Research and Inspiration

Stress Less Group Project

Similar Project Research – Neha

Stress is a term that is used to describe our reactions towards feelings of pressure and threat. Whether or not stress can be positive or negative depends on the quantity that one feels. Small amounts of stress can allow one to feel energised and aid us in doing tasks; however, in large amounts or when felt for elongated periods, it can affect one's mental and physical health (Mind, 2022). Additionally, one can feel stress as a result of mental or physical health conditions. This led us to wonder what groups in society are the most affected by stress and what we can do to reduce their stress levels.

Statistics illustrate that those in the age range of 18-24 feel the highest levels of stress, with 60% of the demographic reporting they have stress relative to the pressure they feel to succeed, 32% with housing, and 49% feeling their stress to be relative to the pressure they feel to compare themselves to others (Mental Health Foundation, 2023). As a result of this, we decided that our target demographic should be this age range of 18-24-year-olds, due to the demographic being the most affected.

Within our stress monitor, we decided to implement the use of colour psychology to visually represent different stress levels. Colour psychology affects the decisions people make, with an estimated 90% of 'snap' decisions being influenced by colour.

To determine what colours these included, I looked into research papers that covered this topic. I came across 'The Study of the Potential for Positive and Negative Colour Connotation Through Associations' by James Mecayla Gray. Within this research paper, they referred to each colour as having its individual 'association score', with 0 referring to negative connotations and 100 referring to colours with the highest positive connotations. The conclusions stated that there is a possibility of an increase in this association score as there is movement along the visible light spectrum, with red having the lowest association score and purple the highest.

<u>Product 1:</u>

Within our project, we wanted to take in the user's heart rate data, which a wide range of sensors can do. Looking into already existing projects would help inform us of what current designs are and any positives and negatives of the sensors used.

The research paper 'Design of a wearable bead health monitoring bracelet' does not primarily focus on reducing stress levels for individuals but focuses on the overall health of the user.

Though there are systems that cater to the monitoring of this data, this paper focuses on providing data analysis to provide before medical situations, such as before medical attention can arrive. Their prototype of a health monitoring system device monitors the user's data on their medical conditions and transfers this to an external device that can perform data analysis that can aid medical practitioners when they arrive on the scene. Additionally, they focus on the design having features that appeal aesthetically to the user. The sensors include the ECG Sensor, Optical Heart Monitors, SpO_2, Body Temperature Sensor, GPS tracker, and EDA (Electrodermal Activity Sensor). I will now expand upon the sensors that would be used within our project.

1) ECG Sensor: These measure the heart’s electrical impulses, which can be used to measure the user’s heart rate
2) Body Temperature Sensor: Measure fluctuations in the body’s temperature
3) Optical Heart Monitors: Measure heart rate through the circulation of blood throughout the body.
4) EDA Sensor: aids in monitoring stress levels through measuring sweat secretion fluctuation.

Overall, though this project does not centre around stress, they aim to appeal aesthetically, use cheap and environmentally friendly technology to appeal to a large audience and to protect the users' data, all of which coincide with our project. Our project, however, has the specific target audience of young people and aims to provide a solution for the user rather than problem-solving before the arrival of medical attention.

<u>Product 2:</u>

The study ‘A machine learning approach for stress detection using wearable sensors in free-living environments’ focused on detecting the stress of users using real-time data using wearable sensors in a non-intrusive manner. These non-intrusive conditions were reflected in the components they chose: ECGS (Electrocardiograms), SC (Skin conductance, also called Electrodermal Activity), and ST (Skin temperature). Each of these sensors operates using different input data. ECG sensors take in the electrical impulses given out by the heart, whereas optical heart monitors take in the rate of blood circulation throughout the body. In their study, they concluded that the KNN machine learning model should be used to categorise the stress levels that the user felt. Their project had a 98% accuracy rate, a figure based on a cohort of 238 individuals, illustrating that the controlled lab conditions that were thought to be required within stress detection are not necessary. The usage of machine learning allows for a profile to be built around the user, identifying any triggers and personalising their experience to this.

However, there lies the risk of variability in stress responses, as factors such as age and gender can affect the accuracy of this. Within this project, battery life was a large concern due to a large range of factors outlined below:

1) Continuous data collection means that the device needs to be constantly active, which can lead to battery life being drained quickly.
2) Real-time monitoring can also cause a large processing load and high power consumption.
3) Machine learning can be computationally expensive, which can lead to large energy consumption.
4) Using multiple sensors can drain battery life
5) Communication via Bluetooth or wireless internet can drain battery life.

We considered the usage of machine learning; however, we considered the lack of time we have this term and the consequences this would have on the battery life of the device. Having a longer battery life is important within our project to increase the convenience of use.

Origins of Stress and Consumerism – Aqdas

In modern society, consumerism is seen as something we as individuals do to gain immediate gratification within ourselves, as stated by Sugarman in his analysis of working-class pupils who often go through the immediate gratification process. This process, alongside stress from various factors, creates a psychological mindset which encourages individuals to purchase products with mental stimulation apparatus, also known as fidget toys. James (2004) conducted a study which found that “49% of students experience stress caused by school daily”, with contributing factors being:

- Navigating social lives
- Adjusting to routine changes and transitions
- Pressure to be successful
- Finding or identifying support systems
- Time management

Due to the high levels of stress teenagers (often school children) go through, they tend to turn to a few key “stress relievers” which may include nicotine inhalation devices, harmful addiction and other potential vices. Therefore, these stress relief toys provide alternative ways to relieve stress without the possible chance of hurting themselves with harmful substances. This way, our product provides students a safer way to relieve stress without causing any harm and provides benefits such as health monitoring.

Stress relief tactics (fidgeting)

With there being many methods to fidget, the three key ones we decided to analyse were Mechanical Switches on Keyboards, “Needoh” (high durability silicon) and Fidget Spinners (Equalised Centrifugal Force via Ball-bearings).

Mechanical actuation switches on a keyboard have a tactile audio and physical response outputted to the user when activated. Not only does this provide a confirmation of response, but it also provides a recreational function to which the user is free to interact with since it also provides mental stimulation. These switches use stems and springs to provide an audible and physical response to being activated (as shown below).

The upper housing hosts the stem and the contact, which interacts with the guide, allowing for a tactile feel and when the stem makes contact with the lower housing, the audible click is heard.

Ultra-high resistance silicon can also be used as a stress toy. Since it has a high tolerance to stretching, people can use it as a way to relieve excess tension. Often paired with a thick consistency fluid, it provides an excellent alternative to traditional stress balls. For example, the “Needoh” has gained significant popularity since its introduction, becoming a well-known sensory and stress-relief toy. The combination of the two technologies allows for a near indestructible product by hand product which is great to take stress out on.

Fidget Spinners are also a similar toy that uses centrifugal rotational force to create a balancing object orbiting a handle with a ball bearing joining the two. A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. Fidget spinners can potentially help reduce stress and anxiety by providing a sensory outlet and distraction.

Hardware and Software Research – Aqdas

Components

Primarily, we need a microcontroller, which will be the central processing unit for data acquired by sensors such as beats per minute or other “vital” data. At first, we believed that an Arduino Nano would be a good microcontroller to handle the job; however, we decided to proceed with the Raspberry Pi Pico. This is because it is a low-profile, low-power system with onboard Wi-Fi and Bluetooth, the same as the Nano, but without the extra hassle of external drivers and ARM architecture needed to operate the device. The Raspberry Pi Pico was also abundantly available for us to use. Since it is an easy-to-acquire component and is more accommodating than the Arduino Nano, we decided that it was the better option.

To detect the data points needed, we would need a heart rate sensor. In this case, we decided to move forward with the MAX30102 as opposed to other alternatives. This is needed to detect a stable rate, which can be utilised by the microcontroller to detect a spike in ECG/EKG activity. We decided to use the MAX30102 as opposed to the Elecrow Pulse Sensor since the MAX has more capabilities and functions and can provide a more stable output than the Elecrow. The MAX30102 also has great support for many platforms, one of them being the Raspberry Pi Pico. With the Pico, we can optimise and create an efficient system for the MAX, which will allow us to gather data not only efficiently but also at a pace which will have a minimal impact on battery life, allowing the end user to execute more activities within the same period.

A GSR sensor can also be used. Grove GSR sensors can tell if the person is sweating, which can be a sign of stress and distress. This would be able to provide us with indicators that we can use to determine stress. We can also use a temperature sensor [DHT22] to detect a rise in spikes in temperature, which is an effect of adrenaline being pushed. These two variables are great indicators of whether someone is undergoing a stressful situation. With a combination of sweat and temperature, we can determine a scale at which both accelerate and find an average rate at which both numbers are going up. If the scale is steeper than 30% of its starting value, then we can deem reasonable circumstances to inform the user of the changes found by the device. With a combination of these two, we can determine a procedure that can inform us if the user is currently undergoing stress, which will allow us to take preventative actions, such as visual or audio indicators alongside any physical indicators we decide to go with.

For the power supply, we decided to go with a standard Micro-USB connection, as is standard alongside an RPi Pico. To maintain a consistent charge, we will configure a AAA battery pack at 1.5v for a safe and easy power supply. For an ideal project built to an industrial standard, we would have gone with a Li-ion Battery (3.7v) alongside a TP4056 Charging Module. This allows for quick wireless charging, which is often sought after by shareholders due to ease of access. Furthermore, with a standardised battery system, the product can also achieve a sought-after Right-To-Repair, which means users will be able to use readily available parts available on the market to replace and, in some use cases, upgrade components in the aftermarket. This will cause the system to be more efficient, thus creating a device that is readily available and repairable if needed due to its simplicity and transparent usage of components.

For status indicators, we decided to follow through with RGB LEDs. These are simple lights that will be programmed to flash in different colours or patterns, which will allow us to convey several status messages. For example, if your heart rate has spiked within the last 30s, we would be able to convey that with a flashing red, which is proven by the National Institutes of Health (NIH) to be “a good indicator of danger or need for attention due to its strong association with "stop" and "danger" across various cultures” (Sahin, 2020). Since it will be RGB, we will be able to create multiple alerts, which could warn the user about various numbers of conditions. Therefore, if we need to create an alert requiring immediate user intervention, we can use the aforementioned flashing red sequence to output a pattern which can easily catch the attention of the user.

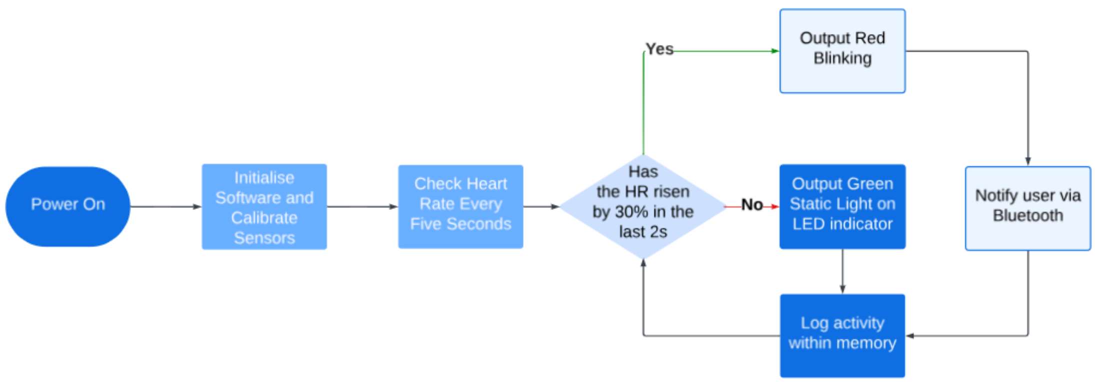
Finally, for the strap, we have decided to use an elastic nylon cloth strap, which will allow us to house our sensors and electronics safely. We will also use an ESD (Electrostatic Discharge) safe material to wrap our electronics to mitigate any damage caused by ESD from our users' bodies, etc. (Vashchenko, 2010). ESD can cause damage to the internal wiring of any components and boards being used since a sudden displacement of electrons can carry harmful charges, which may overexcite the components, resulting in fried connectors and useless components.

Software-wise, since we are looking at using the RPi Pico, the following options are presented to us for us to build the device:

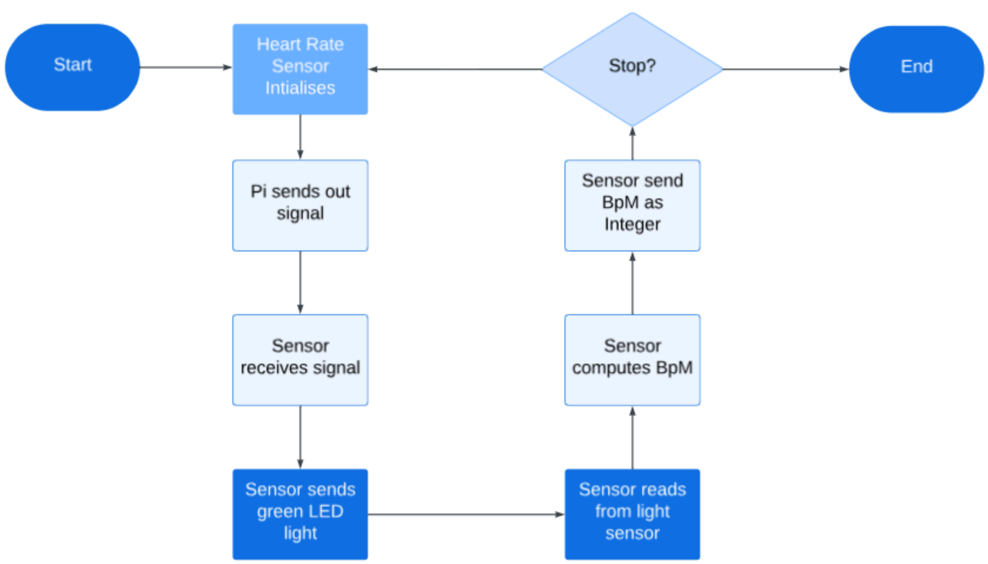
- C++
- C
- MicroPython

Since the development team is already accustomed to Python, we have decided to use MicroPython on the board due to the ease of development and understanding between team members. MicroPython also boasts great runtime execution and great library packages, which can be used to enhance the capabilities of the device should we need it.

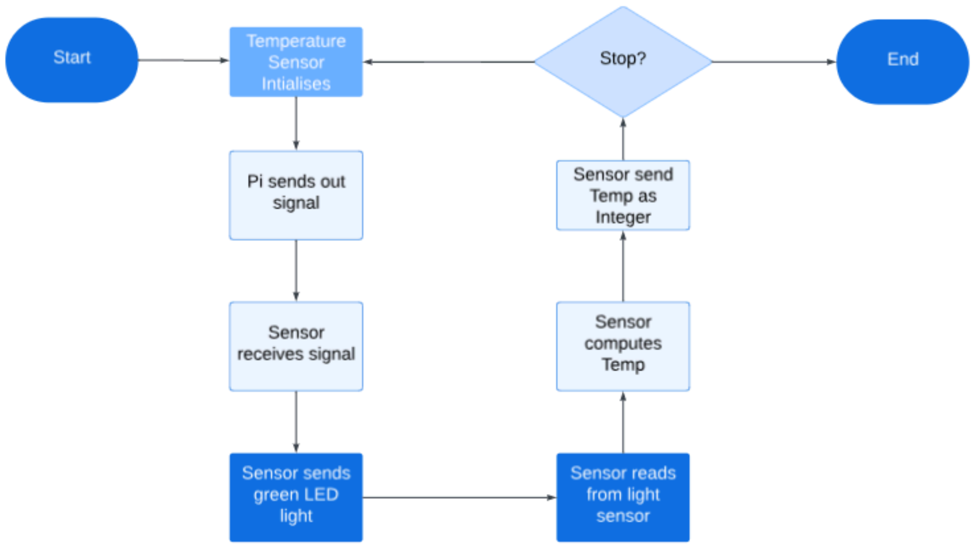
Flowcharts



This flowchart shows the process for the device in a summative form. It shows how the device should function and what procedures it has to take into account for it to work at an optimum rate. At first, the terminal node shows what happens when the device is powered on. The device calibrates the sensors and initialises any software that needs to run. The device then checks the subject's heart rate every 5 seconds. The program then checks if the heart rate has risen by 30% in the last 2 cycles (10 seconds). If yes, then it outputs red blinking LEDS, notifies the user via Bluetooth, logs activity and then returns to a standby state. If not, then it outputs the green static light on the LED indicator (standby mode).



This is a flowchart for the heart rate sensor. When the daemon function is begun, the heart rate sensor initialises and automatically calibrates itself by testing if all components within it are working. The Pi then sends out a signal asking the sensor to check for a pulse. Once the sensor receives that signal, it then activates a green LED light, which is then measured by the light sensor within the heart rate monitor. The sensor computes the beats per minute by measuring the intervals between the green light detections. The sensor then sends the calculated data as integers, and then at the end of the loop cycle, we can decide whether we want to continue with the function or not.



This is a temperature sensor flowchart. When the daemon function is started, the temperature sensor initialises and runs a self-check to ensure that all components are working properly. The Raspberry Pi then sends a signal to the sensor, asking it to begin reading temperature data. When the sensor receives this signal, it initiates its measurement procedure, which commonly involves a thermistor or digital sensing element. It measures the ambient temperature and converts it to a readable figure. The sensor subsequently transmits the estimated temperature data, which is commonly expressed as numbers in degrees Celsius or Fahrenheit. At the end of each loop cycle, the system decides whether to continue running the function or stop the process.

These flowcharts are in different formats due to the nature of their origin. Since flowchart one is a device management plan, the terminal nodes are labelled as “Power On” since that is the initial terminal of the device. The second two flowcharts are procedure flowcharts; therefore, the terminal nodes are labelled as “Start” and “End”, respectively, clearly showing the start node and end node of the function since it does not have a practical initialisation node such as “Power On” or “Switch On” and more or less relies on an internal function to allow it to process.

Design Research– Nana

When deciding on a project concept, we realised it would be easier and more realistic with the time constraints we have to make a watch-like device with a screen rather than a wristband that doesn’t have a miniature screen like many

fitness trackers on the market. Consequently, for our design research, it only made sense to look at the best-selling fitness trackers. The most popular brand of fitness watches by far is Fitbit, controlling 51% of the market (Douglas-Walton, 2025). Second and third are Garmin (15%) and then Apple Watch (9%).

Fitbit

Fitbit was founded in 2007 by James Park and Eric Friedman, with an initial release in 2009 of a comparatively rudimentary design to the Fitbits of this day and age, only displaying numbers and being able to track distance travelled, steps taken, and calories burnt (Santo, 2022). The first version of the Fitbit was not worn on the wrist but instead clipped onto a pocket or waistband. The company then grew to dominate the field of wearables and was acquired by Google in 2021, which wanted to compete with the Apple Watch. One of the first versions of the Fitbit to be released was in 2016. This watch, the Fitbit Alta, was the first from the brand to incorporate an OLED screen and guided breathing sessions (Verizon, 2022).

For our project, we wanted to incorporate the guided breathing session, as we felt it was the best way to help users reduce stress levels, and we received positive reviews that said it helps for those who are often stressed (Pallidino, 2017). Another notable feature is their lightweight and ergonomic design, which allows the device to be worn all day without pain. Many Fitbit models feature soft, flexible bands composed of breathable materials, which reduce irritation during extended wear. We wanted our wristband to follow a similar design strategy, emphasising comfort to encourage daily use. Fitbit's customisable display also allows users to personalise their watch face with different stress indicators, such as relaxing colour schemes, minimalistic data displays, or dynamic images that reflect stress levels in real time. This versatility means that people may interact with stress data in a way that is intuitive and manageable. Although we are not able to make our project customisable, we will have relaxing colours and aesthetically pleasing designs to promote calmness and compel people to use our device.

Apple Watch

Apple released the Apple Watch in 2015, announcing the company's debut into the wearable technology market with a focus on fitness monitoring as well as smartwatch features (Hunter, 2025). Unlike early Fitbits, which focused largely on step counting and basic health indicators, the Apple Watch integrated fitness monitoring with a gorgeous touchscreen display, smart notifications, and tight interaction with the Apple ecosystem. The Apple Watch has changed greatly over the years, with new functions such as ECG monitoring, blood oxygen tracking, and stress management tools such as mindfulness reminders and guided breathing exercises. Its design has been improved, with a stronger frame, always-on Retina screens, and removable bands for increased customisation. The Apple Watch's ability to effortlessly sync with iPhones, combined with its improved user interface and fast processing capabilities, has helped it become one of the most popular smartwatches on the market, setting the bar for wearable health technology.

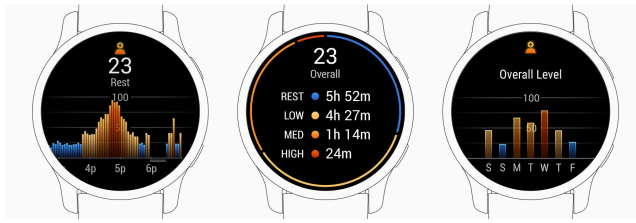
The Apple Watch's user experience (UX) is based on seamless interaction, intuitive design, and personalisation, all of which might be successfully applied to our project. One of its most notable UX elements is the always-on Retina display, which allows users to view their health statistics without having to tap or raise their wrist. A stress monitor may take a similar approach, providing a low-power, glanceable display that quietly transmits stress levels without distracting the user's attention. Furthermore, the haptic engine, which generates soothing vibrations for alerts and notifications, will be employed in our project to provide relaxing haptic input as stress levels grow. Instead of obtrusive notifications, gentle pulses might gently guide users through mindfulness exercises or breathing techniques. Another key feature of the Apple Watch's UX is its seamless integration with daily activities, which makes stress tracking feel like a background operation rather than an extra effort. The Mindfulness app encourages brief periods of guided breathing, while the Fitness Rings system stimulates users by providing a clear visual picture of progress. Our stress monitor might draw inspiration from this by employing adaptive, goal-based tracking, in which users are encouraged to take breaks or engage in relaxation techniques depending on their stress patterns.

Garmin

Gary Burrell and Min Kao started Garmin in 1989, with an initial focus on GPS technology for the aviation and marine markets. The company quickly moved into consumer fitness gadgets, launching its first fitness watch in the early 2000s. Garmin's early products were primarily geared towards GPS tracking for runners and cyclists, giving customers detailed location-based data throughout workouts. Garmin grew into one of the leading brands in the wearable market by including heart rate monitoring, stress tracking, and sleep analysis in its watches.

Garmin's user experience (UX) is tailored to performance-driven, data-hungry users, providing precise health stats while preserving a simple and functional interface. One of its most notable features is customisable data panels, which allow users to tailor how they perceive health insights, such as heart rate variability and recovery time. Within our project, we are implementing this by allowing users to customise how stress data is shown, whether through extensive graphs, simple numerical indicators, or colour-coded stress levels. Another major UX innovation is Garmin's always-on transflective display, which improves readability in a variety of lighting conditions while preserving battery life. Our stress monitor might employ a comparable low-power, high-visibility screen to allow users to easily assess their stress levels throughout the day without requiring excessive interaction or backlighting.

Furthermore, Garmin devices prioritise offline functioning, ensuring that essential features like stress tracking, guided breathing exercises, and wellness prompts are available even when the smartphone is not connected. Our stress-monitoring wearable with customisable displays, trend-based stress insights, and offline usage might provide a Garmin-like experience for consumers who seek in-depth, dependable health tracking without extraneous distractions.



Wristband Materials – Neha/Nana

After looking into more similar projects and a feedback session, we realised that for the project, we could make the wristband more interactive by incorporating the breathing exercises into the wristband material with the use of LED lights indicating when and how long to inhale/exhale. This would also enable us to make the wristband and screen more integrated, making use of all the parts of the device. We also thought we could add embroidery to the wristband material that could act as a fidget toy, as another point of functionality. In addition, it would add to the overall aesthetics of the project, as we could make the embroidery a pattern or image of some sort. We then visited the Textiles and Wearables Laboratory within WSA to see what materials would be available to us: Rubber, Nylon, and Felt.

Rubber is one of the most popular materials for wearable wristbands, especially for fitness and health gadgets. Its appeal is mainly due to its durability, flexibility, and water resistance. Rubber can tolerate repeated bending, pulling, and exposure to moisture without losing shape or structure, making it perfect for daily use. It is also hypoallergenic in various forms, making it an excellent choice for those with sensitive skin. Rubber's soft texture ensures comfort during extended usage, and it can be easily moulded into various shapes and sizes, allowing for unique fits and designs. Rubber is also easy to clean, which is vital for long-term wearable devices such as stress monitors. Despite these advantages, rubber has several limits, particularly in terms of appearance. It often provides a more casual, sporty design, which may not be appropriate for projects that require a more sophisticated, handcrafted, or personalised appearance. While rubber was a solid choice for our project due to its toughness, we finally opted to look into other materials that would better suit the visual and tactile approach we were going for.

Felt is a soft, non-woven fabric formed by compressing fibres together, typically from wool, synthetic fibres, or a combination of the two. It has a distinct texture and a warm, comfortable feel, which makes it an appealing material to consider for our wearable stress monitor. Felt is lightweight and easy to cut, sew, or glue into different forms, making it ideal for a variety of designs. Its tactile softness may have provided a calming, comforting element to the bracelet, in line with the emotional goals of a stress-monitoring device. Felt has the interesting benefit of being able to transmit electricity if produced with conductive threads or treated properly, which could lead to the development of integrated touch-sensitive or smart textiles.

However, felt has significant drawbacks when it comes to durability and daily wear. It is not as resistant to moisture, stretching, or general wear and tear compared to rubber or nylon. Felt can pill, lose structure, and degrade quickly when exposed to sweat and movement. Because of these limitations, we decided not to use felt for the final wristband design. While it felt inspired by ideas for softer or decorative elements, it lacked the practical strength we needed for a fully functional wearable.

Nylon is a lightweight, resilient, and highly adaptable material that is increasingly used in wearable electronics, particularly in applications that require flexibility and design modification. Unlike rubber, nylon has a softer, woven texture that may be readily embroidered, coloured, or patterned, allowing for a wider range of creative options. It is also durable and tear-resistant, making it an ideal choice for a wearable gadget that must withstand repeated use while remaining comfortable against the skin. Nylon bands are often breathable, which helps to prevent skin irritation and sweating, making them excellent for wearable stress monitors. In our project, we ultimately chose nylon because it allowed us to include embroidery right onto the band, allowing us to create unique, tactile motifs that reflected the device's relaxing, contemplative ethos. Nylon achieved the ideal blend of durability, comfort, and customisability, meeting the practical requirements of a stress monitor while also improving its visual appeal and user experience.

An additional concern we wanted to address was that of allergic reactions. Allergies to felt itself are not common; however, wool as a component of felt is a material that many people are allergic to (Norris, 2018). It is the same for polyester; rather than an allergy to polyester itself, the components present in polyester are what cause people to have allergic reactions (Team, 2024). The manufacturing process of polymer involves the fabric coming in contact with chemical residues, which lead to skin irritation and, further, to an allergic reaction(Team, 2024). Nylon is shown to cause the least allergies, as the hydrophobic tendencies cause moisture to be trapped between the material and skin; this can easily be remedied by loosening the fabric’s grip around one’s skin.