posture can be harmful to an individual's health, with the severity increasing as long as the habits are not corrector (Cuéllar and Lanman 2017). Poor posture can develop at an early age, even before a person reaches adolescence (Kratenova et al. 2007). Even though the symptoms appear at a young age, these behaviours are frequently left untreated for the remainder of one's life, which can develop into a range of musculoskeletal difficulties in later years (Boyle, Milne, and Singer 2002). It's likely that if those suffering from the impacts of lousy posture had developed correct postural habits at a younger age, the repercussions would have been reduced, if not entirely prevented. Posture and emotions are intertwined, and one's posture might reveal their present emotional state. Happiness makes us feel uplifted, awareness makes us sit upright, and rejection or disappointment makes us feel lethargic(Roscoe 2016). Bad posture causes both physical and mental problems. It disrupts the body’s internal working and causes the discomfort mentioned above in the back, neck, and shoulders. Because of the improper posture, there is much strain on other organs that aren't evenly distributed. Some muscles become hyperextended, while others get shortened, putting tension on the body regions that bear the burden of improper posture. Breathing, blood flow, and digestion are all hampered due to this. It is essential to maintain good posture to protect our bodies and live a stress-free life. It also encourages pleasant moods and inspires people to finish activities, and emotions influence posture (Roscoe 2016). "The postures we assume provide clues to not only the condition of our bodies – old and new traumas and injuries, mild or more serious pathologies – but also how we feel about ourselves, our confidence (or lack thereof), how much energy we have (or lack thereof), how enthusiastic (or unenthusiastic) we are, or whether we feel certain and relaxed," Jane Johnson writes (or anxious and tense). Intriguingly, we almost always adopt the same postures in response to the same emotions." (Johnson 2012)

2.2.2 Consumer Posture Products

There is significant technology development in the modern corporate world, applied mainly in simplifying human activities in different sectors. The health sector has also benefited from the high technology innovations like wearable devices. The high technology innovations in healthcare have also assisted patients in managing their organs more effectively. For instance, the technology can then be used in monitoring the sitting postures. The device used to correct the sitting poses includes a *Posture check* developed in this research. Posture check mainly keeps the users in the correct positions to maintain good postures. However, the Posture check device also has other competitors that need to be addressed to establish the best operational ways to promote the product's value in the market. Therefore, this research addresses the differences in designs for other competitors for the posture check design.

Lumo Lift is one of the leading competitors for posture checkers. Lumo Lift was in 2014, and it appears among some of the top products for postures management. Lumo Lift is unique in its design since it is simple and effective. For instance, it is tiny that one can quickly move with it unnoticed. It is also designed to fit any position, (Kuo et al. 2019). It is also intended uniquely to understand its use better, making it one of the leading competitors for the posture check device to be released into the market. The main difference is the design and how the wearable device is attached to the body.

Lumo Lift has a specific technology applied to solve the developing positioning problems in a particular posture. The Lumo Lift technology addresses similar features in other posture detection technologies. For instance, the technology achieves the objective by resting against the users' upper torso using the hardware algorithms or sensors to measure the body's alignment, which would limit the actual problem experienced in the body (Kuo et al. 2019). Therefore, the technological concept applied by Lumo Lift was among the leading in the groups but with reduced effectiveness in the market since it did not meet the demands of most users.

Figure 2 Diagram explaining features of existing Commercial Consumer Products

The other effective device for maintaining the best posture includes **Mevics**. The Mevics technology presents an effective device applicable in improving the daily activities and poses with the expression of the posture tracker and personal fitness needed to contain the best terms for the body requirements. It uses an impressive technology concept to be used by any individual since they are also designed for children (Barone et al. 2019). It applies the newest technology, which means it is the most improved version among all the posture management devices. It has other advantages, such as longer battery life that might last up to seven days; thus, one can enjoy its use when travelling or engaging in more outdoor activities. Therefore, it is considered the most ideal and competitive posture device since the whole family can use it in most cases. It has the latest technology and gears that are the most incredible in achieving its crowdfunding campaigns.

Lastly, the Mevics technology performs better in the market than others since it effectively applies the best technological applications for medical devices in the stylish accessory. Most of the concepts involved in making the Mevics technology are available in the market, making it one of the leading posture management devices since users are well conversant with its use. For instance, it can be applied to children to help them have the best advantages in gamification, making it more applicable and straightforward in achieving the necessary use in the market (Barone et al. 2019). Therefore, Mevics is known to perform best compared to other devices since they are effectively needed to achieve the results of operations through maintaining the market's demands by having more advanced features required to promote the process of upholding the best results for their purposes.

Upright Pro is another competitive device used to monitor human posture and manage health statuses for the individual. The Upright Pro technique is also an ideological technology approved to be working by helping the users keep check of their positions to maintain the best health statuses. The device's technology has a significant influence, with a smaller version helping the initial users maintain their jobs effectively without the help of the tiny device after some time (Elliott 2019). The technology is simple to set up, thus making it one of the leading posture technologies in the market. The pro version is the predecessor’s more straightforward and improved form, thus making it one of the top approaches applicable in maintaining the correct posture. It also has better adhesive, making it practical to last longer on the body than other similar purpose devices. Therefore, Upright Pro is considered one of the best approaches to keeping healthy postures.

From its predecessor, the Upright Pro device is known to perform best in the modern market since it acts as the improved version of the previous device used in checking the actual position. Therefore, it is considered one of the leading posture training products used in the market compared to others, such as the Lumo Lift, which has already faded due to rebranding. Also, the low prices compared to its competitors makes them the most effective structure used in keeping the best operations and requirements that would support the nature of the process and how it is needed in promoting the general conditions to maintain the value of organisations in the operational fields (Elliott 2019). Therefore, using an Upright Pro is essential since it fits any age bracket, and anyone can use the technology to maintain the best sitting postures.

Similarly, **Upright Go** is another posture check device effectively applied to establish the actual problem of the nature of the sitting position. The technology is effective since it can correct the users' sitting position in two weeks of use. Most chiropractors and physiotherapists perfect the posture. The technology functions as a comfortable strapless corrector for the poses placed on the upper back to remind individuals to sit or stand on a specific pose that would not harm their statuses. Therefore, the device has reported a successful use since most users report success, with most users showing tremendous improvements in a short time after use. After two weeks of use, one would quickly master the recommended sitting or standing posture that would make it effective in achieving its objectives for ensuring the best achievements for using the item.

Compared to other similar products used to keep the best posture, Upright Go can be used effectively in achieving the recommended objective. It is considered the best and newest product with advanced technology, making it one of the best options in the market. The technology of Upright Go fits effectively on the spine since it has a larger adhesive that makes it possible to stick on the body for a more extended period to achieve the best purposes. The technology also provides better feedback and more precise monitoring for the posture needed to promote the individual's health requirements (Peper 2019). However, the approach is ineffective since the adhesives are not designed for rough or more humid conditions. For instance, the adhesive cannot stick on the human's body for a longer time if they sweat, are rained on, or are experiencing more challenging conditions in their life experiences. Therefore, the technology must improve to compete with other options such as the Upright Pro.

2.3 NOTIFICATION SYSTEMS

Notifications are unavoidable in today's multitasking and socially connected environment. People get distracted from their activities when they receive notifications from many sources simultaneously. Furthermore, notifications are a standard feature of practically all popular technological platforms (Okoshi, Nakazawa, and Tokuda 2016), and many apps employ them without exception (Weber, Shirazi, and Henze 2015)

We live in a time when information is becoming more active. The demands on our limited attention get more intense as something becomes more vibrant. Manually checking for new information regularly is inconvenient and time-consuming. Improved technological services are required to keep us informed of further information while reducing the negative impact that interruptions can have by diverting our increasingly fragmented attention.

Interruptive notifications, such as alerts for new emails, remote backup completion, or a rapidly draining laptop battery, are examples of notification services that help us maintain awareness of changing system state while allowing us to focus on other tasks because they do not require context switching and instead communicate on the periphery.

On desktop computers, notifications usually give a passive awareness of incoming information rather than prompting users to shift their primary duties (Iqbal and Horvitz 2010). Notifications, particularly in the workplace, have negative consequences such as disturbances and interruptions (Cutrell, Czerwinski, and Horvitz 2000)(Czerwinski, Horvitz, and Wilhite 2004). The perceived difficulty of resuming work after an interruption is influenced by the kind of primary task, its complexity, duration, and the length and number of interruptions (Czerwinski, Horvitz, and Wilhite 2004). Furthermore, receiving messages while performing quick, stimulus-driven activities causes more distractions than receiving notifications while performing more prolonged, more effortful semantic-based tasks (Cutrell, Czerwinski, and Horvitz 2000).

Therefore, as seen in the earlier "Consumer Posture Product" section, the current posture correcting devices have only Haptic feedback to tell the users about their slouching stance. Notifying and giving feedback to users is very important; however, it may also result in frequent interruptions at inconvenient times, which might distract users repeatedly.

Prior research has demonstrated that disruption at undesirable times can reduce task completion time (Cutrell, Czerwinski, and Horvitz 2001)(Monk, Boehm-Davis, and Trafton 2002), increase task mistake rate (Bailey, Konstan, and Carlis 2000), and affect the user's emotional and affective state (Adamczyk and Bailey 2004). (Adamczyk and Bailey 2004)(Bailey, Konstan, and Carlis 2000). In an article by The New Yorker (Marx n.d.), a survey was conducted where people were made to try different types of posture correcting devices; they identified the two devices as Buzzy and Non-buzzy. Where buzzy are the electronic gadgets that use Haptic feedback as a responsive method, and non-buzzy is tangible posture correcting braces that can be worn on the body. It was concluded that the Buzzy devices are very annoying and continuously vibrating and causing interruptions. In contrast, the non-buzzy devices feel very tight and inconvenient to wear for many hours or outside in public.

Through this thesis project, I will be exploring non-intrusive ambient feedback that can encourage users to sit up straight and adjust their posture while working. The proposed feedback will be subtle in the corresponding device like the computer itself or in the environment where the user is sitting. As the device only focuses on sitting posture, it will avoid interference during the user's other chores. The advantage of having a feedback method within the desktop would distract the user relatively less while they are working. The quick response to the visual feedback would also encourage them to sit up straight immediately.

CHAPTER THREE: RESEARCH METHODOLOGY AND METHODS

This thesis situates itself in the present scenario where people have been using different devices to be more aware of their sitting posture. As the project involved experimenting with different types of technologies like microcontrollers and sensing methods to discover and explore what can be different ways of giving feedback to the users, the research makes use of Research through design as a methodology that allows exploring, experimenting and development creative approaches that are evolved during the process. The prototype development process will include iterative prototyping and design thinking, drawing on my creative practice in Industrial Design. This section examines the methods developed in the thesis development process.

3.1 RESEARCH THROUGH DESIGN

Research through Design focuses on integrating practice as a form of research. Archer (Grand and Jonas 2012) distinguishes first between science-based research and practitioner-based research. "We interpret practice as something that belongs to and is determined by a certain context, whereas theory is conducted by getting away from a specific context to reflect on it from a more neutral or objective point of view" (Friberg 2010). Research through Design may be defined as reconnecting theory and practice.

"The outlook for Design is based on the practice of Design. According to H. Research via Design, artistically / creatively constructing objects, interventions, processes, etc. to obtain information." (Bang et al. 2012) Practice-based research strategies, or research by Design, are generally related to the progress of practice and the nature of the course. This includes practitioner strategies such as action reflection, participation surveys, and action research. Research through Design (RTD) uses methods and processes from design practices and legitimises it as a proper form of inquiry (Zimmerman, Forlizzi, and Evenson 2007). The outcomes are the knowledge that is gained through the design process. It does not start with an end goal, such as a defined product. Instead, the artefact revealed at the end of the research process reflects the knowledge found and gained by (Giaccardi and Stappers 2014). The research questions and resources inform the designer's decisions along the way.

The design process allows designers to imagine futures and possibilities that may not exist today (Zimmerman, Forlizzi, and Evenson 2007). The new knowledge generated from the RTD project can enable contemporary discourses and perspectives about the future.

(Koskinen 2011). RTD is a good option for designers who use the design process to ask questions about future objects, environments, or scenarios, leading to new research. I want to explore non-conventional notification methods and experiences to improve how posture correction devices notify people in my project model. I want to make people's experience with the sensors more interactive and comfortable than ever. I hope these new approaches to postural awareness might help alleviate back pain and related problems people have experienced in recent years.
This study examines a wearable prototype that detects posture and gives users various real-time visual feedback options while working on their laptop/desktop. Research through Design enables a platform for using the design process as a form of research. The study, therefore, results in creating prototypes of wearables and visualisations where Prototyping serves as a tool for defining and performing analysis on manufacturing processes resulting in the final artefacts and spreading new information. The design process can be different from the technique used, such as Iterative Design, so this method allows you to retest your hypothesis. RTD is flexible and challenges rigorous research concepts. The result is to share the process and theory for imagining new scenarios.

3.2 ITERATIVE DESIGN

Iterative prototyping plays a crucial role in the design process of this project through several stages. The work entails ideation, sketching, 3D modelling, rapid prototyping, and testing. The method also explores the placement of the wearable device on the body from the first to the final iteration of the prototypes. (Lindenmann et al. 2021) The iterative design methodology is based on a cyclic process of prototyping, testing, analysing, and refining a product process. In this case, it will be applied in our project, showing a step-by-step procedure of implementing a wearable device that will be used to detect a person's sitting position. (Luger et al. 2021) The iterative model will outline all the steps clearly, making it easier to make changes whenever necessary in implementing the prototype to ensure that the desired design is achieved altogether.

Iterative design compares the steps that have been used in implementing other existing methods. It gives people imagination of the final product and how it will work. Researchers can guess what is expected as the project's final output with the iterative method. (Abele and Yzerbyt 2021) It gives an overview of each stage of development, how it should be done, and the resources used. For our case, for instance, implementing the wearable device that will be using sensors to collect data.

However, after collecting the data on a person's sitting position, the data will be processed by converting it to angular values. The user can be notified, that is, the feedback, through the vibration of motors to alert him whenever a poor posture has been detected.

The approach in this thesis is implementation which is like the postural monitoring system developed by Wang (Ohlendorf et al. 2021). In this case, he used two sensors attached to a garment.

To conclude, I shall be using the design prototype to implement the wearable device to detect body posture. The functionalities of every part of the wearable device and exploration of visualisations will be shared in the documentation. In addition to this, I have analysed the existing systems used to develop my more efficient interpretations. We are after reducing any strain that can always be caused by poor sitting position.

Research using the iterative model will allow me to identify any usability issues of the wearable device before the final product is implemented (Luger et al. 2021). Additions that will be used in the later stages of the wearable device will be identified and considered in the earlier stages of the development. My main goal is to explore unconventional and non-intrusive ways of notifying students and other users in our community to be more aware of their sitting posture while studying or working. This could encourage them to improve their posture regularly.

CHAPTER FOUR: PROTOTYPING

This chapter explains the conceptualisation and construction of wearable and real-time visual feedback prototypes. The chapter is divided into two groups: Earlier studies and a summary of Posture Check, including sensing method of electronics, feedback profile of digital visualisations, and case design of the final wearable device. The result is a single wearable gadget comprising an electrical component for sensing posture that may be worn on clothes and six various types of real-time visual feedback on the desktop screen. Furthermore, design concepts are presented through sketching, CAD modelling, and 3D printing, combining functionality and aesthetics to visualise the form and design of wearable gadgets.

4.1 EARLIER EXPERIMENTS

This section of the chapter highlights experiments conducted to determine which sensor can be used to detect a changing posture in the most accurate way possible. The experiments also include exploring different ways to make people aware of their stance in an ambient environment.

4.1.1 DIY Flex Sensor and LED

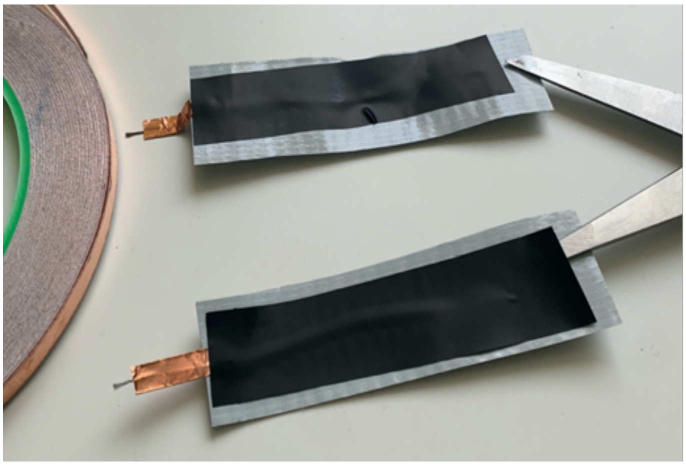

Figure 4 DIY Flex sensor

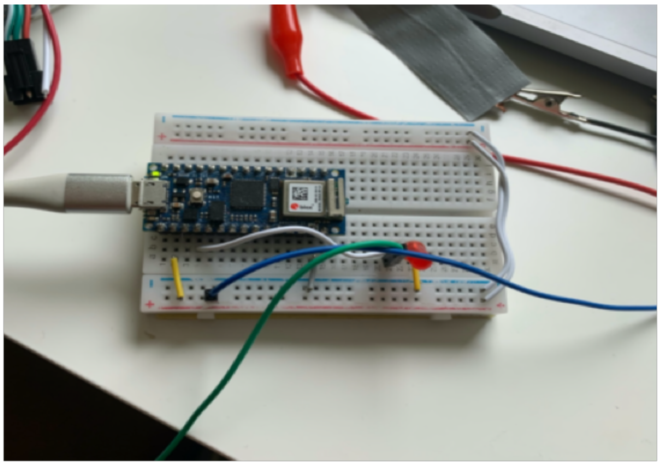

Figure 3 Circuit created to test flex sensor with LED lights

Description - The experiment focuses on creating a DIY flex sensor using a conductive and resistive material at home. The DIY prototype was made to start the project and experiment if the Arduino would read values if the DIY sensor were placed on the back and the LED is switched on as soon as the person bends.

Parts and Materials - Tape, Velostat, Conductive thread, conductive tape, DIY flex sensor, Breadboard, Jumper wire, Arduino Nano IOT 33, LED.

Learnings - I observed during the experiment that the readings from the DIY sensors were not very accurate, and the LED light was flickering. As the material of the sensor was makeshift Tape with Velostat and conductive thread, the readings in the serial monitor were not specific and kept fluctuating again and again. Therefore, the LED kept turning on/off instead of fading prominently.

4.1.2 DIY Flex Sensor and LED matrix

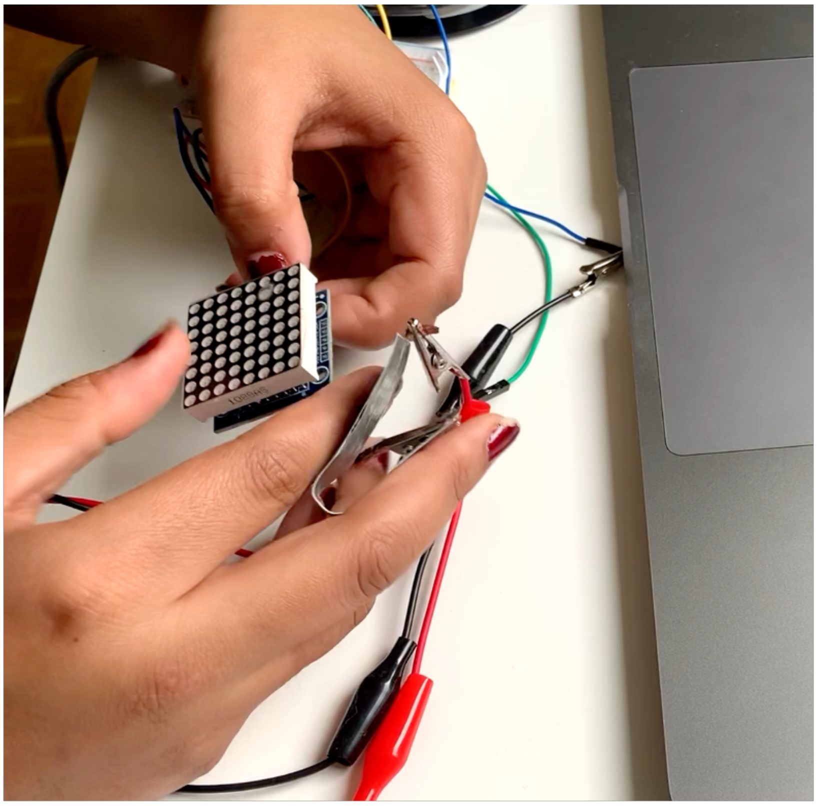

Figure 5 DIY Flex sensor with LED matrix

Description - The experiment explores connecting a DIY-made flex sensor and using an LED matrix as a notification system. This notification system will further be explored by creating patterns that change according to the flex sensors' measurements.

Parts and Materials - Tape, Velostat, Conductive thread, conductive tape, DIY flex sensor, Breadboard, Jumper Wire, Arduino Nano IOT 33, LED Matrix

Learnings - I observed during the experiment that the DIY sensors' readings were not very accurate, and the LED matrix outcome was not very specific. Therefore, I decided to switch to using a ready-made flex sensor.

4.1.3 Standard Flex Sensor and Servo Motor

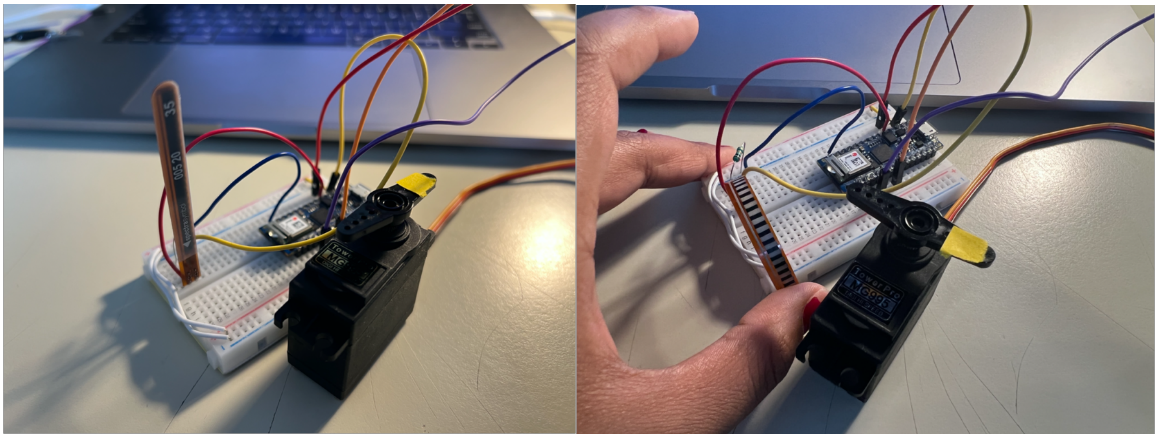

Figure 6 Testing flex sensor with servo motor

Description - The experiment explores how a flex sensor can be used to notify people in an ambient environment. The investigation is about interaction with the flex sensor and servo motor. The servo motor rotates as soon as the sensor bends and goes back to its original position when the sensor is straight.

Parts and Materials - Flex sensor, Breadboard, Jumper wire, Arduino Nano IOT 33, Servo motor.

Learnings - I learnt that this way of notifying people might not be the best way as it could be an additional module that a user will have to keep on their desk while working. This could also be a distraction for someone concentrating on their work.

4.1.4 Standard Flex Sensor and LED Lamp

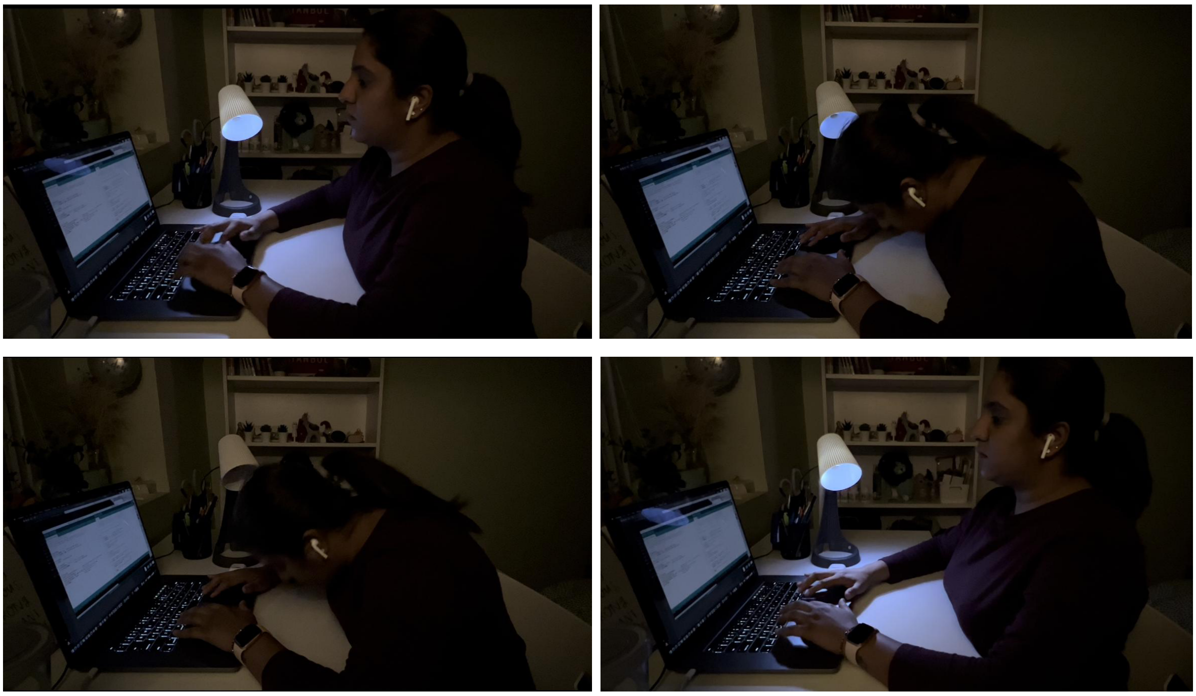

Figure 7 Testing how LED lights fade as the posture changes with flex sensor movement

Description - This is the first trial experiment of a notification system of fading LEDs using the flex sensor. The flex sensor is connected to the back of the clothing to collect the bend angle data. The light fades as I bend forward and brightens ups as I sit up straight. The main aim is to simulate and test the application of the light in the user's environment, which can further be applied to in-room lighting. The experiment explores how a notification system can be a part of your ambient environment instead of having an additional device distracting you. This is a small gimmick of room lighting tried in a lamp.

Parts and Materials - Flex sensor, Breadboard, Jumper wire, Arduino Nano IOT 33, LED lights, Lamp structure.

Circuit Diagram –

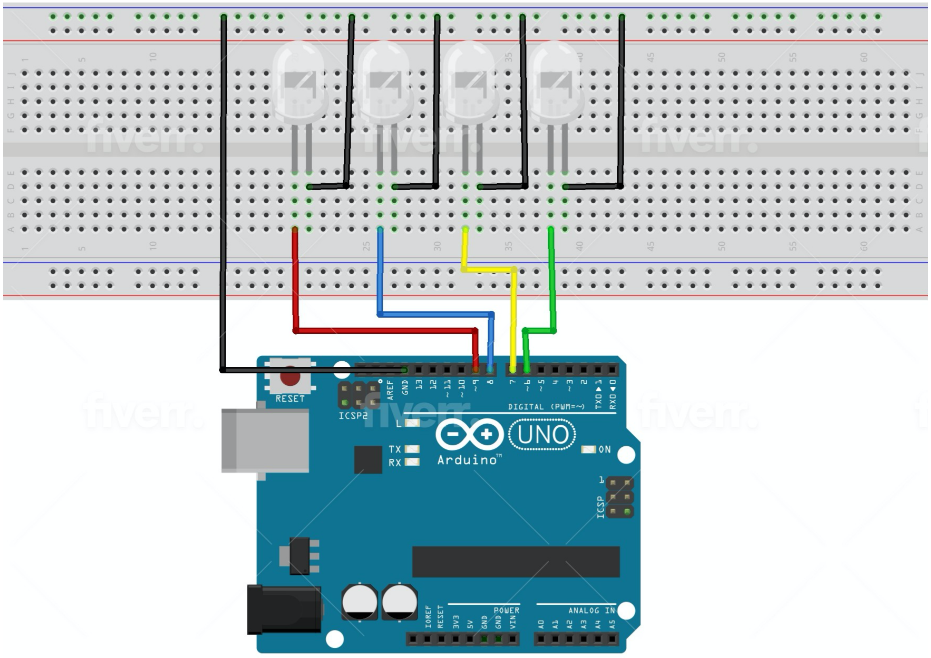

Figure 8 Circuit diagram for the above circuit where LED is fading with the changing posture position

Learnings - During this experiment, I discovered that incorporating feedback in the user's environment is a creative approach, but it can also be distracting. I also realised that notification is a lamp is an approach that can easily be used during the nighttime, but I am not sure if it would be beneficial during the day. In testing this experiment, I discovered that to make feedback less intrusive, it would be best to incorporate feedback visually on the desktop itself rather than having an additional device.

Conclusion – The above experiments were done using flex sensors with different ways of exploring ambient notifying practices. During the process of conducting these experiments, it was observed that the flex sensor could detect just the forward bend movement of a user. The value and detection were appropriate, but when it comes to a person's sitting posture at a desk, it can vary to different positions other than just bending in a forward direction. Therefore, to make the wearable posture detection device more versatile, I decided to explore a gyroscope and magnetometer, which is in-built into an Arduino to detect various sitting positions.

4.2 OVERVIEW OF POSTURE CHECK

This section of the chapter explores the creation of a sensing unit and how the creative coding is done on p5.js relates to the Arduino microcontroller. The section also explores design ideation and explorations to understand how the product will be designed in terms of aesthetics and functionality.

4.2.1 Sensing Methods

A gyroscope is a device that measures or maintains angular velocity and orientation. It's a spinning wheel or disc with an axis of rotation (spin axis) that can take on any direction. The motion may be measured via accelerometers, gyroscopes, and magnetometers. These are packed in the same way as other integrated circuits and can output analogue or digital signals. Therefore, to further explore my iterations, I decided to use Gyroscope as a sensor to detect different types of sitting postures.

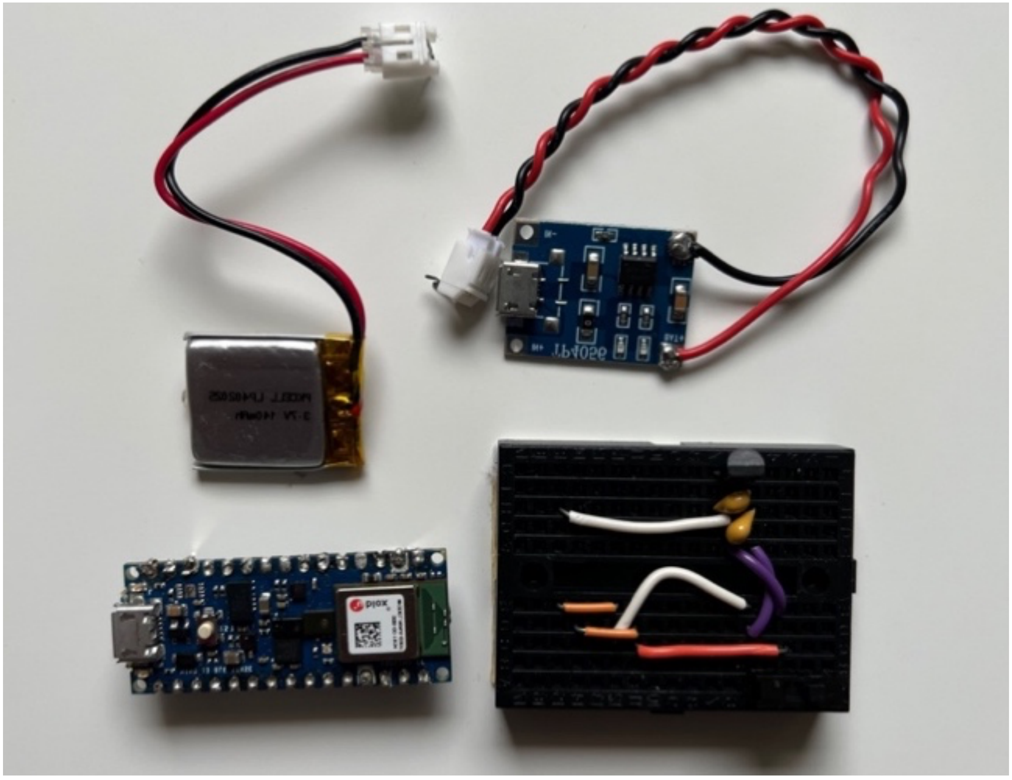

Figure 9 Components of the circuit including breadboard, Arduino Nano BLE, Lithium battery and charger

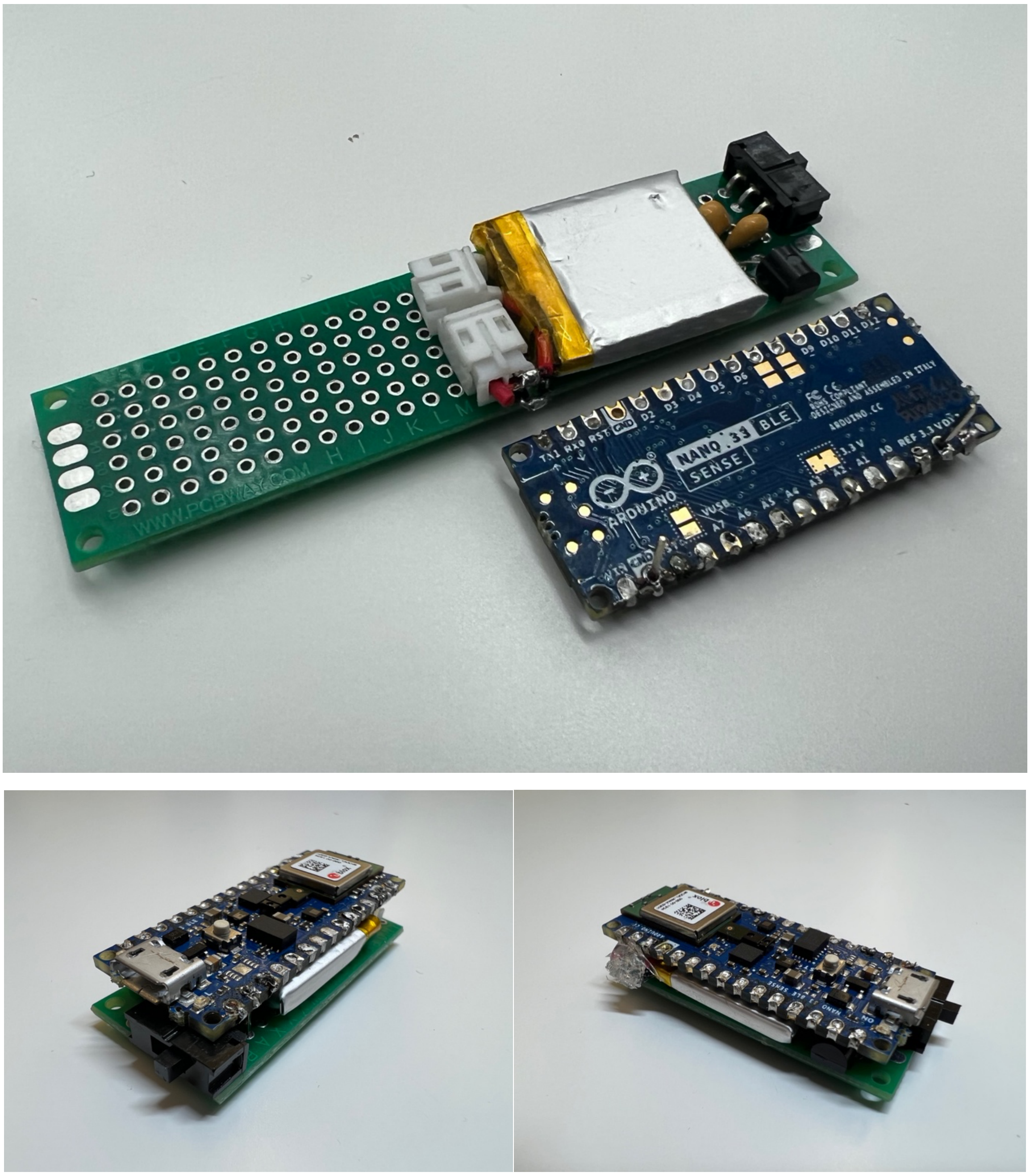

Figure 10 - Compact circuit for the final prototype

Parts and Materials - Arduino Nano 33 BLE, Micro Breadboard, PCB, 1uF capacitor -2, Li-Ion battery and charger, JST 2 pin PCB socket – 2, JST 2 pin wire – 1, Slide switch, Li-battery charger, jumper wires

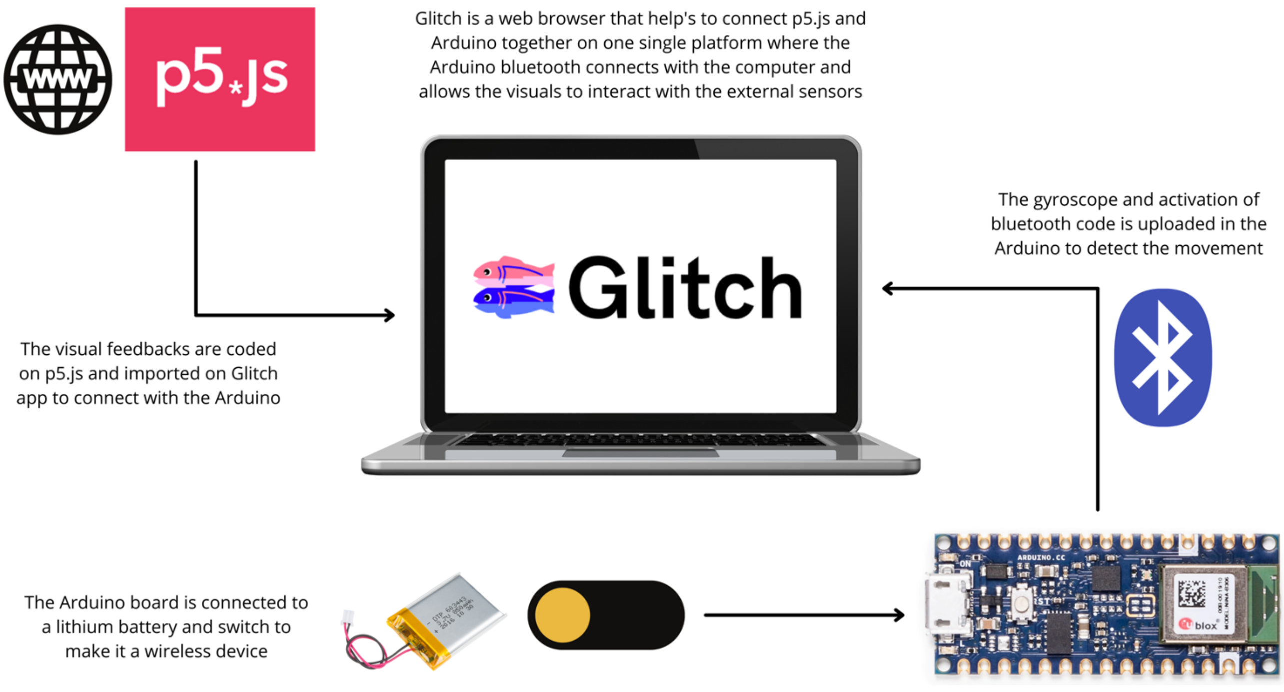

Figure 11 System Diagram for p5.js and Arduino describing the interaction across the devices

How does it work?

A hardware component plus a web application component makes up the wearable gadget. As shown in the system design (Figure 11), a layer between the Arduino microcontroller and p5.js is required to permit serial communication. I chose Glitch.com for my project because it is a creative and expressive tool that anybody can utilise to build online interactions. It's an excellent alternative to the p5.js editor, especially since it allows you to share live code. When you're working with folks remotely, this can come in helpful.

The circuit consists of a Slide switch that allows turning ON/OFF the device. Therefore, the device is connected to a rechargeable Lithium Battery as a power source to make it a Wireless device. The code for Gyroscope movement and connection to Bluetooth is uploaded in the Arduino first. The p5.js codes are then added to the glitch application. It is further connected with the UUID code to activate the Bluetooth and let the p5.js sketch communicate with the external microcontroller. As the code is run, the first thing is to connect the Bluetooth of the microcontroller with the Desktop to allow the visuals to be controlled by the Arduino. Therefore, the Arduino can sense the pitch & roll movement and prevent the visuals on the screen.

4.2.2 Profile of Feedback

During the research and exploring how users can be notified to make them more aware of posture, I realised there could be several non-intrusive ways within the existing device in front of them instead of using an additional device. As my aim for this thesis is to focus on training the brain rather than training the body to make people more aware of their posture, I decided to explore real-time visual feedback in a different scenario that can be communicated to the user directly through their Laptop/Desktop. The user can also select which real-time visual feedback they would like to be notified within different scenarios.

This section of the chapter discusses six different non-intrusive real-time visual feedback options that I have created to make users aware of their posture in the most subtle way possible. The different feedback systems were chosen keeping in mind what different activities and tasks a student performs while working on their desktop during remote learning. The feedbacks were narrowed down by understanding different applications used and specific tasks that are performed while attending online classes and self-study.

The main aim of choosing these subtle feedback systems is to notify user through the device they are using at that time instead of focussing on having notifications on an external device for example mobile phone. The external device can therefore act as a distraction while working/studying. If the user receives feedback within the desktop/laptop screen, it will not deviate them from their work and make it much easier for them to be aware on their posture.

Visual Feedback 1 - Brightness Control

The first Visual Feedback is Brightness Control, where the brightness of the screen changes as the user changes their posture. As the user sits down and attaches the wearable device to their clothing, they can connect the device to the desktop using the “Connect to Posture” button, as shown in Figure 12. Once the user is sitting upright, they can reset the device by selecting the “Reset Posture” option on the screen. At the bottom (Figure 12), the slider button at what intensity the user wants the screen to change brightness. If the switch is at its maximum (towards the right), the screen brightness will fade and become dim when the user slouches at an extreme position. And if the button is at its lowest (towards the left), the screen brightness will fade slightly and not a hundred per cent when the user slouches in an extreme angle.

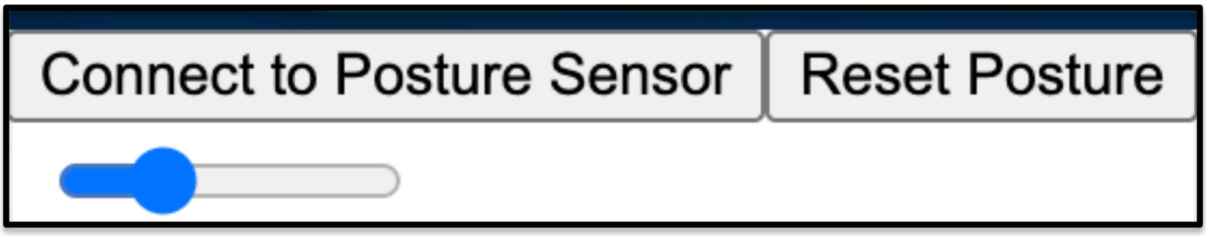

Figure 12 Device connection and control Panel

After resetting the posture to the user's straight, the screen's brightness is complete when a person sits upright, as shown in Figure 13. As the user moves from the proper position, the screen's brightness reduces (Figures 14). The screen's brightness will depend on the user's posture and at what angle they are bending, with the maximum angle the screen being at its lowest brightness (Figure 15). Therefore, the brightness will also change if the user moves in any direction other than sitting up straight. This way of subtle on-screen feedback can be chosen while working, watching a movie, or playing video games.

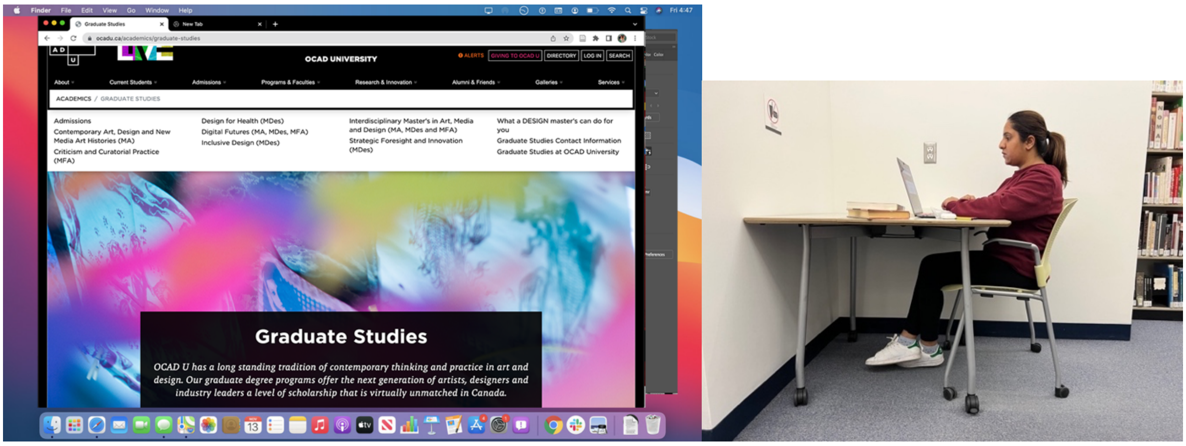

Figure 13 Brightness control - Desktop and Posture 1

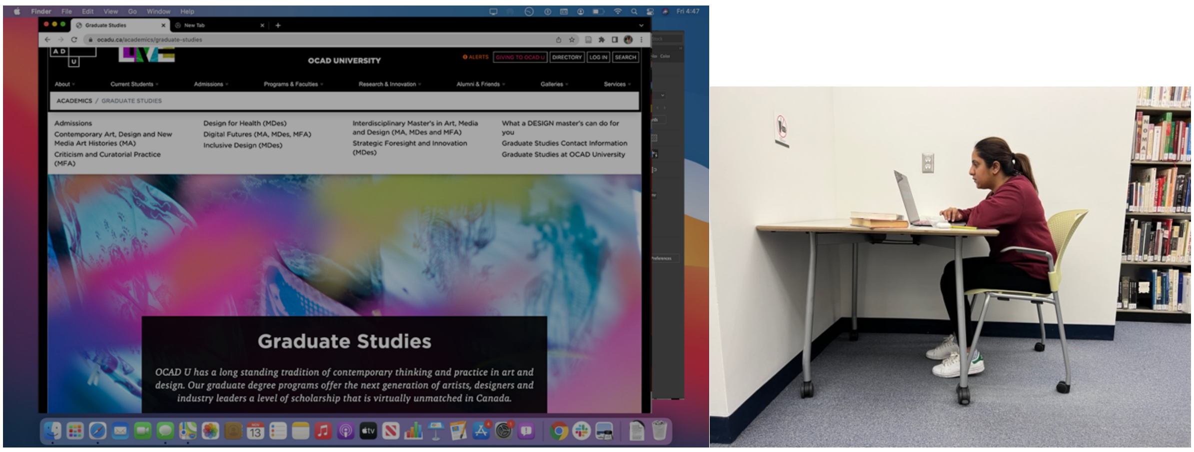

Figure 14 Brightness control - Desktop and Posture 2

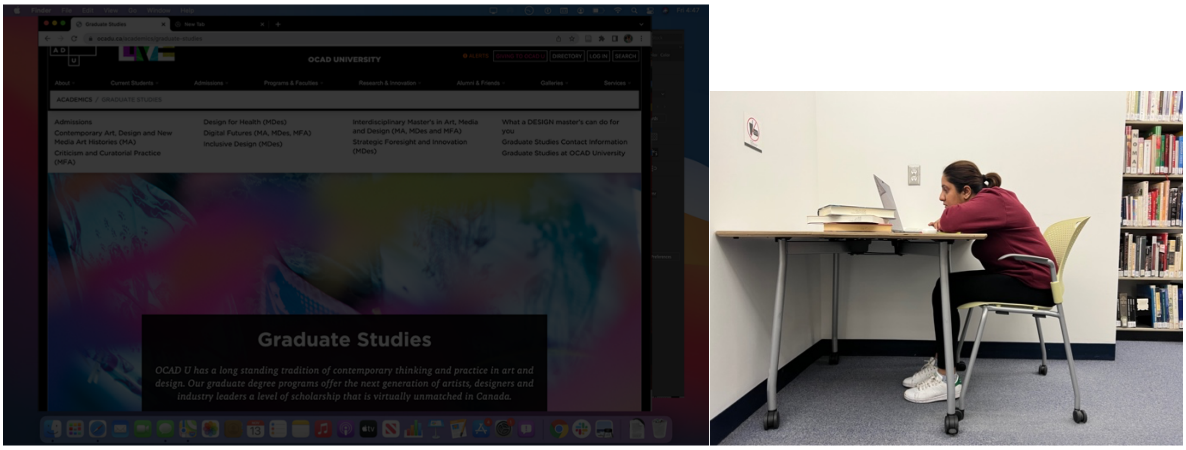

Figure 15 Brightness control - Desktop and Posture 3

Visual Feedback 2 - Border

The second Visual Feedback is called Border colour; it is a subtle and non-intrusive way for users to receive real-time feedback to be more aware of their posture. In this feedback, the device will be attached and reset in the same way as the previous feedback. As you can see in Figure 17, a bright coloured border will start appearing as soon as the user starts changing the angle of their sitting position. As the user leans forward (Figure 18), the borderline will become brighter and be visibly prominent on the desktop screen and, therefore, indicate sitting back up straight. This way of subtle feedback can be used by the user when they want minor interference with their desktop interface yet be made aware of posture.

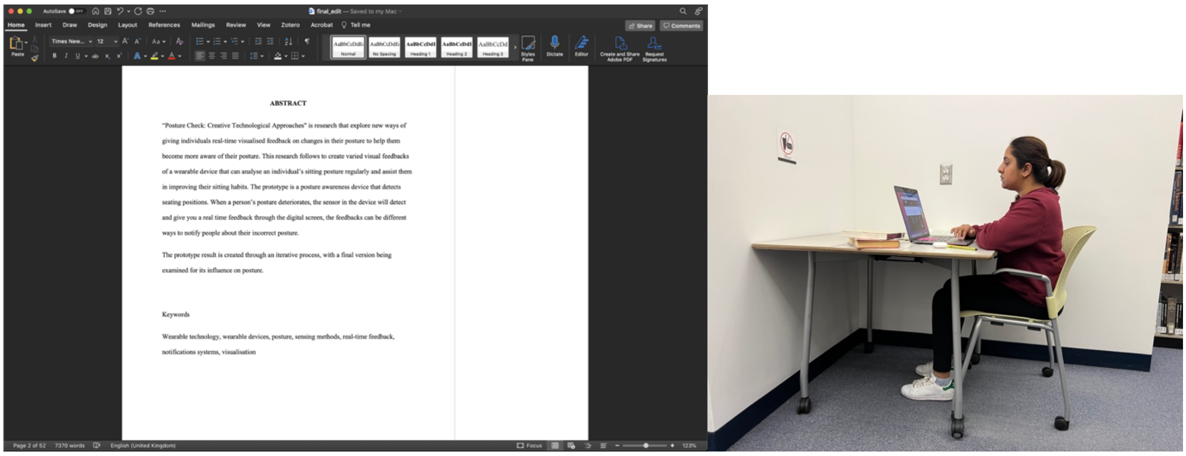

Figure 16 Border - Desktop and Posture 1

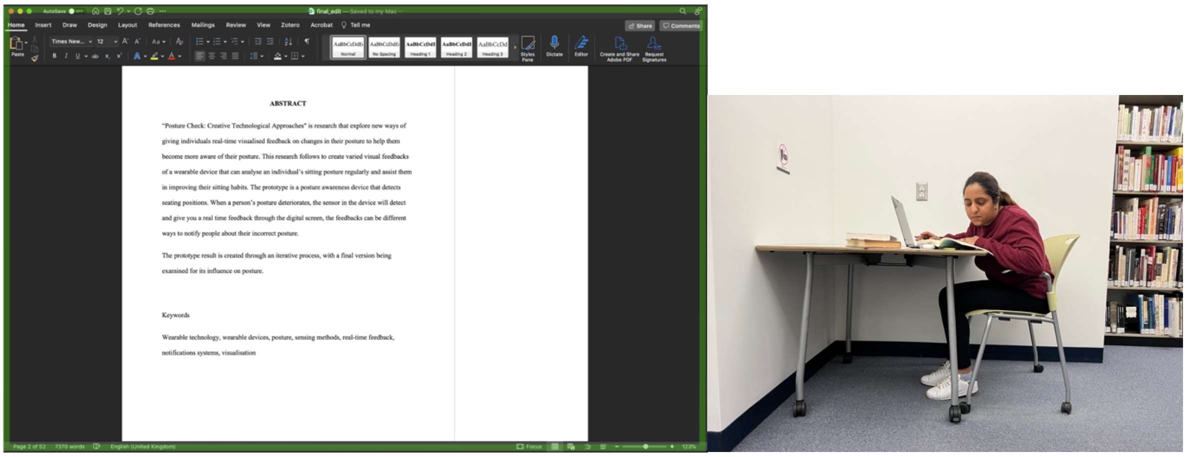

Figure 17 Border - Desktop and Posture 2

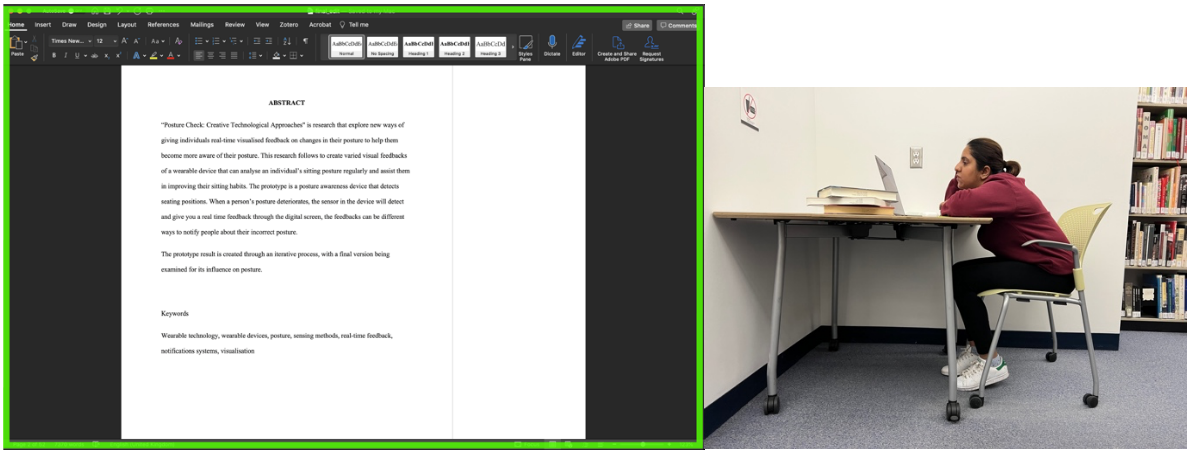

Figure 18 Border - Desktop and Posture 3

Visual Feedback 3 - Orientation of screen during a video call

This visual feedback has been created explicitly by keeping in mind the scenario of video calls while using platforms like Zoom or Teams. This scenario is exciting and engaging user interaction. In this feedback method, when the user is sitting up straight, the orientation of the video boxes in the Zoom call remains in its original form (as shown in Figure 19). As soon as the user leans forward or backwards, the orientation of the video boxes starts changing (Figure 20) and eventually alight in a straight line when a person is leaning in an extreme position (Figure 21).

Figure 19 Video call orientation - Desktop and Posture 1

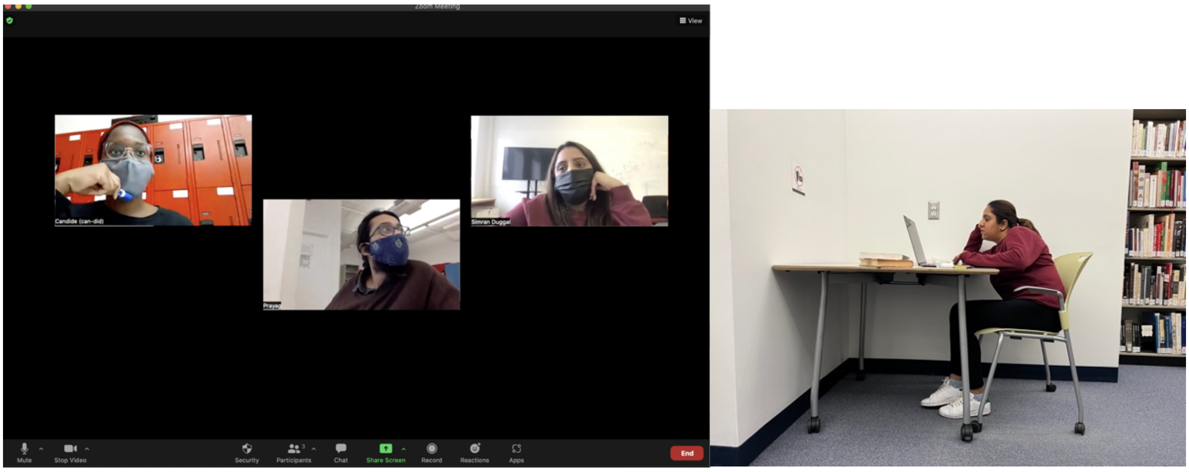

Figure 20 Video call orientation - Desktop and Posture 2

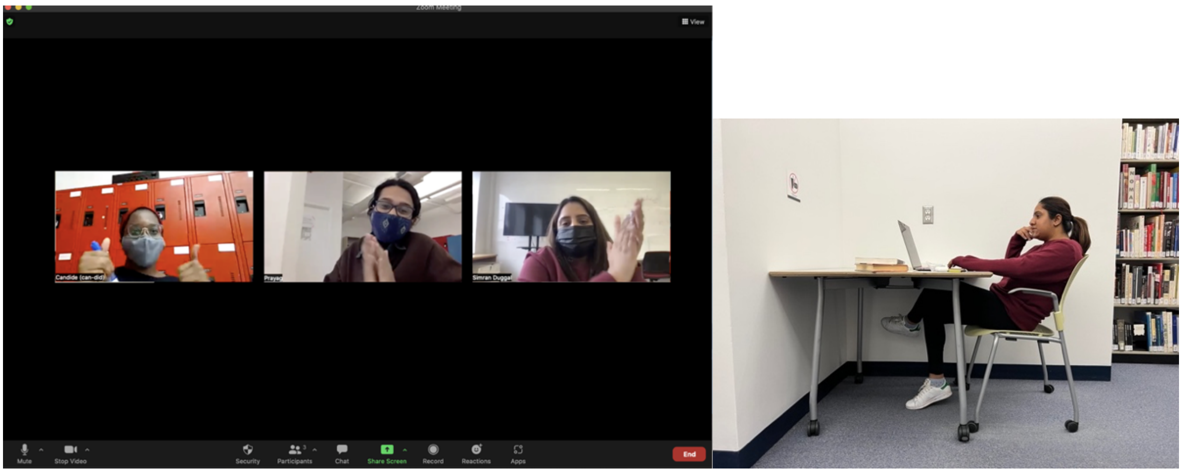

Figure 21 Video call orientation - Desktop and Posture 3

Visual Feedback 4 – Hue / Saturation of the screen

The fourth visual feedback the user can receive is tied to the hue or saturation of the screen. Figure 22 shows the natural screen saturation when the user is in an upright (ideal) position. The screen's saturation changes when the user slouches, as seen in Figures 23 and 24. This lurid visual feedback is provided to the user whenever the user wants to choose a somewhat stricter feedback mechanism.

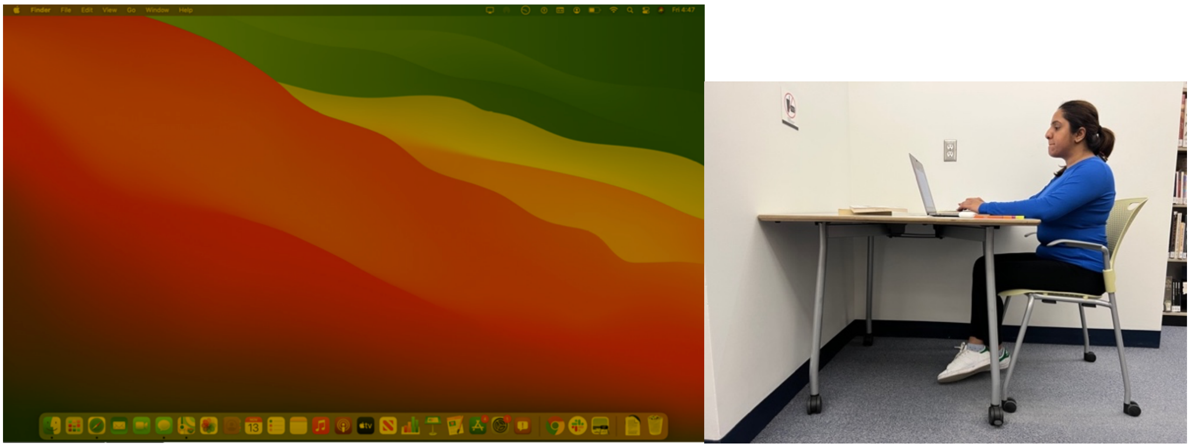

Figure 22 Hue - Desktop and Posture 1

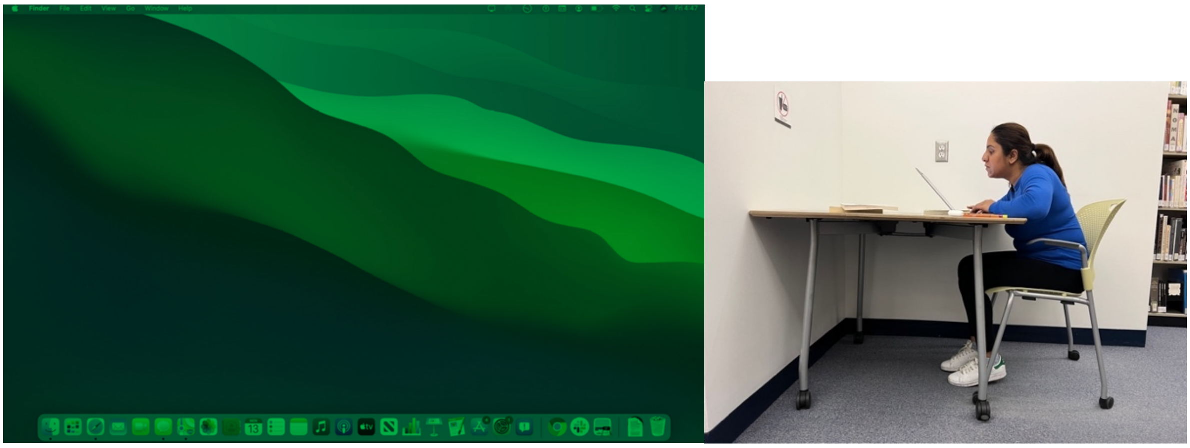

Figure 23 Hue - Desktop and Posture 2

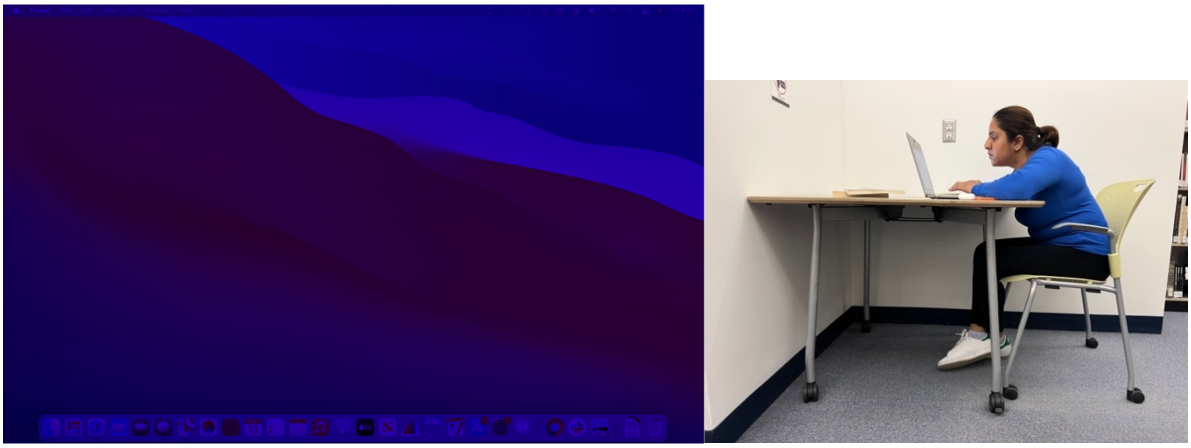

Figure 24 Hue - Desktop and Posture 3

Visual Feedback 5 – Browser/Desktop Blend

The fifth visual feedback type increases the screen tab's transparency and blends it into the background. Whenever the user tries to change posture – leaning forward in Figure 26 and leaning back in Figure 27 – the corresponding screenshots show that the screen blends into the background, thus giving the user the required feedback. This feedback mechanism is relatively easy on the eye but equally effective.

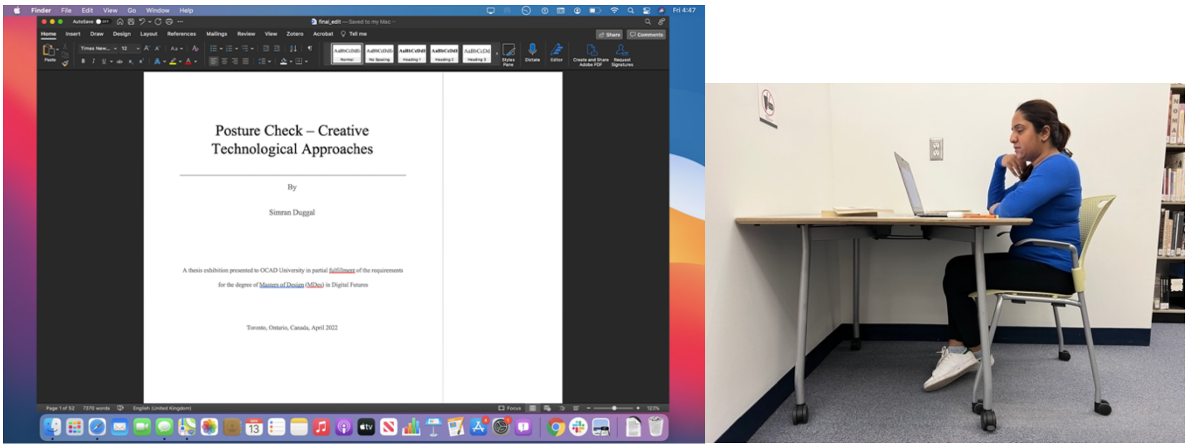

Figure 25 Blending Screens - Desktop and Posture 1

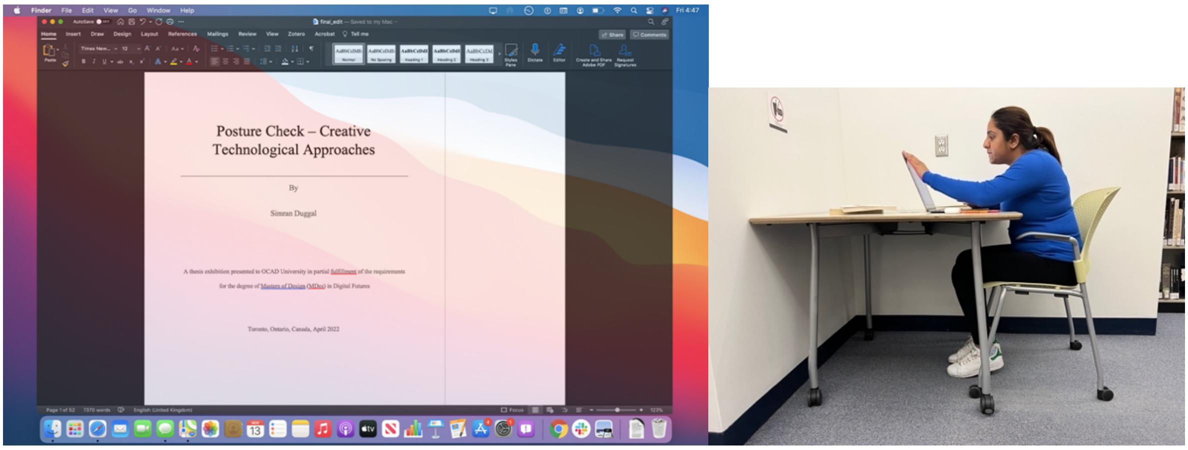

Figure 26 Blending Screens - Desktop and Posture 2

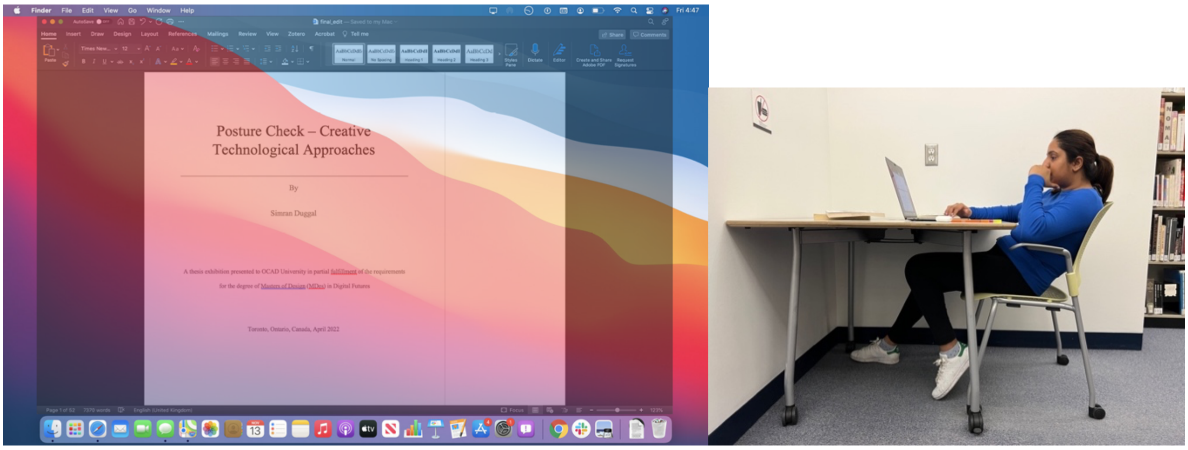

Figure 27 Blending Screens - Desktop and Posture 3

Visual Feedback 6 – Icon cluster

The last visual feedback is a subtle prompt on the user's screen when they are probably not working and open their screen. As you can see in Figures 28 and 29, the icon's position on the desktop screen scatters as soon as the user leans back and forth. This exploration can be an intuitive way of making users aware of their changing posture and encouraging them to ensure their desktop remains clean.

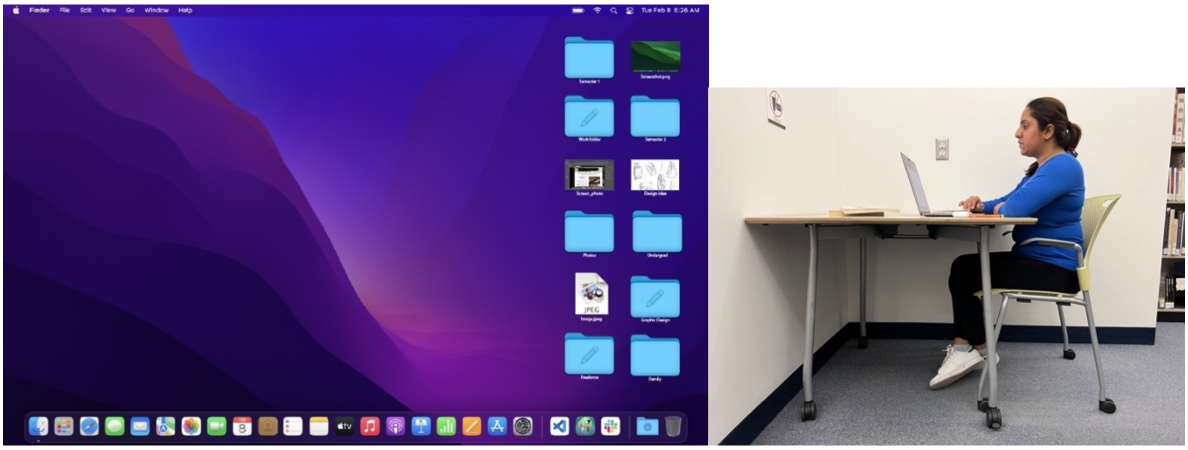

Figure 28 Icon - Desktop and Posture 1

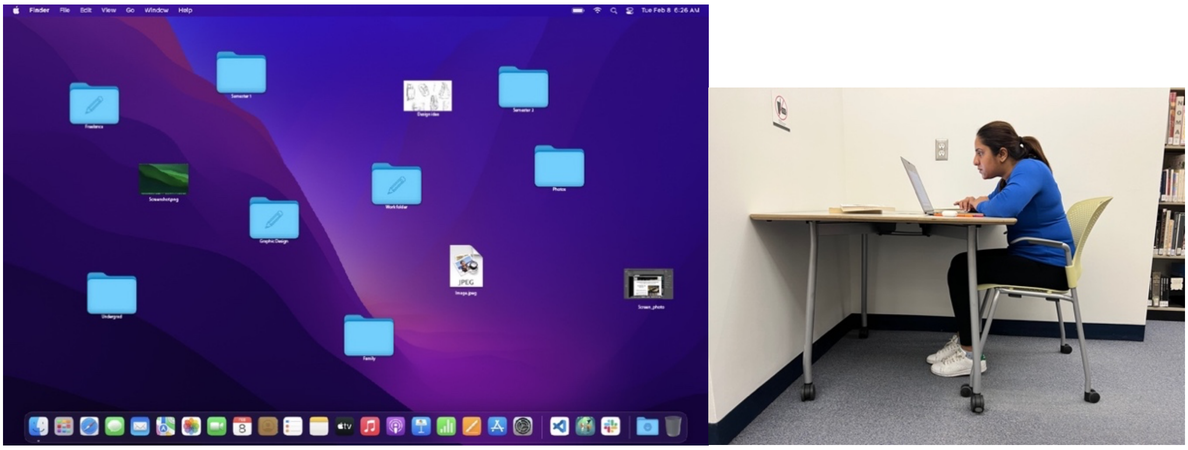

Figure 29 Icon - Desktop and Posture 2

To conclude the process of creating real-time visual feedback, all six feedback experiences have been designed to keep in mind different scenarios aligned with users' tasks and activities when sitting and working at their desks.

The six visual feedbacks are prominently different yet have been explored in the most subtle and non-intrusive way. These various visual feedbacks give users multiple options to select from and decide which way they want to be made aware of their posture.

4.2.3 Design functionality and aesthetics of the product

This section of the chapter describes the functionality and aesthetics of how the wearable product can be placed on a user's clothing. As seen in the existing consumer devices in the previous chapters, there are two main ways of attaching a posture sensing device to the user's body – Attaching it to the clothing using a magnet which then snaps with the product or by using reusable body adhesives in products that can directly be placed on the user's back.

During my research and explorations, I identified if there could be easier and more convenient ways of attaching these devices at different places on the user's clothing yet in the easiest way possible. In the process, I identified that the most subtle form of attaching this wearable device could be using the clip mechanism. The clip can easily be connected directly to any part of the user's clothing without worrying about needing an additional amount for the attachment or wearing the product on their body.
A simple clip-on mechanism for attaching the device to the clothing allows the wearable product to be dynamic in terms of usability. It can be versatile in that users of different builds and sizes can wear worn universally. It also ensures that people of all age groups can easily set up wearable products.
Along with the form and attachment mechanism, for the working prototype, there is a Slide switch that has been incorporated into the device to ensure that the device can easily be turned ON/OFF. A sliding mechanism to fit the electronics in the casing has also been explored, keeping the use case scenario of the device.

Form explorations

As illustrated in Figure 32, many types of housing and clip attachment styles have been explored—form conceptualisation based on how the product case will appear depicted in the sketches below. I attempted to keep the shape modest since I wanted to employ 3D printing to make the product's casing. The device is designed to fit the PCB board with the microcontroller conveniently and contain the Lithium battery within the case itself, keeping in mind its function and circuit size. The slider mechanism to open the casing was most suited for the prototype since the battery is rechargeable.

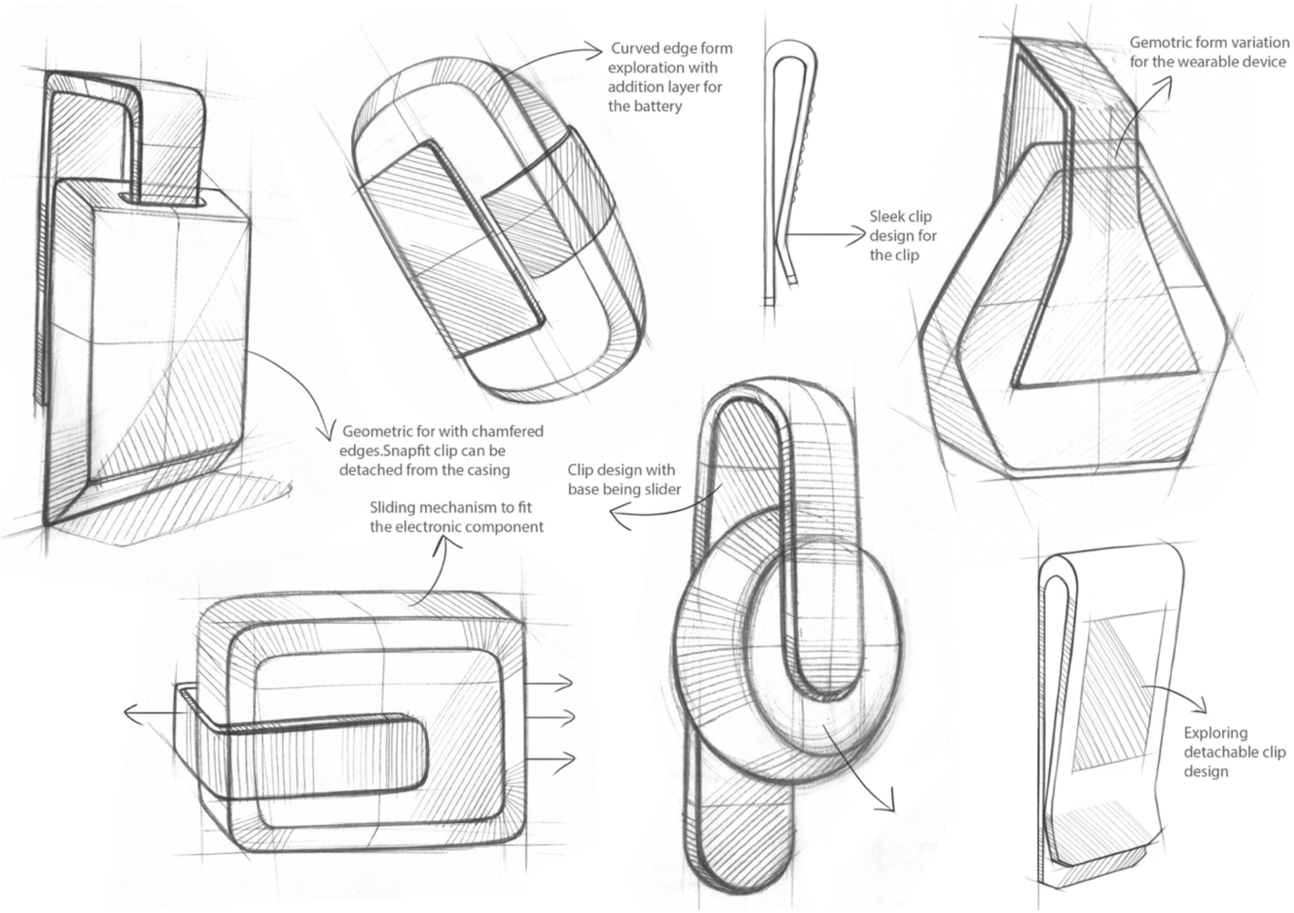

Figure 30 Form explorations for the wearable device

How and where can the product be placed on the body?

The wearable prototype has a simple clip mechanism that the user can easily place and set up within a few minutes. The real-time visual feedback has an option to "Reset posture" (Figure 14) after connecting the device with Bluetooth. The device can be easily attached to the user's clothing and set up according to their straight sitting posture.

As you can see in the figure below (Figure 33), different places have been marked where the wearable prototype can be placed on the clothing. The device can either be attached to the back of the user's shirt to detect entire upper body movement or the edge of the pants to focus mainly on the lower body movement. The device can also be attached to the front of the shirt – collar, pocket or around the shirt opening.

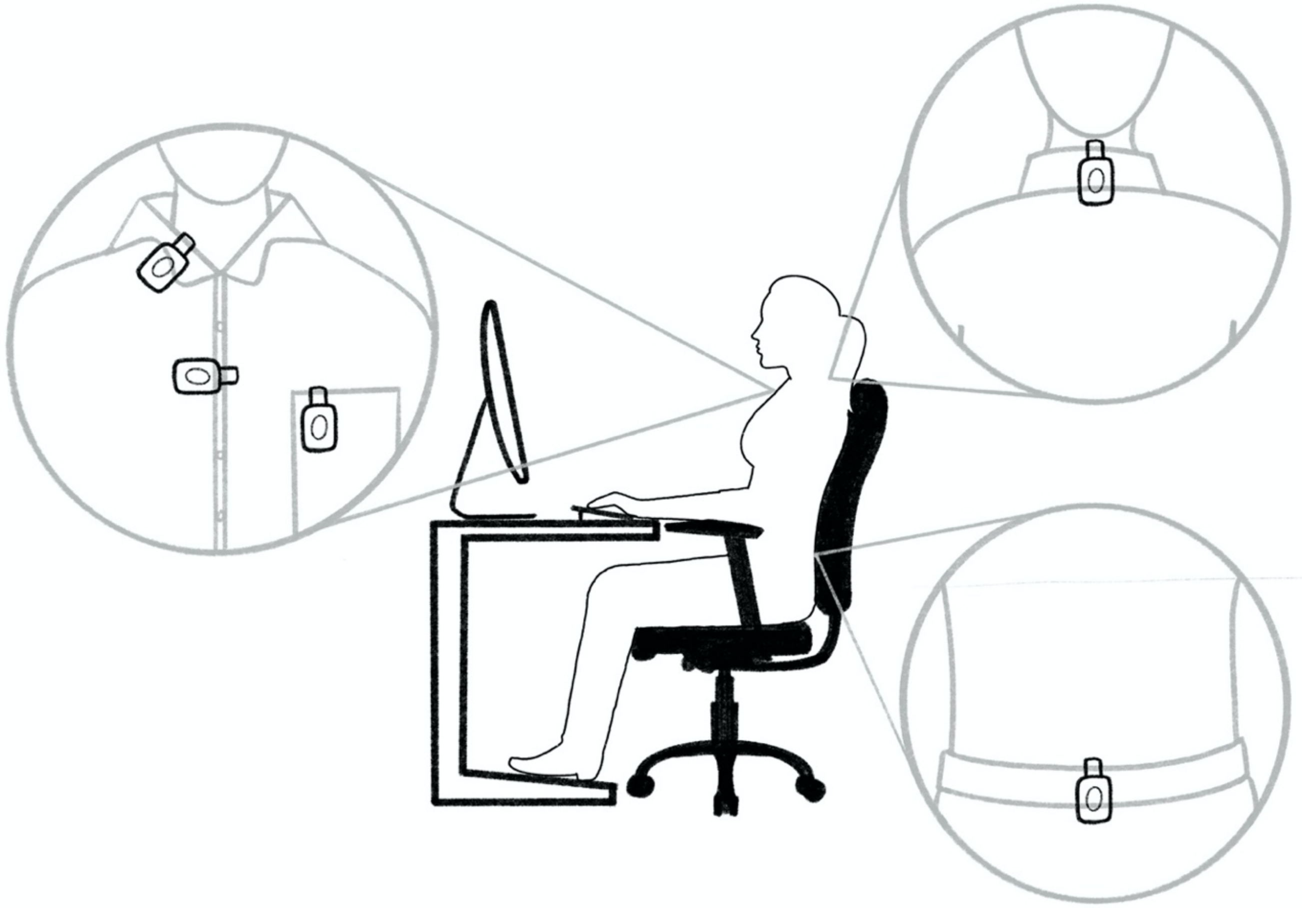

Figure 31 Illustration showing placement of the wearable device

3D CAD model explorations –

This section of the chapter includes 3D CAD model explorations that are being done to create the case for the PCB and microcontroller. Creating the 3D printed casing is an ongoing process in the thesis project, which I'm currently working on. In Figures 34 and 35, one case has been created, which is geometrical in shape with slight chamfers on the edges. The case consists of a sliding mechanism to incorporate the PCB board and engraved arrows to indicate the direction the box will be opened. In addition, I will be modelling and printing different explorations of case options to identify which one will look sleek, minimal, and compact.

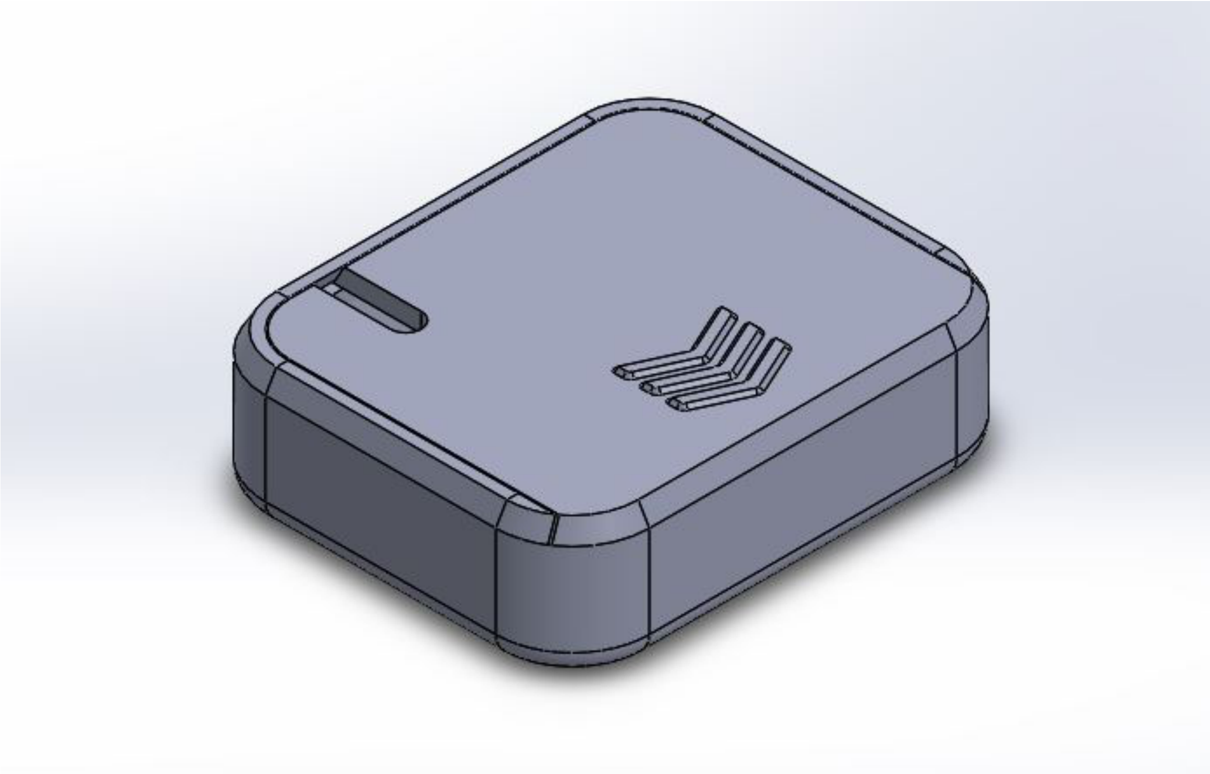

Figure 32 Form exploration of Rectangular Case Design for the device

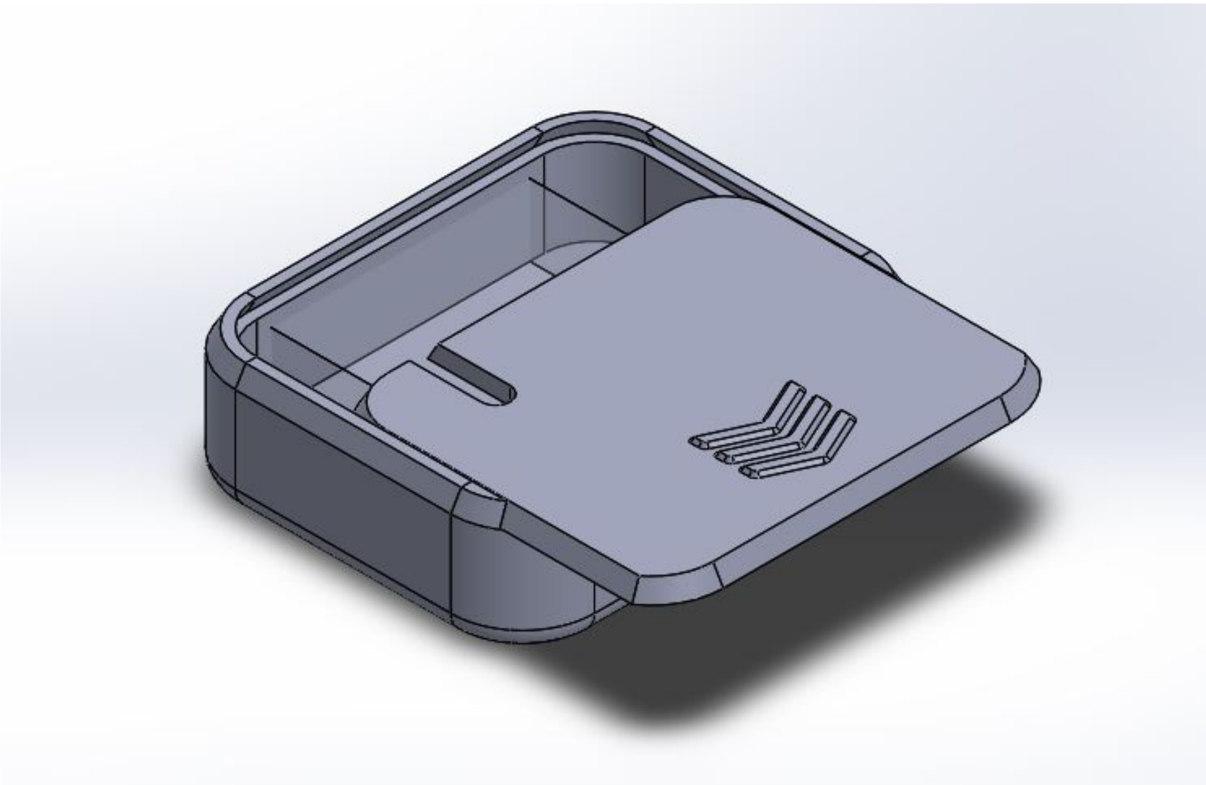

Figure 33 Form exploration of Rectangular Case Design with slider mechanism for the device

Final Prototype – Wearable Device and Web Application

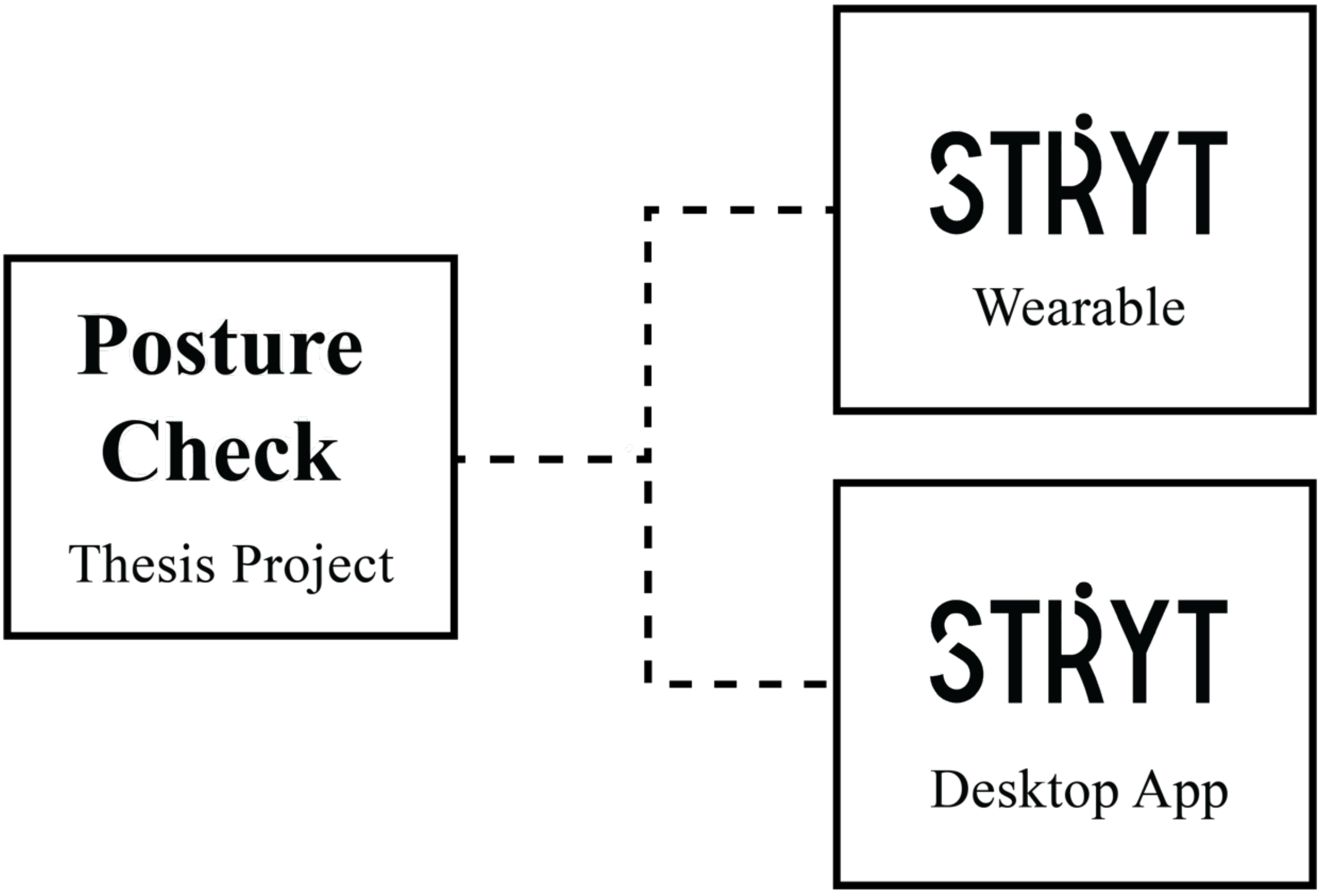

Figure 34 Final outcome of the thesis project – STRYT (Wearable device and Desktop application)

The outcome of the thesis project consists of two prototypes – The wearable device and a desktop application to support the idea and functionality of the product. The name of product and the application is STRYT which means “Sit up right”. The wearable device is ergonomically designed in a way that it can be clipped on to the clothing of any user and they can reset and calibrate the device according to their “straight” posture. The web application has been designed to support the wearable device and give a platform to the user to select the feedback system that would be suitable for them during the task that they are doing on their desktops. The application also has an onboarding process explaining how the device will be set up.

CAD Model – STRYT (Wearable Device)

Figure 35 Four different views of the CAD Model

As you can see in figure 35, the form of the device is minimal and simple focussing on the ergonomic features of the device including the slider to access the internal circuit of the device and clip to easily put the device on. The wearable device has an enclosed compact circuit with an Arduino microcontroller, lithium battery and switch as shown in the exploded view of the device in Figure 36. The device therefore connects to the desktop using a Bluetooth. The CAD model for the device was created using Rhinoceros 3D modelling software and further rendered using Keyshot.

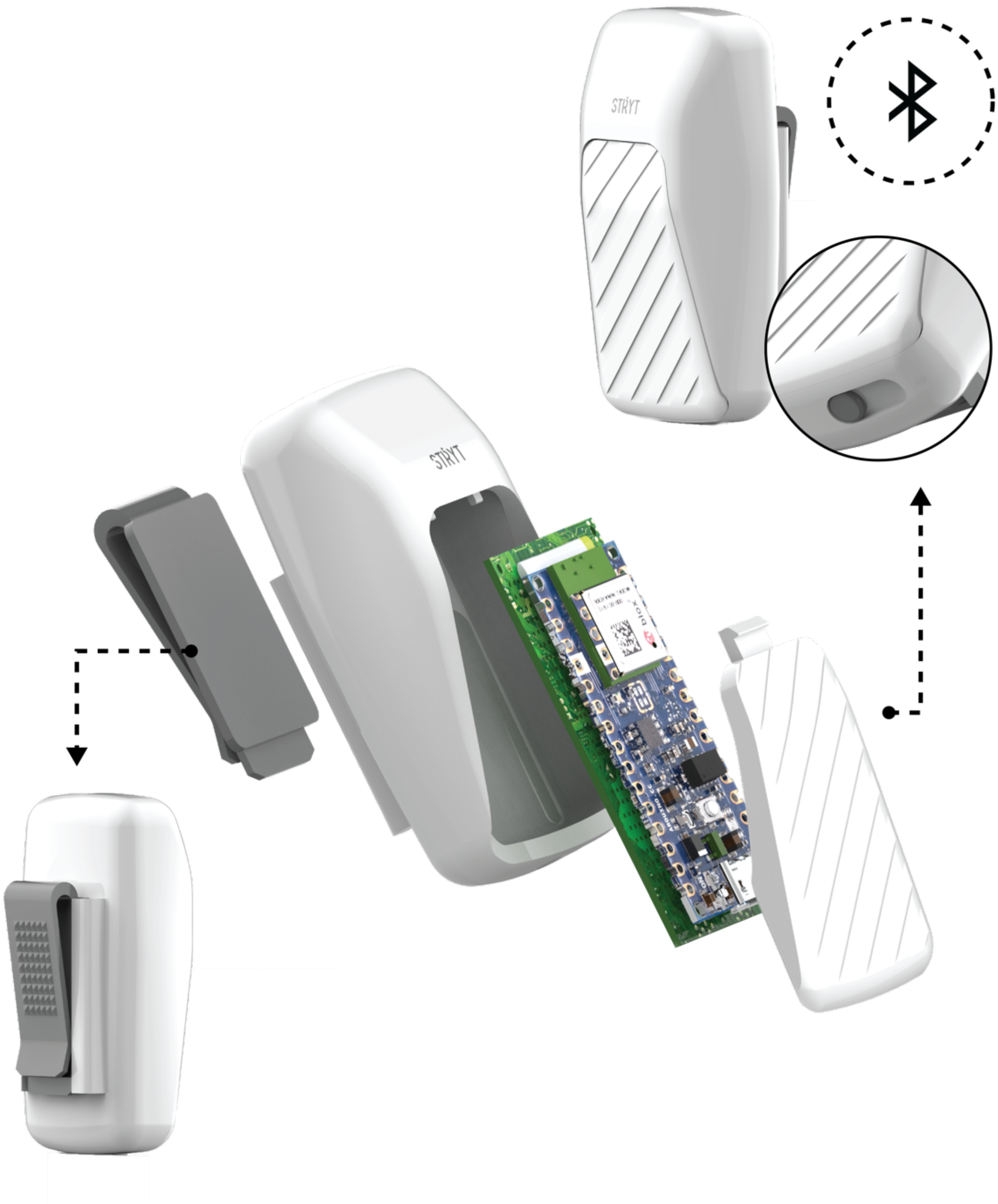

Figure 36 Exploded 3D view of the product by highlighting the product features

3D Prototype – STRYT (Wearable Device)

Figure 37 Different stages of creating a 3D printed prototype for the wearable device

The construction and design of the 3D printed prototype was done keeping in mind the functionality of the device. As shown in Figure 37, different forms were explored to ensure that the circuit fits in perfectly in casing. The casing was therefore 3D printed using the PLA plastic filament. The 3D printed device was further coated with a layer of dry wall putty and smoothened using a sand paper to even out the surface. To give the product a more finished look, I painted the device in white paint along with a player of clear finisher.

The 3D printed prototype is a fully functional that can easily be put on the user and tried to see how the device responds to the user's posture movement on the desktop screen. Figure 38 shows the finished look of the wearable device prototype.

Figure 38 Finished 3D printed prototype of the wearable device

Prototype – STRYT (Web Application)

STRYT is a web application prototype that has been created to demonstrate how the wearable device will interact with the desktop. The app demonstrates how the users can get control of their feedback system and how they can easily access changing it by the ease of a click.

The web App consists of a simple onboarding process of a user (as shown in Figure 42) which allows the user to create an account to store their data in the system itself. The onboard process is followed by simple process of installing the device and connecting with the desktop using a Bluetooth. This step allows the user to understand how the device needs to be connected every time they are using it. Further ahead, there is a user dashboard that consists of two main options – Feedback Type & Connection (Figure 40). The Feedback type therefore consists of 6 different feedback demonstrations explaining how each feedback system works. Therefore, the user can simply go through the options and change their feedback type according to the tasks they are doing.

Figure 39 Welcome screen of the Web App with the logo - STRYT

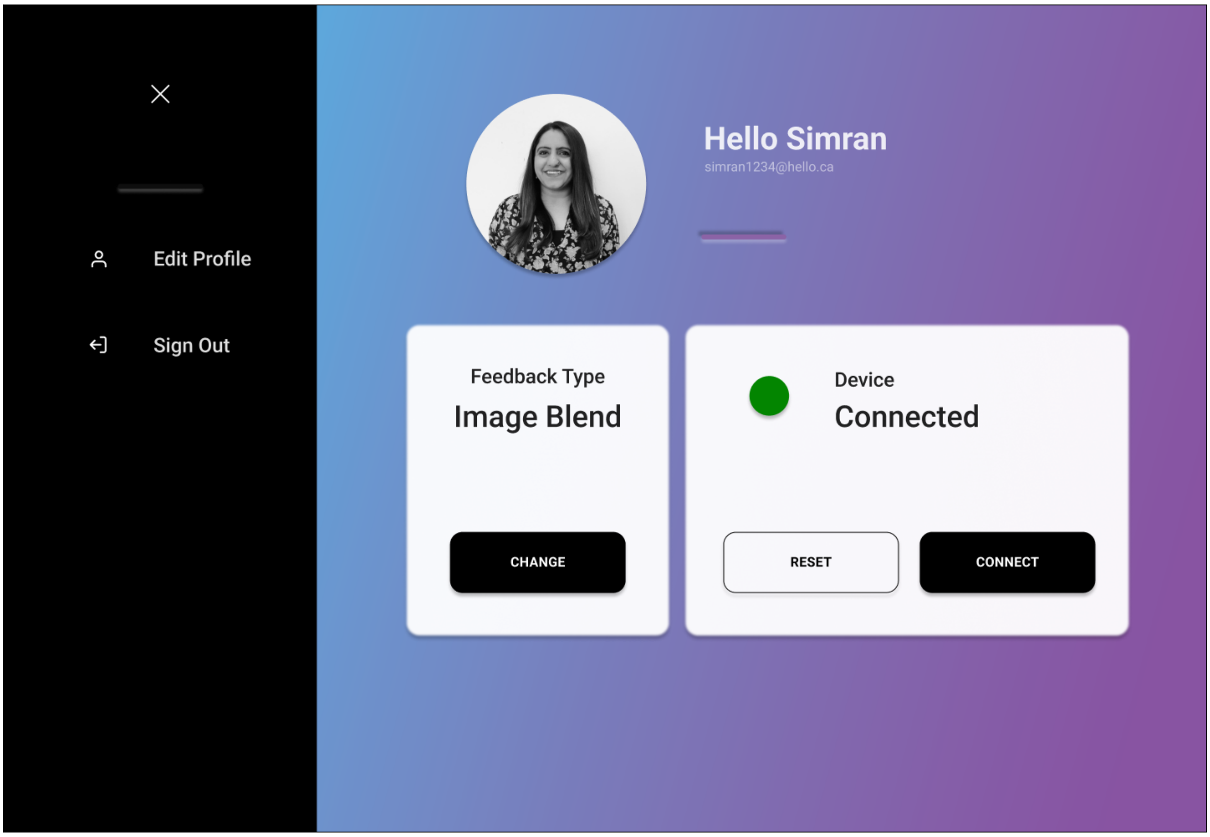

Figure 40 User Dashboard of the Web App indicating the user where to change the feedback method and connect the device

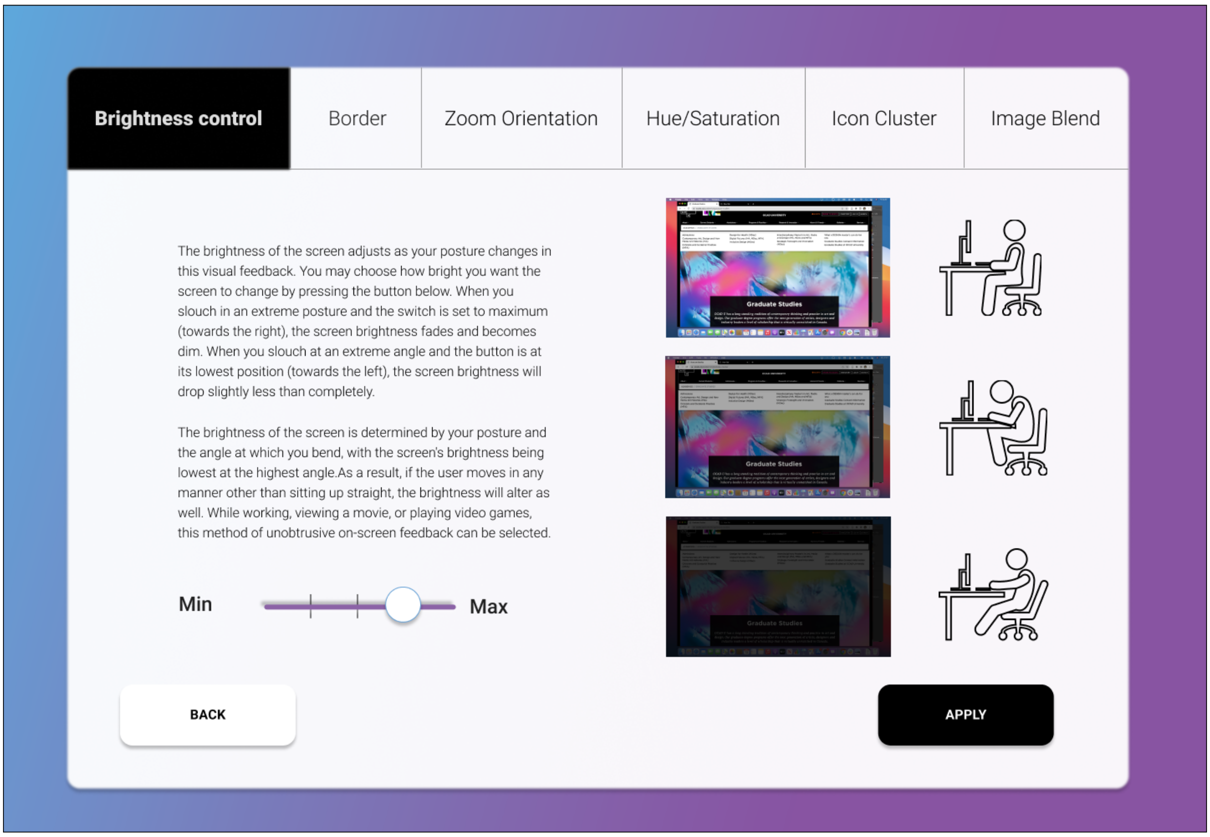

Figure 41 One example of Feedback demonstration for user to understand how the feedback system works

Figure 42 Diagram explaining the User flow of the Web Application

OUTCOMES AND REFLECTIONS

This thesis project was inspired by my own experience of studying online during the pandemic. It inspired me to draw attention to a problem that sometimes remains unaddressed by people in their everyday life. The project involved researching and understanding the issue in-depth and analysing how wearable technology and advancements in technology can participate in developing solutions. The outcome of the project was one method of non-intrusive feedbacks through screens that has been catered in this project.

Thus, the goal of this project was to provide a tool that would make the user more aware of their posture and creatively present this feedback. The wearable device is therefore non-conventional compared to the existing devices in the market as existing devices focus on only haptic feedback to make people more aware about their posture movement. Therefore, the wearable device that I created indicates a user in the most subtle way possible instead of distracting them from the task that they are doing. Subtle feedbacks allows user to continue concentrating on the work they are doing and train their visual memory in the most subtle way possible. It also allows user to only be notified when they are slouching while working on their desk instead of repeatedly sending them feedbacks when they are performing other tasks. The proposed design has promise. However, there is still space for development.

In terms of the methodology, I discovered that the Research through Design and iterative design approach works well for designing and developing wearables. Compared to non-wearable technologies, I found that form and function components are deeply interwoven. This makes it more challenging to create incomplete prototypes that test one feature.
By creating six different non-intrusive visual feedbacks, I am trying to enhance a user's experience by giving them an option to decide their feedback method in various scenarios other than just haptics.

Exhibition –

As you can see in Figure 43, different people tried the wearable device and experienced how the product exactly works and shared their feedbacks. I observed that amongst the six feedback types, majority of the users preferred three feedbacks in order – Brightness control, Border, and Image blend. The users shared feedback that they can imagine themselves using these three feedback types more compared to the others. They also were very intrigued by how responsive the product was to their changing postural movements and were very enthusiastic to try different sitting positions to see if the product works well.

Some of the users spent some time on the desk to understand whether these feedbacks system act as distraction when they are working and realised that it doesn't cause much disturbance to them and realised that it doesn't distract them what they are doing but it would take them some time initially to get use to this type of feedback method. In addition, the design and mechanism of the device was liked and encouraged how the device was so compact. The web app display also made it easier for people to understand how the device will be set up.

The feedbacks and observations from the exhibition made me realise that in the future works of the project, the number of feedback types for this method of desktop feedbacks can be reduced.

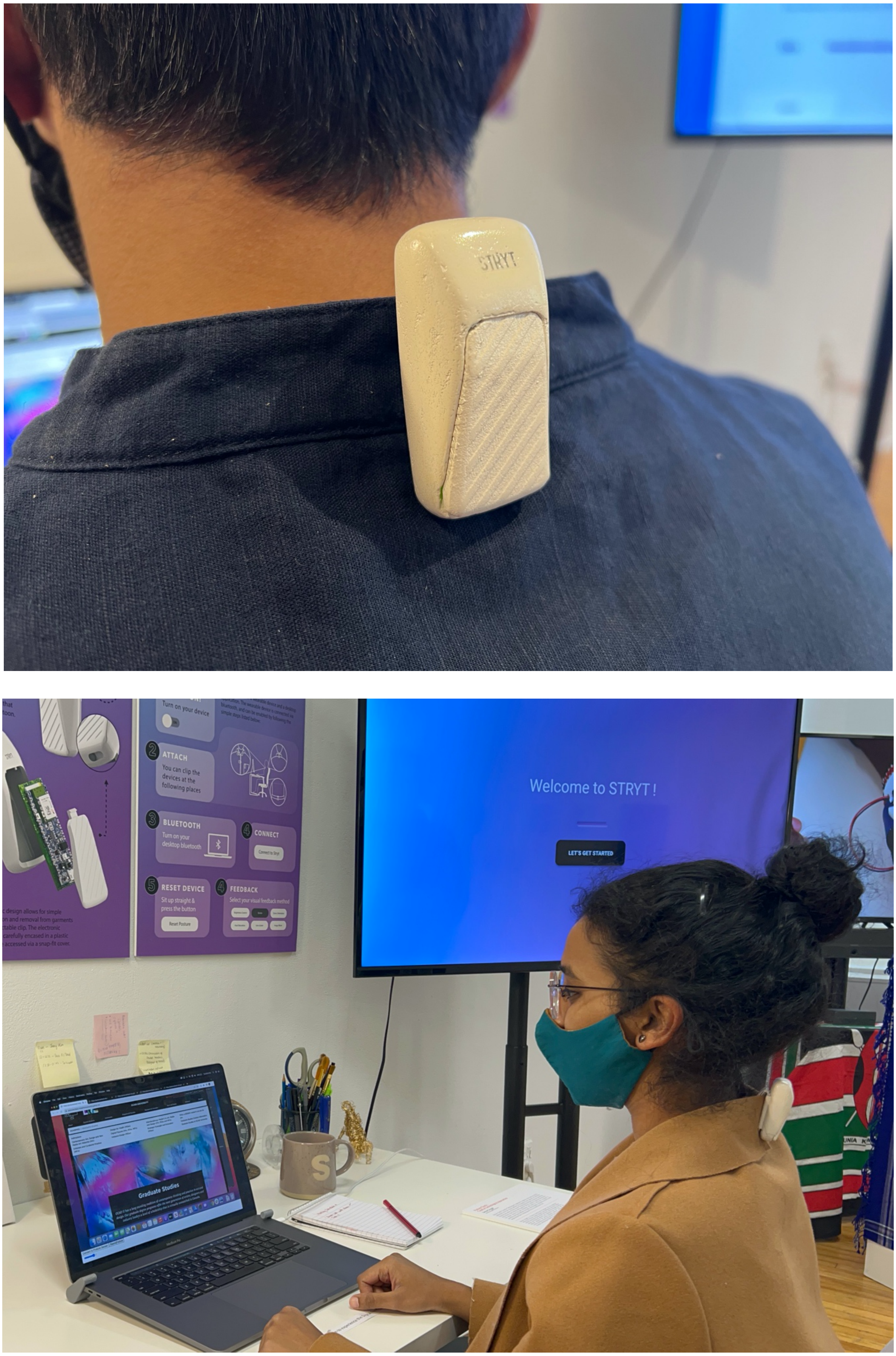

Figure 43 People at the exhibition trying out the prototype and sharing their feedback

FUTURE WORK

The next step for this project will be user testing to validate the outcome. The user testing will be conducted with a focus on the target audience of university students. Users will be asked to test each of the six real-time visual feedbacks and observe the posture-sensing prototype in terms of functionality and ergonomics. Following the REB protocols, the user testing will be followed by asking questions and opening discussions to discover their reaction and preference amongst the different visual feedback. Furthermore, observations will be recorded, and feedback will be incorporated into the project.

In addition, I get an opportunity I want to create wireframes of a laptop application for the product just as a potential component that can help me reach out to competitors and well as independently pitch the non-intrusive feedback options.

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