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P3: Prototype
Approach 1: Emphasis on Evaluation & Feedback from Users

Recap

We are working on helping students improve their computer posture through better real-time posture feedback. From a survey and interviews, we found that students are aware of the need to improve their posture but are unable to maintain a good posture when they work on their computer for extended periods of time. This is mainly due to them forgetting about it, as their primary focus is on completing their work. Students also seem to not care enough about their posture that they are willing to make major adjustments to the way they work. Whatever solution we design, it has to be minimally disruptive, with a very low barrier of entry.

Selecting 1 Design from the 3 Finalists

For the in-class design sprints, we had prepared three ideas: augmenting the laptop with LED feedback, a figurine for the desk mimicking the user posture, and a chair that would inflate in different places to put the user back in the right position. The last two ideas were equally popular but the first one was very much a flop.

To decide between the desk display and the chair, we went through careful considerations. The main concerns with the chair revolved around feasibility: we did not possess the required skillset or time to make a solid prototype and the chair being a corrective device required us to delve into what good posture is and what it means to move from bad to good posture. The desk art display was also going to be challenging to build but we had some idea of how to go about it, which was a lot more than we could say for the chair. We also felt that the chair was less true to our target user group characteristics because of the distraction it creates. Finally, the chair solution was clearly not as scalable as the desk display is, which makes it a less viable solution for campus on the long term. We therefore decided the desk art figurine to be the most fitting solution to the problem of poor computer posture and apathy towards it among students

From Idea to Implementation: A Bumpy Road

The main specifications for the desk art object coming out of the design sprints were as follows:

- Posture is sensed through pressure sensors in the chair seat
- Posture data is sent to a physical character stationed on the desk
- The character tilts to the side or forward if the user tilts or slouches forward
- The longer the user tilts or slouches for, the more the object’s posture decays
- The object is equipped with LEDs that indicate when to take breaks from work

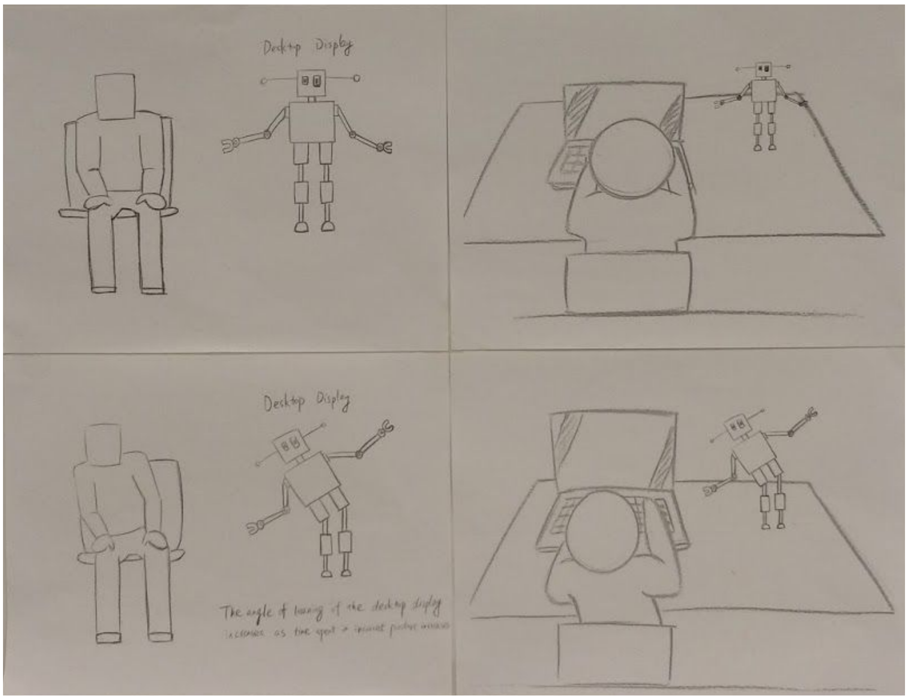

Figure 1. Representation for the desk art object at the end of P2

A full implementation of the desk art display thus entailed two separate components: a posture sensing chair and a desk object for feedback. We settled on Arduino as our main tool, and on the use of servo motors to animate the desk figurine. Each main component would depend on its own Arduino board and the two boards would communicate over Bluetooth, as shown in Figure XX below.

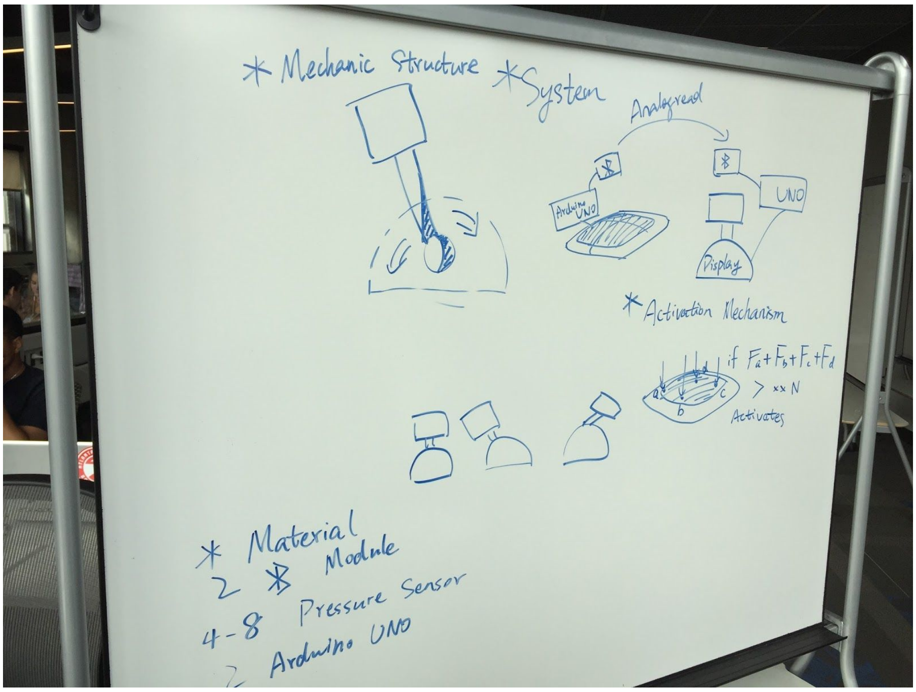

Figure 2. Preliminary full system diagram & List of materials to obtain

We felt somewhat confident in our ability to build a cheap but effective pressure sensing seat cushion, based on a paper from Barba, de Madrid, & Boticario (2015): *Development of an Inexpensive Sensor Network for Recognition of Sitting Posture*. Using Velostat, aluminium, and tape, we could build a series of pressure sensors and embed them in a foam seat cushion so as to form matrix of sensors. We would then have to learn the pattern of pressures created by each sitting position so we could map the pressure data to the feedback in the character.

The Velostat came through the post, we excitedly built a pressure sensor (see Figure XX), and quickly realised the pressure sensing seat was going to be a real challenge. First, there is very little information available about Velostat. We did not know what type of values we would be dealing with until we plugged our sensor into the board. In theory, the more pressure is applied, the lower the voltage reading is, which we were able to observe. However, the variations in values were extreme, almost binary: when no pressure was applied, the readings were in the 1000s, but when pressure was applied, even as we tried to vary the amount, the readings would invariably go down to 18, 20s. There was no in-between. The other issue was that the readings seemed to be unreliable. Sometimes even when no pressure was applied, the readings were around 20, for reasons we could not comprehend.

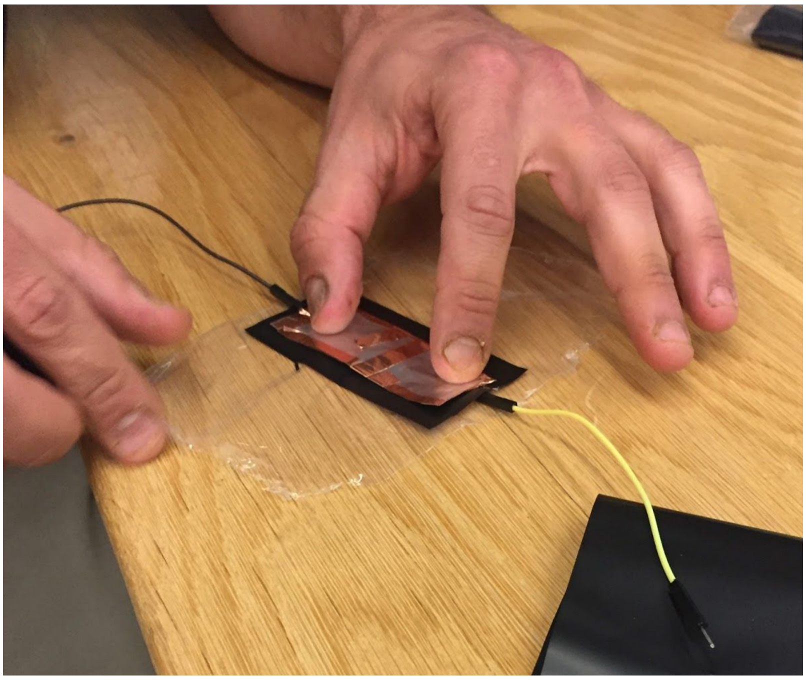

Figure 3. Pressure sensor built using Velostat

As we tinkered around with the Velostat, we came to the conclusion that building the seat was not a good use of our time. We had set out to create a novel way of providing posture feedback, not to change posture sensing. We were already pressed for time in this prototyping phase and there was no point reinventing the wheel. We thus refocused our efforts on building the desk art object and decided to wizard-of-oz the pressure sensing seat.

From the start, we knew that creating a fully articulated desk figurine would be difficult as it would require each body part to be animated separately, with its own motor. For the purpose of prototyping, we thought a stiffer figurine would be enough. The figurine could follow movement patterns similar to that of a joystick (going left, right & forward), instead of having different parts of the figurine move independently. First, we focused on getting the mechanics of moving and shifting a figurine working. After carefully looking into the different servo motors available on the market, we purchased a pan & tilt kit. It was ideal for our beginner level understanding of Arduino as it was fully assembled, and it included a mounting platform where we would install the figurine. We then started to look into how to model the figurine.

In doing so, we became aware of issues with the feedback we had in mind. Originally, the figure would tilt to a side to reflect the user tilting, and the longer the user tilted for, the more the posture of the object deteriorated, up to a point of no-return when the figurine would crumble entirely. However, we were now looking at a figurine that could only tilt as a block in a gradual manner, and could in no way crumble. This meant we had lost the ability to signify that important state change when the user has been in a poor posture for too long and needs to shift back to a good one. In context, the user does not look at the figurine all the time so he needs to be able to glance at it and immediately understand what is going on. If the figurine only shifts gradually, the user cannot distinguish the point at which a corrective action should be taken. Another issue was that of building an aesthetically-pleasing figurine and deciding what shape it should take. We were concerned that modelling it after a human was a) going to be very complex, and b) likely to convey the wrong idea to the user: the figurine is not mapping the user at all time, it moves as a function of both posture and time spent in a bad posture. Making a human-like figure also raised issues as to what gender it should be, whether it might be something users would want on their desk, etc. In P2, we had also played with the idea of the object being an art piece for the desk, something that would not be obvious in its posture-monitoring function. This would solve the issues involved with the figurine being human-like, but it might confuse the user further as to the mapping relationship between the object's orientation and the sensed posture. After a quick brainstorming of new ways to model the object, we started considering two fundamentally different ideas: a robot character or a minimalist art piece. We recognised advantages and drawbacks in both and could not make a compelling argument for choosing one over the other. We therefore decided to carry out both prototypes so we could test the two designs and compare them to make an informed conclusion. Both representations are described at length in the next section.

Implementation Challenges

On top of the challenges we encountered in adapting our idea from hypothetical discussions to a real physical prototype, we also faced technical and logistical challenges. First, we had to learn about Arduino and making interactive electronic prototypes. We had to dedicate time from the already short prototyping window to tinkering with Arduino, sensors, & motors, and get a feel for what we were going to be able to use in our prototype. This came hand in hand with the difficulty of sourcing working pieces of equipment on & off campus. We expected to find the majority of the components we needed in the various prototyping labs on campus, but found that those were pretty limited. We had to turn to online shopping, which meant further timing delays and more uncertainty.

We also had a hard constraint on the timeline imposed by the time taken to 3D print the figurines. Having to leave at least a full day for printing the pieces meant we were pressed for time in our definition of the object's design and implementation. We were concerned with making our final prototype look as clean as possible, which mainly meant hiding the wires, motors, and motherboard as much as possible. To hide them in the base and figurine, we needed to fully know where each component would go in the finished version. The time taken by 3D printing also meant we likely would only get one shot at printing the pieces. There was not much room for errors.

When we start combining all the 3d printed parts and the arduino UNO board together, more problems came up. The wires easily came out of their slots, especially the LED ones and we needed those to be secured to be able to have a consistent and robust device. We therefore had to tape the wires together in a durable manner so as to only have to set up the wiring once for each device and then just plug the figure to the board.

Measuring the servo motor base was tricky and not precise so the 3D model bases ended up slightly too narrow to hook themselves to the base. We thus had find a way to make the base of each figuring firmly stuck on the motor while also allowing for easy switching between the two models since we only had one set of motors.

While experimenting with different states with the LEDs, we burned a lot of LEDs because we did not use the appropriate resistors. It took us a couple of hours of working with the prototype to realise our mistakes. On top of that, later in the prototype development, we decided to provide more flexibility for the light colors used in the devices. We thus decided to replace all single color LEDs with RGB programmable ones. This meant going from 1 input pin and 1 ground pin per LED to 3 input pins and 1 ground pin, effectively doubling the number of input and ground pins needed, as well as the number of wires. With the pins occupied by the two motors and the battery, we had used up all the pin capacity of our board and had to switch the circuit design to one using two boards. This resulted in the need for 2 team members as 'Wizard Oz' in the usability testing session. The first team member will be controlling the servo motor movement and initial stage of the tilt, and the other member will control 2nd and final stage of the tilt with LEDs. The code also had to be significantly modified to reflect the circuit changes.

Prototype Specifications

The base structure is the same for both designs as the figurine is just added on top of the servo motors. This exploits part commonality in the design and reduced the number of components needed for prototyping.

The structure uses 2 servo motors, one pan and one tilt for horizontal and vertical movement respectively, that come attached together as one element. They are controlled by an Arduino board plugged into a laptop with 'Arduino.cc' installed that allows the moderator to provide input to the arduino via keyboard. The motors live inside a base that is equipped with a white LED. This light turns ON/OFF with the device. Each design comes with more built-in LEDs, which is covered in the next section.

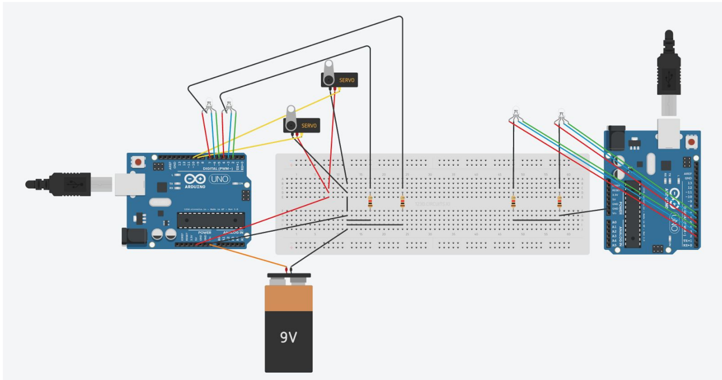

Figure 4. Circuit Diagram of the working Prototype

Since there are no pressure sensors in the seat built-in, we plan to perform wizard-of-oz prototyping, where we will manually control the state of the system by observing the user. The motors are keyboard-controlled as specified below:

- ‘a’ - move the pan servo motor left by 20 degrees.
- ‘d’ - move the pan servo motor right by 20 degrees.
- ‘w’ - move the tilt servo motor forward by 20 degrees
- ‘s’ - move the tilt servo motor backward by 20 degrees.
- ‘x’ - reset both servo motors to their default position, that is 90 degrees for the bottom servo motor and 0 for top servo motor.

The movement of the structure is limited to a maximum of three steps forward and three steps from default central position to either side. The horizontal movement is used to orient the figure in the direction of the user’s posture. The tilting is a function of the time spent in a bad posture. For every five minutes spent in a bad position, the device takes one tilt-forward step. From a bad posture state, for every minute spent in good posture, the device moves one step back towards its central position. By sitting in an upright posture, the user “earns” the figure’s correction to an upright stance. It is worth noting that the times included in the current prototype are subject to change and will be reevaluated after user testing. Ideally, the timing for these two state changes minimizes the amount of time spent in bad posture without interrupting or bothering the user, while maximizing the amount of time a user will sit in a corrected posture.

For modelling the characters and the base for the prototype, we used Autodesk Fusion 360°. After the modelling was complete with precise dimensions we printed with the campus 3D printers. The 3D model for the base can be seen in Fig 5. The models for the art sculpture and the character are presented later in the document.

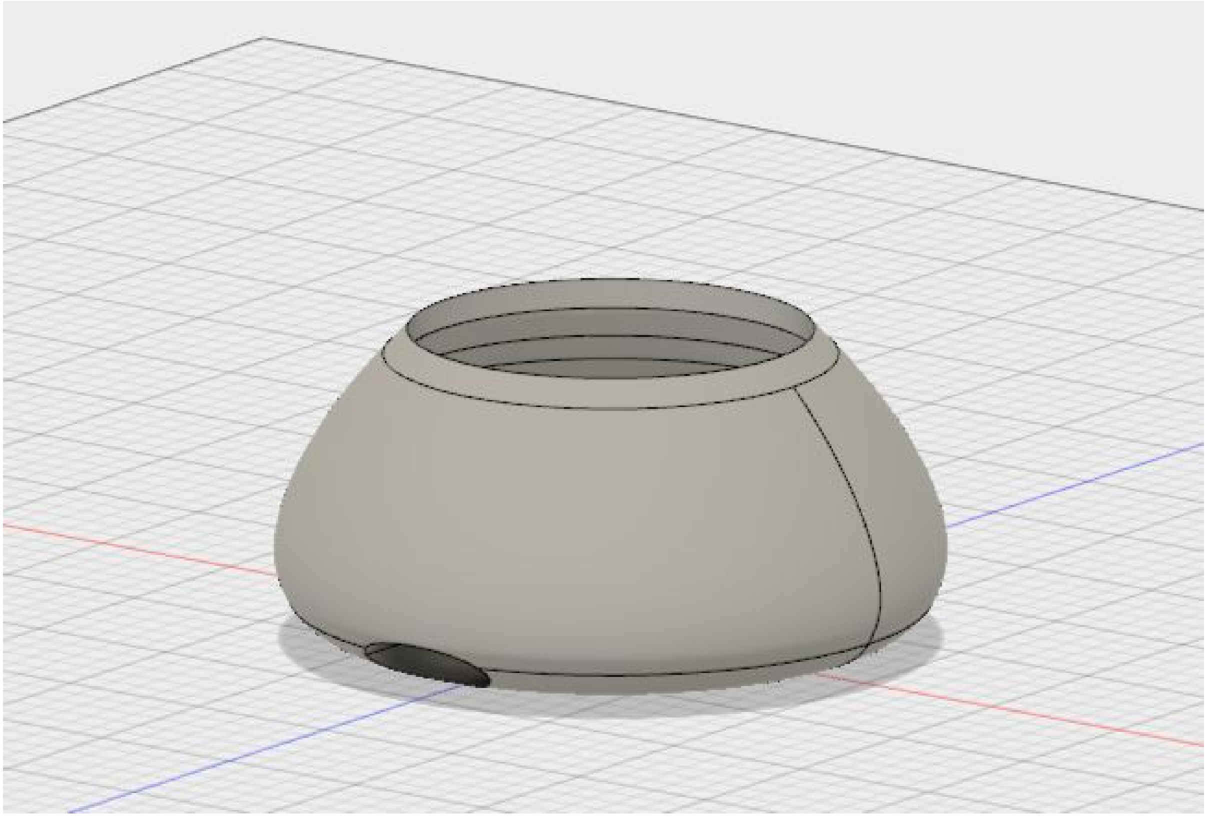

Figure 5. 3D Model of the base for prototype

1. Desk Character- RobotMan:

RobotMan is designed in a way that allows for movement in both arms. The original intent of the feature was to allow the arms to fall down or sway as the figure tilts and rotates. This would serve as an additional signifier that the object is not fully upright. Unfortunately, due to a relic of the tilt-pan mechanism, the character only tilts when facing the direction it is tilting in. As a result, the arms do not move as intended.

It is equipped with two red LEDs that are mounted inside its ears, and serve as the signifiers of the critical state. The critical state is the one that strongly suggests a posture change to the user. Whenever the character reaches a state of three tilts forward, the ears light up. As soon as the figure moves out of a three-steps-forward state, the LEDs turn off.

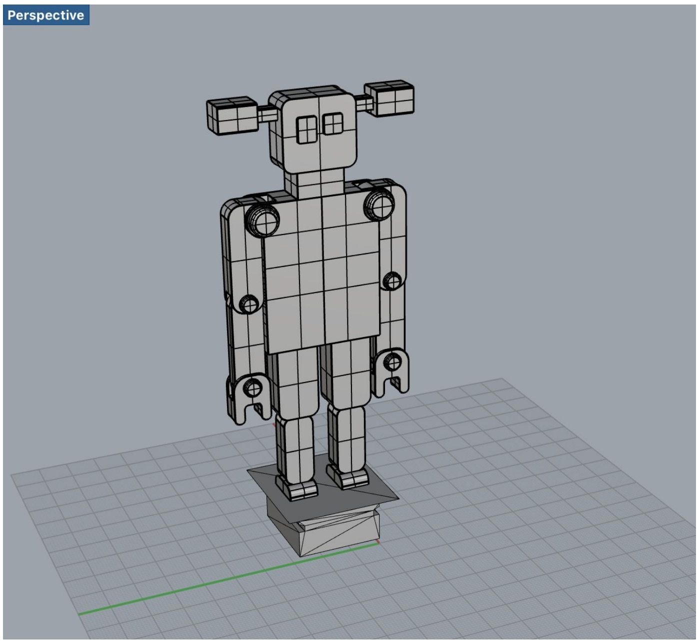

Figure 6. 3D Model of the desktop character

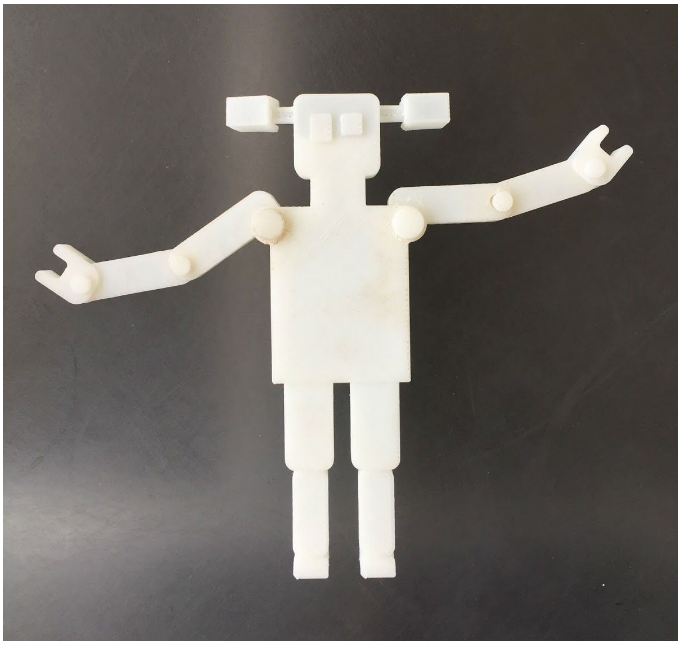

Figure 7. Printed 3D Model of the desktop character

2. Desk Sculpture- Floating Orb:

Figure 8. Preliminary sketch for the Floating Orb

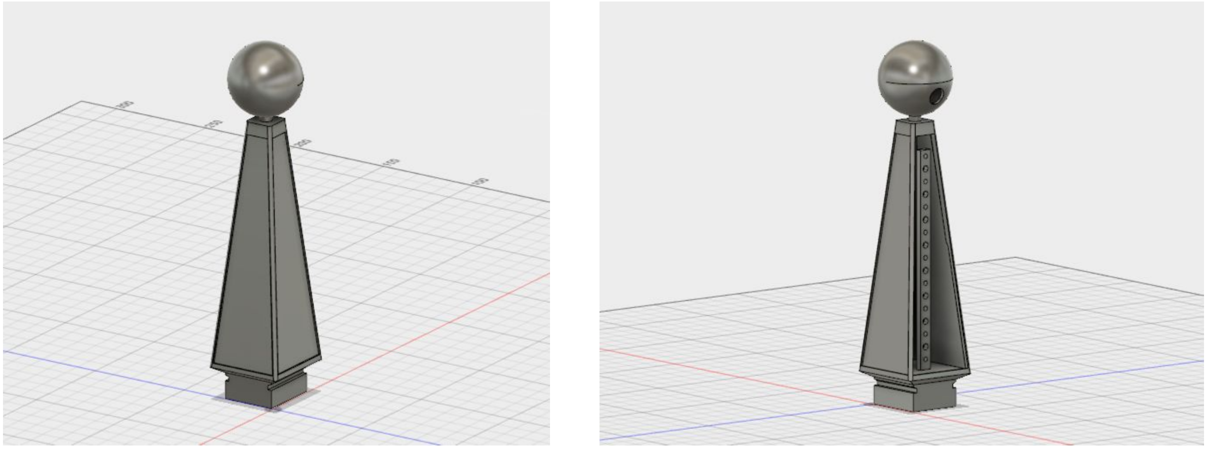

Figure 9. Front and back views of the 3D Model for desktop art sculpture

This structure is fitted with 3 LEDs, two in the column, and one in the top ball. This allows for more redundancy in the feedback at each stage as for each tilt step, a change is reflected through the LEDs. Tilting forward causes the LEDs to light in an additive sequence from the bottom to the top: at the i^{th} tilting step, all LEDs up to and including the i^{th} one are on. At the critical state, the orb lights up red. As the device comes back to its central position, the device goes through the inverted sequence of LEDs turning off. When it reaches the good, central state, the ball is lit up with green for 5 seconds to indicate full return to good posture.

Final Working Prototype

The following images show both designs (RobotMan and Floating Orb) in a series of states to the left direction in response to a user leaning to the left. The prototype is also capable of performing this series of states to the right and forward.

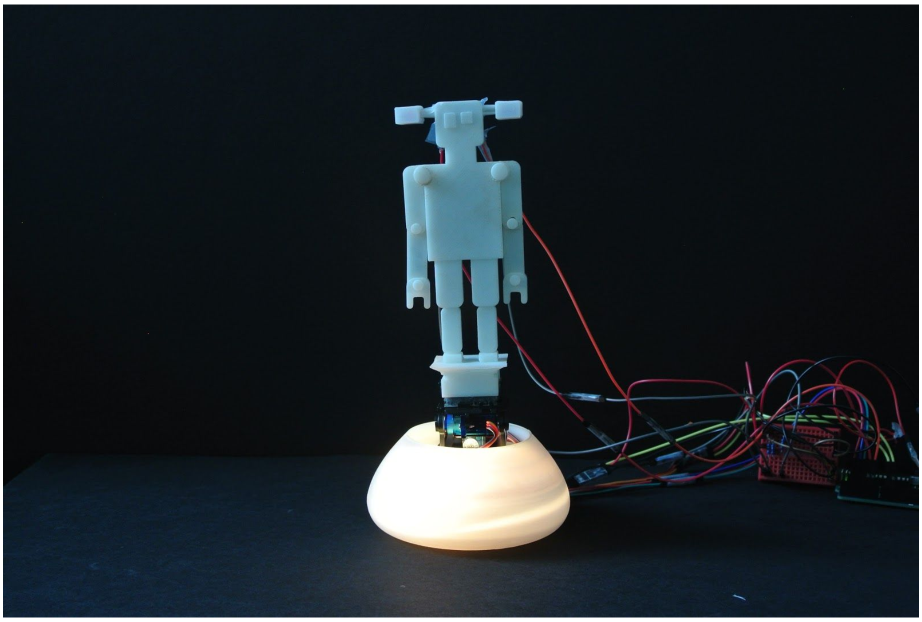

Figure 10. Initial (“Home”) State for RobotMan

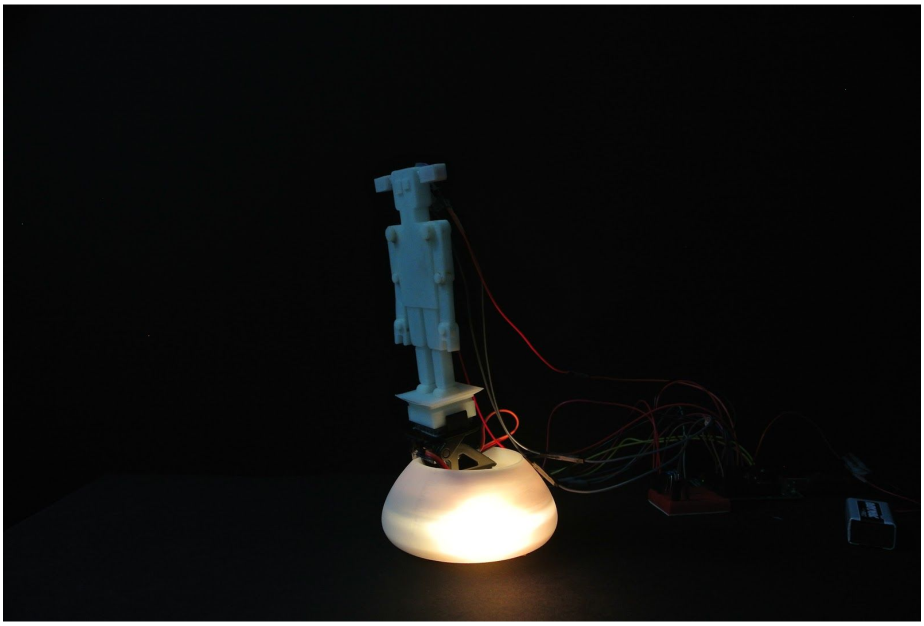

Figure 11. RobotMan after first of three tilts to the left

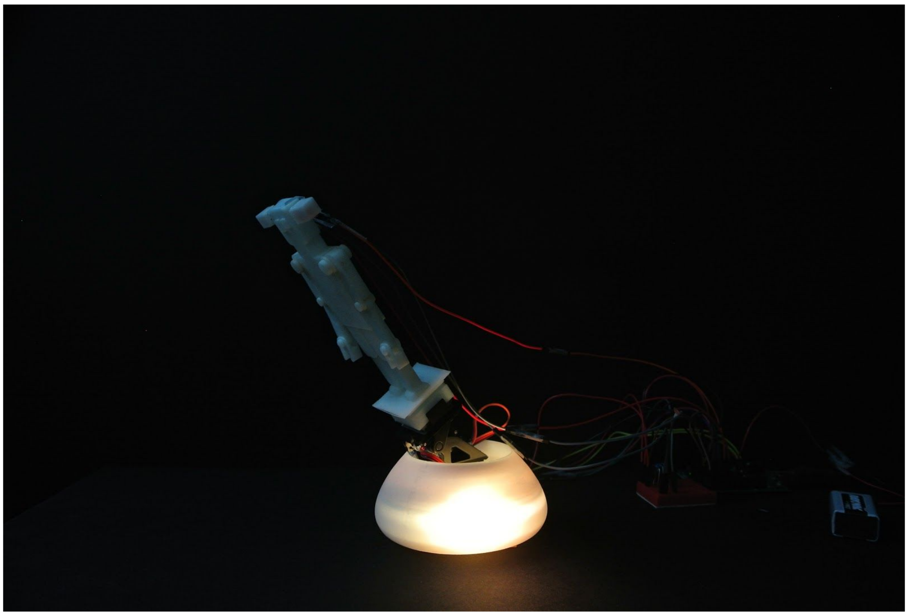

Figure 12. RobotMan after second of three tilts to the left

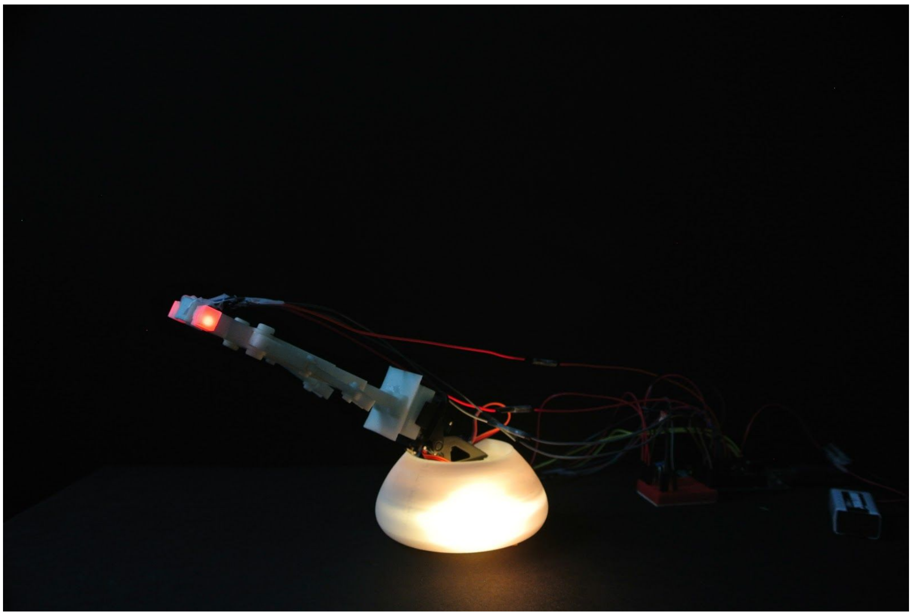

Figure 13. RobotMan in Alert State after third (final) tilt to the left

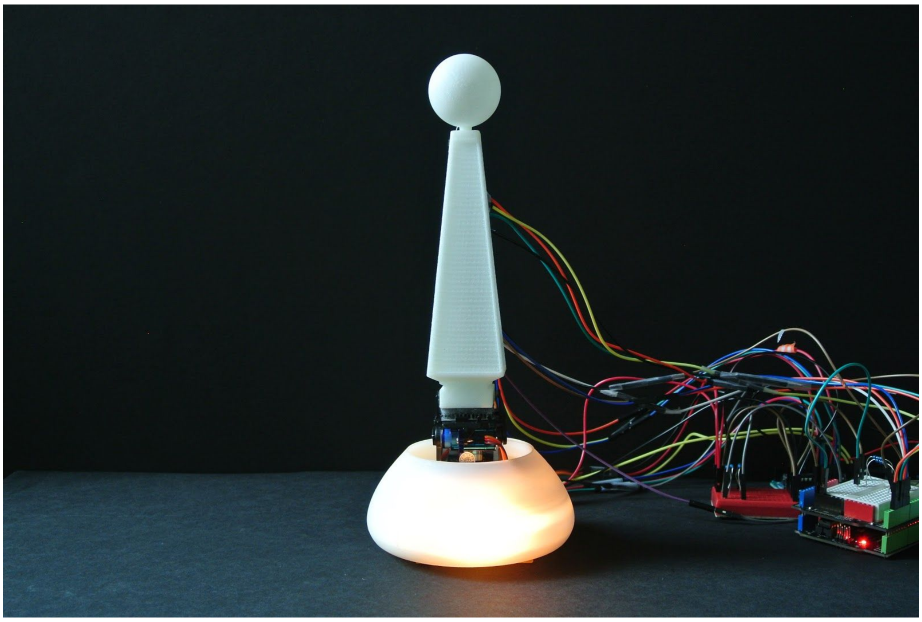

Figure 14. Initial (“Home”) State for Floating Orb

Figure 15. Floating Orb after first of three tilts to the left

Figure 16. Floating Orb after second of three tilts to the left

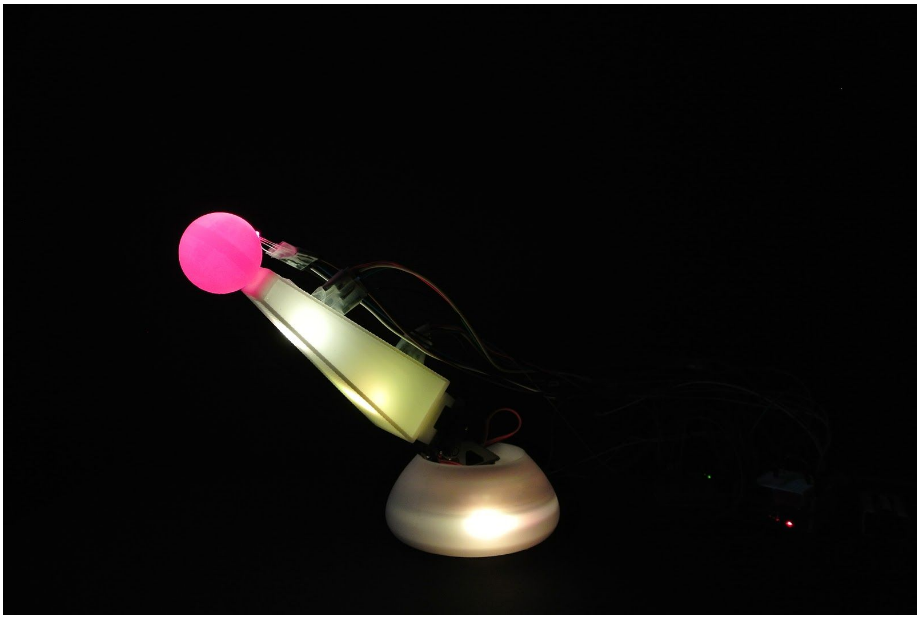

Figure 17. Floating Orb in Alert State after third (final) tilt to the left

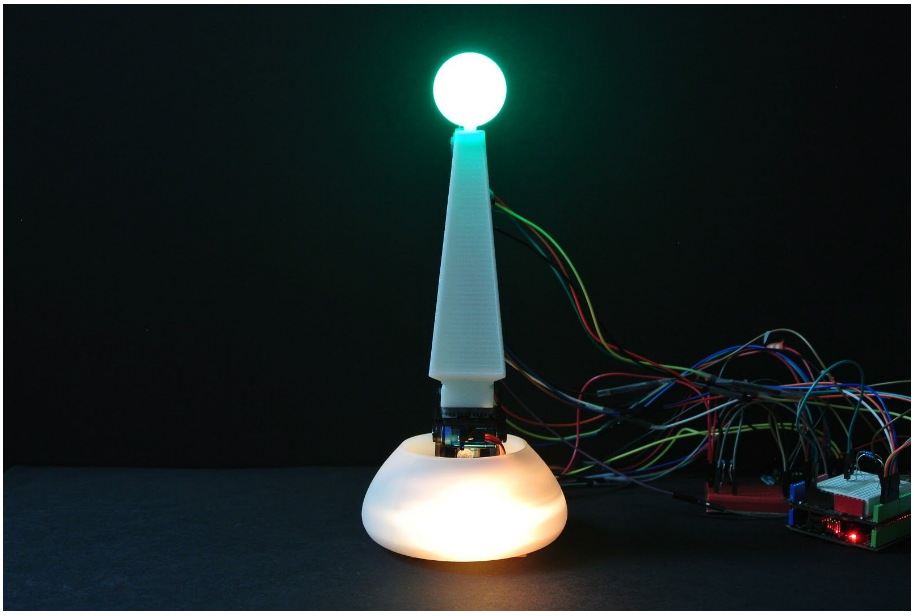

Figure 18. Floating Orb in Corrected State (“earned” after Alert State)

Design Specifications:

Objectives:

Our design aims to provide real-time ambient feedback of posture. The objective of our design is defined by the constraints of our user group. Namely, the design must be something that users can access with minimal effort, as our target users are not sufficiently motivated by posture correction to make accommodations on their own. Additionally, the feedback provided by the design should not be distracting or require immediate attention. Essentially, the design must be something that our target users can implement on site without orientation or setup. Users should have the freedom to ignore or attend to the feedback provided.

Since the device is meant to track posture, a method of sensing posture is required. A seat cushion with built-in pressure sensors is able to provide data about leaning and slouching by calculating the imbalance in load received between sensors. A seat cushion is low-impact and does not require the user to undergo any sort of preparation to initialize the interaction.

The fundamental objective of our design is to interpret the data received from the pressure sensors in the seat cushion to be displayed by a desk art device that informs users of their posture.

There are also considerations to be made in terms of size and location. Since the object is located on desks, it should be moveable and have a small “footprint”. Users should not feel like the device is limiting their workspace or cluttering the area.

Since the purpose of this device is to provide corrective feedback about posture to a user group that is not willing to invest any significant time to meet this goal, the method of feedback must be restrained. By providing feedback using ambient light and physical position, the design is able to offer information to users about sustained periods of poor posture. The intent of this feedback is to gently remind the user to correct their posture.

In order to meet these objectives, our design must offer two types of feedback- gradual changes related to the amount of time spent in poor posture and an alert state that nudges the user to correct their body position.

Finally, since this device is intended to serve as a desk art object, our design must address aesthetic concerns related to the preferences of our user group.

Supported Tasks:

Our design aims to support the task of reminding users to modify their body positions after long periods of poor posture. Since maintaining posture is not a task in itself, our design is intended to support a number of primary tasks that require working at a desk.

Design Evaluation:

Overview:

The process of evaluating our prototype will take on a three-pronged approach. The first phase will be to conduct an expert heuristic evaluation. Due to time constraints, we will be using ourselves as the experts, though ideally external experts would be employed. The purpose of this round of testing will be to evaluate the design using a standard set of criteria in order to find any major issues prior to user testing.

The second phase of testing will be a 'quick and dirty' usability test using Georgia Tech students as participants. The process of posture degradation is a slow and variable process, which puts major constraints on time and the ability to gather data from many participants. As a result, this phase of testing will simply guide the user through the stages that would typically be experienced while interacting with the object. Specifically, this phase will focus on the clarity of the device output, the ability for the user to understand the function of the device, and will generate some early feedback about the design. Additionally, since we have chosen to proceed with two object designs (Orb and Robot) to this point, the second phase of testing will be utilized to get feedback about these alternatives in order to choose a single design for the final phase of usability testing. The final object for the design will be chosen based on which offers more intuitive feedback of posture as well as the direct input of users about their experiences/opinions of between versions.

The third and final phase involves observing users in a situation that more directly resembles the true context of its intended use. In this phase, since a pressure-sensing pad is not synced to the device, a 'Wizard of Oz' protocol will be utilized, wherein one member of the team will manipulate the device through keyboard input (as outlined earlier). Participants will be members of the target user group, that is undergraduate students at Georgia Tech. Participants will be observed for an extended period of time (approximately one hour) while they work at a desk using their computer. As they work, the device will function as if it were connected to a seat sensing system by making an approximate judgement of whether the user is leaning and the extent to which they are leaning. Since the purpose of this design is to provide ambient, non-distracting feedback, they will be allowed to work uninterrupted for the duration of the test. Certain metrics will be obtained via observation alone. After the session, a set of follow up questions will be asked. Users will be prompted to recall their experience as well as respond to the questions in a System Usability Scale (SUS).

Phase One: Heuristic Evaluation

In order to evaluate our design, we have merged the relevant components of various usability heuristics, derived largely from Nielsen and Molich. From these, we decided that the following heuristics are important evaluation metrics for our design:

- Responsiveness
- Precision
- Impact on environment
- Visibility of system status
- Recognition not recall
- Match between system and real world
- Ease of access
- User attentiveness requirements
- Clarity of feedback
- Ability to inspire action

Since this analysis was conducted during the implementation process, it was primarily used to guide the functionality, features, and states of the design. It was also useful in determining which metrics to assess and which considerations must be made during the usability testing phase.

Responsiveness

In order for the design to be effective, the desk object must respond appropriately to the posture of the user. In this case, the main consideration is related to what factor determines how the device will tilt and the degree to which is tilts. The desk object is not directly reflecting posture on a moment-to-moment basis, meaning that the desk object does not change immediately in response to the user's position. Instead, the goal of our device is to inform the user about accumulations of time spent in poor posture. So, sudden changes or temporary changes in posture do not impact the movement of the object.

Precision

The desk object should decide direction and intensity of tilting based on the users direction of tilting and the time for which user is tilting in a particular direction. It should always present the correct direction of tilting for the user so that the user can understand the precise incorrectness of their posture and correct it. If the criteria of precision is violated, it can result in confusion and mislead the user by providing incorrect feedback about their posture.

Impact on environment

Using this heuristic we intend to measure the disturbance the desk object causes to people sitting around the user. In our tests we will ensure that we include users who are not sitting alone on a desk and ask follow-up questions to the user and other members on the table about the impact the desk object has on their work.

Visibility of system status

Essentially, there are three states that our object can occupy: posture that is within the acceptable range, posture that is outside of the acceptable range in a specific direction and posture problems that have persisted for long enough to warrant an 'alert' to change body position. To inform the user of these changes in system status, LED lighting and physical changes/tilting to the object are used. The LED lighting in the base of the desk object glows when the user initially sits down, informing them that there is a connection between the seat cushion and the device and that the device is now active. The tilt of the device character in both models is meant to communicate sustained periods of poor posture. LED lighting in the body of the 'Floating Orb' also serves this role. Finally, LED lighting at the top of the character (the head in the 'Robot' design, and the orb in the 'Floating Orb' design) glows to signify that a posture adjustment is needed. Additionally, the LED lighting used to signify an alert to change posture is a different color than the 'On' and 'Build-up' state colors.

Recognition not recall

Since this design is meant to be interpreted passively, it is particularly important that the user is able to understand the output of the system without needing to remember previous states. Due to the gradual changes of the object in relation to posture, it is possible that the user might not recognize small changes in the device output. In other words, since the shift between degrees of tilt is relatively minor, it may be difficult for the user to understand that their posture deteriorating. To address this criterion, two considerations were made. First, both designs have a clearly defined 'alert' state that is signified using LED lights at the top of the character. Second, in the "Floating Orb" design, LEDs that run up the body of the character turn on in sequence to help the user recognize that the posture is changing.

Match between system and real world

The ability for our desk object to connect to the user’s mental model of their posture is extremely important consideration. Our design must be able to match the user’s model of sitting in a chair with different postures well enough to allow that output to be acted upon. Our desire to find out how well our desk object relates to the user’s mental model was the primary inspiration behind making two different models (‘Orb’ and ‘Robot’). The ‘Robot’ design is more anthropomorphic, and therefore, may be a better match to the user’s conceptualization of sitting/posture. Some issues may arise from the fact that the robot is standing, whereas the user is sitting. In the ‘Orb’ design, a more abstract representation of posture is applied. Whether this design is capable of capturing the mental model at work is something that must be addressed during usability testing.

Ease of access

One of the major findings from our research is that students without preexisting back pain are not motivated to bring additional accommodations to their workspace to support good posture habits. As a result, it is vital that the design is easy to access and requires minimal setup. To address this, our design will be placed on the desks in CULC study areas. Since the object is already there, the user will not need to plan ahead to implement our design. Additionally, the device is activated by sitting on the seat cushion sensors. This also reduced the barriers to use. Since the feedback, ideally, is passively received/ambient, the user can choose to disengage by not paying attention to the desk object even though it will still be actively sensing their body position. An additional ‘temporary off’ switch is included to turn off the device for the current sitting session if the user specifically wishes to have the device disabled.

User attentiveness requirements

This heuristic going to measure the amount of attention user pays to the desk object while focussing on their work. Since noticing the desk object and correcting their posture are secondary tasks while they are working on their school work, the desk object should not grab the user’s attention more frequently such that it becomes irritating and frustrating. The object should provide ambient feedback using its position and LEDs so that the user can correct their posture whenever they decide to see at the object. At the same time, using the LEDs we have dedicated states that intends to grab users attention and inform them about their incorrect posture.

Clarity of feedback

The position of the desk object and the LEDs should, at any given time, should inform the users about what actions are expected from them. For example, when the desk object is leaning forward and the LEDs are turned red, it means that the user is slouching for a long time and should correct their posture. Using a combination of the direction of tilting and color intensity of the LED's on the desk object should provide the right feedback to the user about the current state of their posture. Also, the user should clearly understand the cues provided by the object and perform the desired action of correcting the posture.

Ability to inspire action

Ultimately, this design is only successful if it is able to provide the right feedback to inspire our user to correct/change their body position. Since the feedback is passive/ambient, there is the potential for the device output to lack the appropriate stimuli to make the user correct their position. In some ways, there is an inherent contradiction in passively informing someone to act, especially since we are designing to allow the user the ability to ignore the output if they choose to do so. We addressed this heuristic by focusing on providing a clear 'alert' state that relies on noticeable indicators that are quickly recognizable when viewed. Depending on user feedback, it may be necessary to adjust this mechanism to provide more/less subtle cues.

Phase Two: "Quick and Dirty" Feedback User Testing

Location: To keep things somewhat uniform, testing will be conducted in CULC whenever possible. TSRB will be used as a back up.

Duration: Approximately 15 minutes.

Participant Screening: Users should ideally be undergraduate students at Georgia Tech. However, due to time constraints and the generalizability of the design, graduate students (namely, fellow MS-HCI students) are also acceptable candidates for a portion of the tests.

Incentive: Provide free coffee to students waiting in line for Starbucks at CULC. The line for Starbucks is always quite long. By providing free coffee on demand, the participants will be spending the same amount of time providing feedback that they would if they continued to stand in line.

Format: Users will be oriented to the device, run through the various states that are possible, and asked questions at the beginning, after each state change, and at the end of testing. Throughout interactions, users will observe a speak-aloud protocol so that more detailed data can be gathered about user experience, designs, and the current setup for providing feedback.

Team Member Roles:

- MC Facilitator

    - One team member will be responsible for conducting the test, from introduction to follow up questions
- The Actor:
    - One team member is responsible for carrying out the actions of a representative user. This person follows the predetermined sequence of actions and does not interact with the user.
- The WIZARD!
    - 1 team member will be responsible for operating the device from two laptops to control the two Arduino boards. The device will move in time with the 'Actor' posture changes and in accordance with the testing scenario.
- The Keeper of Record:
    - One team member will be responsible for taking notes about the participant's responses throughout the process. This person will also try to track the user's more subtle forms of feedback such as tone, body language, and facial expressions.

Major Considerations:

- Since- due to time constraints- the testing is not directly mapping the user's behavior, their ability to define a relationship between their posture and the device may be limited. Figuring out how to overcome this obstacle is the single largest determinant for the success of this study. It may require an adaptable strategy as we uncover what works and what doesn't. In pilot testing, the user was not asked to adopt any posture changes in order to trigger the various states of the device. This was a major source of confusion for the participant. In our new evaluation plan, we are taking a novel approach to solve this problem- the user will observe one of our team members and will be told that this person is sitting in a posture sensing chair. The participant will be standing behind the person in the chair in order to view both their posture and the device simultaneously. The reason for this design is to make the connection between posture changes and the device more apparent without it being artificial or inconsistent.

- The amount of information given to the participant to orient them to the project is another consideration that must be addressed and potentially updated in response to testing results. We do not want to over-explain the connection between the device, the seat, and posture, as this will degrade the data that we collect about the clarity of feedback and device purpose. At the same time, not providing enough information may make it frustrating or impossible for the user to make the necessary connection between those components.

- Given that there are two designs for the indicator object, considerations must be made for order effects and the differences in feedback between the two objects. The impact of order effects will be mitigated by evenly distributing the test device between the two designs. All participants will be shown both devices at the end of testing in order to gather feedback about user preferences. Data will be compared across subjects to determine the success/viability of each object's feedback modes.

Research Questions:

- How do the users interpret the various states of the design?
- Is tilting an adequate indicator of posture?
- Does the light initializing when you sit down enough information to connect the act of sitting to the mechanism?
- Does the alert communicate the need to change posture?
- What do the color changes communicate?
- What do the LEDs in the Floating Orb mean?
- Is the fact that the tilting is forward-facing confusing to users?
- What are the user's impressions of the device?
- Which of the two devices would they prefer having on their desk?

Structure:

Introduction: Hi, welcome. We really appreciate you taking the time to provide feedback on this prototype that we are testing (*point to desk object to infer that this is the primary test subject, not the chair).* The person in front of you will be sitting on a pressure sensing chair. (***If testing proves additional information is necessary:* "We are testing a desk object that is meant to help you maintain good posture while you work at a desk.") Please feel free to ask questions at any time. You are free to stop the test at any time if you feel like it. Thanks so much, let's get started!

Orient user to device. The 'Actor' is standing up.

1. What are your first impressions of the design?

When the 'Actor' sits down, the base glows.

2. Is the device on or off?

- **How do you know?**
  - **If off/no mention of light:**
    - **did you notice that the object lit up when you sat down?**
    - **What do you think the base lighting up means?**
  - **If on:**
    - **What do you think caused the light to turn on?**
    - **How do you think the device turns off?**

'Actor' assumes leaning posture to the right and maintains the intensity, direction, and

degree of tilt of that lean. Device state transitions to partial tilt to the right. On Floating Orb, the first LED turns on as well.

3. What behavior do you think would cause the device to reach this state?
4. (If user doesn't mention in Q3) What do you think the tilting is for?
5. (Only for Floating Orb) What is the lighting telling you right now?

'Actor' still holding position. Device state transitions to second of three tiltting phases. On Floating Orb, the second LED turns on.

6. What behavior do you think would cause the device to reach this state?
7. (If user doesn't mention in Q6) What do you think the change in tilt means?
8. (Only for Floating Orb) What is the lighting telling you right now?

'Actor' still holding position. Device state transitions to third of three tilting phases. On Floating Orb, the ball turns on, and on Robot Man, the ears turn on.

9. What do you think the device is telling you right now?
10. (Only if not mentioned in Q9) How much further do you think the device will tilt in this direction?

'Actor' switches posture from right lean to apparent forward lean. Device stays in alert state and pans to center. In Floating Orb, all three lights remain on.

11. What behavior do you think would cause the device to reach this state?

12. What behavior do you think would bring the device back to its original state?

'Actor' comes back to a good posture. Device takes one step back towards the central, good state. Alert LEDs turn off for both designs. On Floating Orb, the column LEDs are still on.

13. How do you interpret this change? Is this what you expected?

14. Wrap up questions:

- **How confident or not confident are you in your understanding of the system?**
- **Are there aspects of the system that are confusing or unnecessarily complex?**
- **Is there anything you would change to improve the design?**
- **What aspects of the design did you find most effective? Least effective?**
- **There are multiple options for the design of the object and we would like to get your opinions on them.** *Show user the alternative design.* **How do**

the designs compare? Which of the two designs would you prefer having on your desk? What do you like or dislike about them?

- **Do you have any final thoughts you'd like to add or questions you'd like to ask?**

Phase Three: In-context Usability Testing

Location: Conducted on site in the CULC. This venue is the primary focus of our research and formation of user characteristics. Therefore, despite the generalizability of working at a desk, this site will serve as the best source of data.

Duration: Approximately one hour

Participant Screening: Students should be undergraduate students at Georgia Tech. Because the characteristics of students with pre-existing pain conditions are notably different from those without, this phase of testing will screen to select only those students who do not currently consider themselves to have a pre-existing pain condition. Additionally, due to the noise of the servo motors and the importance of gathering data about the distraction level caused by this device, a further criterion of regularly using headphones while working will be applied (see Major Considerations for more information about the purpose of headphones/noise screening).

Incentive: Use students that have yet to find a table at CULC or are willing to relocate to our testing table. Similar to Phase Two incentive, offer coffee as initial Incentive. Modify incentive if needed. Another option is to set up at a desk and then allow the participant to "keep" the desk after the test has ended. Due to the hectic schedule around finals and the difficulty of finding a desk in CULC, this may be a feasible alternative. The drawback, of course, is needing to set up our device in a new location after each test.

Format: Due to the constraints of being a secondary task and a design that should not be a distraction from work, the participant will be allowed to work at a desk as they normally would for the duration of the session. Metrics will be gathered during the study. Questions will be asked after the session has ended.

Team Member Roles:

- The Observer (of all that is and ever was...or something)
  - One team member will be responsible for subtly observing and taking note of the user's behavior, glances at the device, posture corrections, facial expressions, etc.
- The WIZARD!

    - 1 team member will be responsible for operating the device from two laptops to control the two Arduino boards. The device will move based on the participant's posture in accordance with the guidelines established before testing.
- The Keepers of Times and States
    - Two team members will keep track of time kept in a certain posture while taking notes on the behavior of the participant and the number of times the device reaches certain states. These members are largely responsible for gather the data on the metrics listed below. Having two of them will allow for inter-reliability testing, making the data more robust.

Major considerations:

- Servo motors are noisy. Participants may look at the device because of noise created by movement, rather than the notifiers that would be part of the final design. As part of the screening process, users will be asked if they regularly listen to music using headphones while they work. Only those who respond 'Yes' will be included in the testing process. By asking them to use their headphones during the work process, we will be able to isolate the attention they pay to the device from the noise that it is making as a prototype.

- By orienting the participant to the design, they will become aware of its role as a posture sensing device. This may contribute to an observer effect wherein the participant is carrying a different posture than they normally would. It also might make them think about posture more than our research suggests these users normally do.

- Providing truly ambient feedback is a very delicate process. Since this is a prototype, adjusting the level of light intensity and diffusion is not very feasible. Therefore, the current iteration of the design may be more or less noticeable than desired in terms of the brightness and positioning of the LEDs. However, learning more about how these factors impact users will be useful information when creating the final product.

- Without a true posture sensing chair, the determination of what is "good" posture and what is "leaning" is entirely dependent on our observation and our research into the subject. While efforts have been made to thoroughly understand what is entailed by good posture and standards have been discussed as a group for what constitutes a "lean", the lack of a true sensing device leaves this crucial component up to interpretation and possible inconsistencies. In order to alleviate the potential for inconsistencies, several pilot tests and follow-up discussions will be conducted. If necessary, a single team member can be permanently assigned the role of ‘Wizard’ to ensure a greater degree of consistency.

Research Questions:

- Do the users understand that the tilting is a gradual process based on sustained posture problems? Or do they expect it to be a direct mapping?
- How much prompting does the user need to understand the purpose of the design?
- Is the device intrusive on their workspace? Do users move, “hide”, or reorient themselves because of the device’s location on the desk? Is the device desk footprint appropriate?
- How effective is the device as a reminder to correct posture?
- How often does the device get the user’s attention? Are certain state changes more noticeable than others?
- Do users feel that the device is an effective tool for correcting posture?

Metrics:

- Frequency and duration of ‘glances’
  - Due to time, practical, and budgetary constraints this metric will be evaluated through observation alone. Eye tracking would be the true tool for taking this measurement, but that is not a feasible process to undertake given the constraints. Additionally, the distraction that this measurement tool would cause would degrade the data gathered anyway. The team member tasked with being the ‘Observer’ for a given test will keep track of this information. Glances can be described qualitatively (extremely brief, brief, extended, etc.), rather than quantitatively (.5 sec, 3 sec., etc.).

- Number of Alert States reached per hour
  - ‘The Keepers of Times and States’ will keep track of the number of times the Alert State is reached in the hour allotted for testing. Additionally, they will track the amount of time that passes before the first alert state is reached.

- Recognition of Alert State
  - Once the device goes into the Alert State (red LEDs on device top), we aim to determine how much time passes before the user glances at the device after transitioning to this state. The team members tasked with being ‘The Keepers of Times and States’ will record the amount of time between the initiation of the Alert State and the first glance of the user when the device is in this state.

- Response to ‘Alert’ State
  - After recognition of the Alert State, this metric will assess the behavior of the user in response to this feedback. This metric will assess the

percentage of times that the user corrects their behavior directly in response to recognizing the Alert State (within 10-15 seconds after recognition). Again, this will be the responsibility of 'The Keepers of Times and States.

- <u>Number of "Earned" posture corrections</u>
    - "Earned" refers to the ability for a user to correct the tilt of the device by maintaining good posture for a set period of time. And, yes, once again, 'The Keepers of Times and States will be keeping track of this using a stopwatch.

- <u>Duration of time spent in corrected posture</u>
    - Regardless of whether the user "earns" a fully corrected object or not, we will gather information about how long they maintain the corrected posture as a result of recognizing the Alert State (if/when they do). The timing for this metric continues regardless of the state of the device based on the maintenance of corrected posture. This job also falls to 'The Keepers of Times and States.

<u>Structure:</u>

Introduction: Hi, welcome. We are testing the prototype of this desk object that is meant to help you maintain good posture while you work at a desk. We would like you to work on your laptop for an hour, while this device is on the desk. It will passively provide you with feedback about your posture, which you are free to act upon or ignore. Please listen to your music, get comfortable, set up your workspace as you normally would, and forget we are here. We will silently observe and not interrupt your work. At the end of the hour, we will ask you a couple of questions about your experience working here today. Please feel free to ask questions at any time. You are free to stop the test at any time if you feel like it. Thanks so much, let's get started!

<u>Post-session Questions:</u>

1. **Walk us through your understanding of the feedback provided by this device?**
    a. **What does it mean when the device tilts further to one direction?**
    b. **What does it mean when the device pans to a new direction?**
    c. **What information is provided by the LEDs in the tower?**
    d. **What do you think the device was telling you when the Head/Orb lit up?**
    e. **What causes the object to return to an upright position?**

2. **How confident or not confident are you in understanding what causes the device to change states?**

3. **Was there anything about this device that distracted you from your work tasks?**

4. **Alert state:**
   a. **If no change made to posture:**
      i. **At any point did you feel like the device was directing you towards a certain behaviour?**
      ii. **Why did you choose not to change your posture?**
   b. **If change made to posture:**
      i. **Did you change posture at any point because of the device's feedback?**

5. **System Usability Scale (SUS)** (printed questionnaire)
   a. I think that I would like to use this system frequently.
   b. I found the system unnecessarily complex.
   c. I thought the system was easy to use.
   d. I think that I would need the support of a technical person to be able to use this system.
   e. I found the various functions in this system were well integrated.
   f. I thought there was too much inconsistency in this system.
   g. I would imagine that most people would learn to use this system very quickly.
   h. I found the system very cumbersome to use.
   i. I felt very confident using the system.
   j. I needed to learn a lot of things before I could get going with this system.

Preliminary Evaluation

At the time of writing, we have conducted one pilot test for Phase 2 of our evaluation. This was conducted with a female 1st-year MS-HCI student who vaguely knew that our project is concerned with posture. We tested with RobotMan for it was the only prototype ready for testing at the time. This pilot uncovered a number of issues with the original design of the protocol.

In the initial version, we had planned to minimise the amount of background and context-setting information to test whether the device could convey its purpose simply by being present. The user would be shown the device in different states and asked to interpret their meaning. The pilot quickly made apparent the fundamental flaw with such a design: there would be no link between a user action and a change in the device state. This caused a lot of confusion for our user: she interpreted the device moving before her as the device suggesting that she makes a change to reach a state similar to the one the device was in. She felt the need to "mimic the posture of the device". This meant the mapping relationship was the wrong way around with the user mapping the device, when it should be the other way around. We therefore decided to change the study design and ask users to adopt a specific posture first and move the device as they do so. If keeping the study length short was not a real constraint, a better approach would have been kinesthetic priming, where we would first distract users with unrelated topics and/or actions so their body would relax back to its natural habits of posture and have the device map their actual posture instead of forcing them into a posture.

At the end of the pilot, we showed the Floating Orb to our user, which prompted her to make a lot of extra comments about the appearance of RobotMan, and be more precise about she liked or did not like. We were originally planning on showing only one device to each user but this demonstrated the value of providing basis for comparison and letting the informed user tell us what they would prefer.

The pilot also started to uncover issues with the feedback mechanism of the device itself. First, the user found that the device turning was more noticeable than the device tilting, when the important part of the motion is the tilting. She also found it important that the device move in steps instead of turning and tilting at the same time.

Additional confusion was caused by the robot's anthropomorphic form that suggested a mental model of true user-to-robot mapping that is not consistent with the actual system model. For example, she expected it to sit down when she sat down because it was standing up when she was up as well. Similarly, the device facing down in the direction of tilting instead of always facing forward was confusing to her. She felt like the device was "doing its own thing and [she was] doing [her] own thing [with her posture]" because the gap between the real world and the system's image was too wide.

At the time of testing, we only had a green LED for our base when we actually intended to make it white. The test confirmed the need for the LED to be white because our user contrasted the green of the base with the red of the robot's ears, and was talking in terms of getting the robot "back into the green zone". While this is not an entirely wrong model, we want to eliminate the potential for confusion from color connotations and will ensure the final version does come with the white base LED.