Vending Machine Report

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The Sweet and Sour Candy Machine

Abstract

My task was to design and construct an electro-mechanical machine that dispenses an item or an experience. The machine's size could not exceed the dimensions 300mm x 210mm x 300mm and had to include the stepper motor, 2 sensors, mechanical parts and a clear feedback signal to the user. All materials used in the construction of the machine had to be recyclable and easy to disassemble.

I feel the brief has successfully been met with the construction of the Sweet and Sour Candy Machine (Fig 1). This machine has a spinning head modelled to look like a soldier and dispenses sweets in a novel and engaging way by encouraging the user to interact with the machine like a game in order to earn their reward.

Fig 1

Objective

Initial thoughts

What I wanted to do, What components I needed, Would this be a toy, a game or purely functional Would this be a finished design or could it be extended to enrich the user experience.

Preliminary Ideas

1. washing machine which spins clockwise and anti-clockwise with what appears to be someone stuck inside, driven by Stepper motor which also drives cams attached to the motor spindle which moves bubbles up and down as though the machine is overflowing. Issues were size , location of components, didn't dispense an object

2. Tarot machine to randomly answer questions with a dial driven by the Stepper motor to point to Yes or No or an alphabet to spell out short messages. Issues: aligning a dial to the characters and relating them to the steps of the motor, potentially complex code, not enough construction, didn't dispense an object.

3. A spinning head, driven by the Stepper motor that vends confectionary and also has an element of surprise because it is not clear what is being dispensed or when, constructed like a toy, made with common household items. Issues: where to locate and fix components , wiring placement, type of dispensing mechanism

Of these I selected idea 3.

Preliminary Ideas

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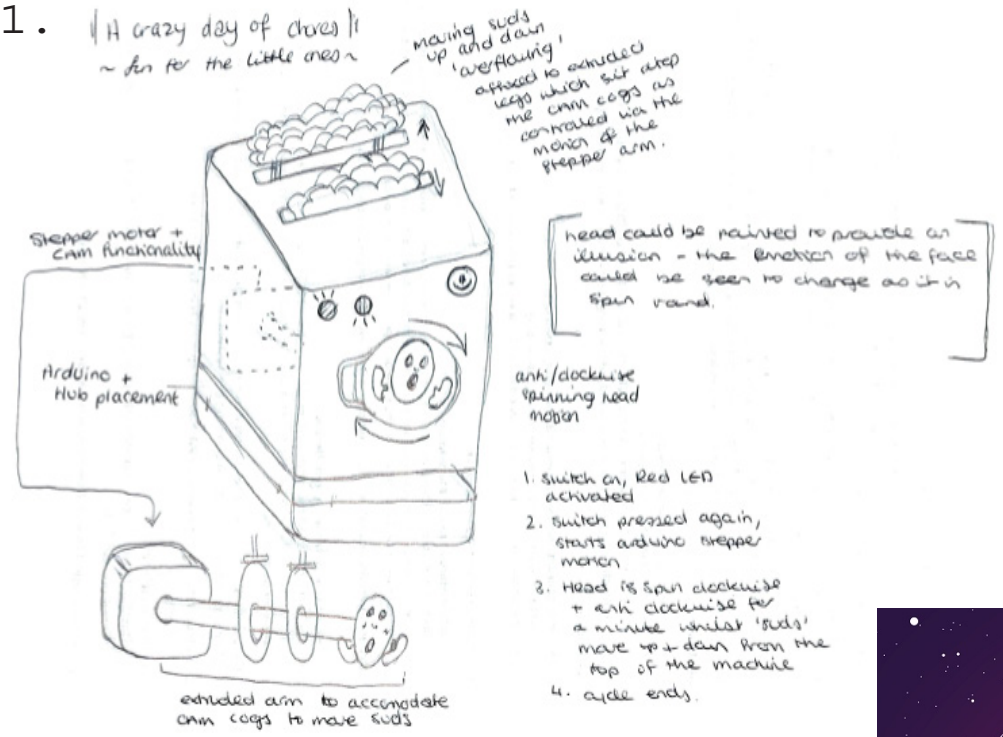

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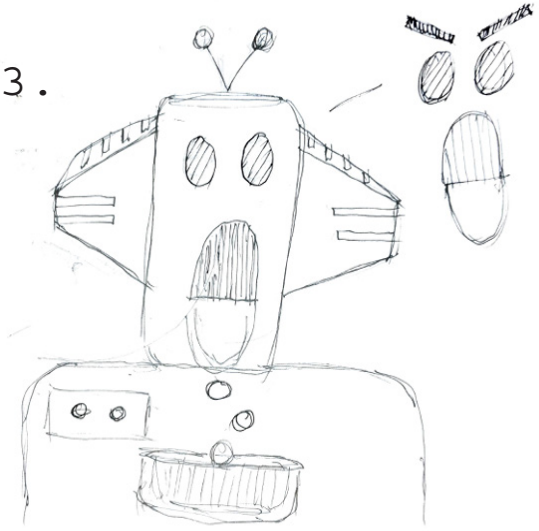
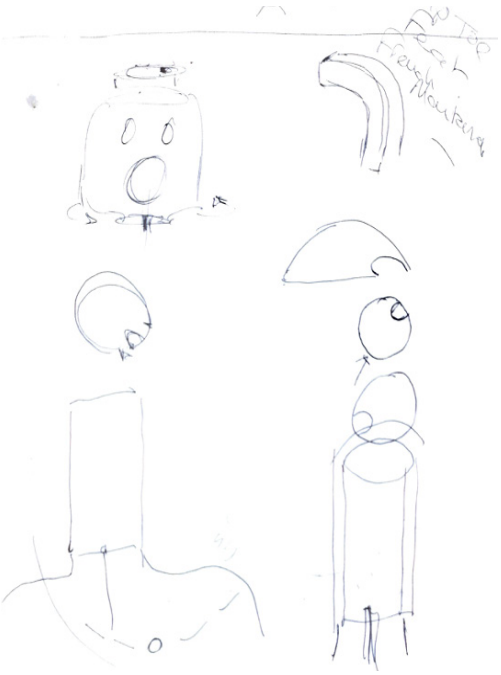
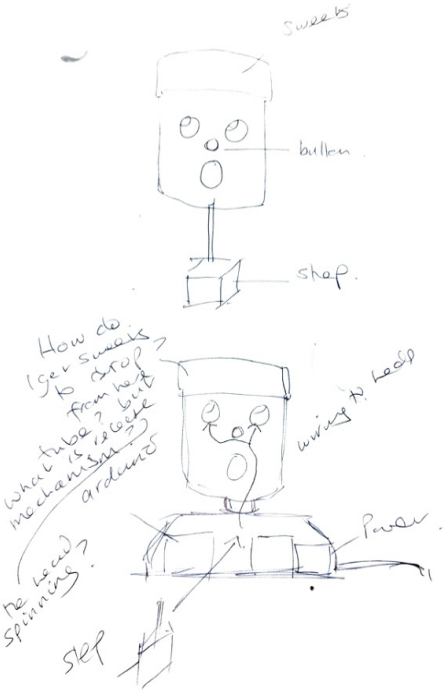
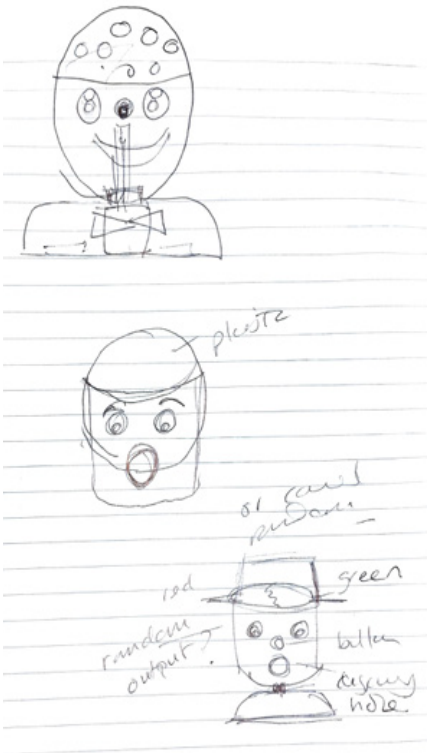








Components

My chosen components and materials were Arduino board, Stepper Motor, Stepper Driver , Button and Potentiometer as it was on the same board and LEDs, cardboard, recyclable plastic, aluminium and other metal, non toxic paint, hot glue, white blue tac, removable plastic tape, wood.

Development of Idea 3 - Extended concept.

To create a novelty character that appears to respond to the user but it is up to the user to work out why and use skill and speed to better the random chance of getting a surprise reward.

Sequence

- A user interface activates the machine
- The user interface is the red button
- The user presses the button
- Red and Green Led lights flash alternately at set speed and time, controlled by the code.
- Flashing lights indicate it is ON and prime the user response .
- If the user doesn't press the button again the lights are timed to continue and then stop
- When the lights are flashing, if the user presses the button on Red, the head will turn left and right , meaning NO and the request is rejected
- When the lights are flashing, if the user presses the button on Green, the head will turn left and right , and then turn around meaning YES and the request is accepted and sweets dispensed.
- By understanding when to press the button the user can maximise their rewards

Ideas on construction and closer analysis

Taking idea 3 forward, the next stage was to construct a basic model of a head using a coffee tin that was sufficiently robust to see how the sweets could be dispensed and where the components could be fitted . I considered dispensing the sweets via a 'mouth', but realised that it would require a much larger tin. Even then it would not be possible to fix all the wiring, cables and components securely in a space that rotated so another structure was needed to accommodate these. The natural choice to accompany a head, would be a set of shoulders. This meant I could use a small tin to hold the sweets and dispenser mechanism and dispense the sweets underneath between the head and the shoulder housing. Following this decision and to enhance the idea of a person I considered that the simplicity of the shapes and structure lent themselves to being a soldier.

Other Considerations prior to construction.

Sweet storage.

• As the tin has no separate compartment a chamber would have to be created to house the sweets
Release mechanism
• Ideally a simple rotational system utilising the rotation of the head by the Stepper Motor to align components and allow sweets from the store to fall into position and be dispensed via a funnel.

Refill.

• Modify the lid in order to create a closable opening. The lid would also take the place of a soldiers Beret
Rotating the Head
• Attach the Stepper Motor to the top of the head so only the head rotates

Housing

• Split into 2 parts, Head and Shoulders. Head for dispenser and shoulders for components and access, plus to counterbalance the movement of the head.
Fixing Components
• To mount on base if possible
• Use fixings in the mounting holes in the circuit boards
• Create pockets or slings to hold components in position
• Use wedges

Dispenser

• Independent from the head and in fixed position attached to the shoulders. To house a device to allow the sweets exit with being lost or jamming.

Wiring

• According to the diagram and minimising wiring tangles so they can be taped and excess stress on the connections avoided.

Access

• Drop down side to access components for replacement/repair

Development

Construction

There were a number of aspects to visualise before I settled on the design. Having dismissed the idea of a single integrated unit I wanted my design to make best use of the components and materials available, to maximise the functions and create a pleasing aesthetic. To do this I tackled the head and dispenser mechanism as one unit and the housing, components and wiring as another, finally connecting them together as the Sweet & Sour Candy Machine

Head & Dispenser Mechanism

This is a partially integrated unit. After considering how they might be combined it became clear that the head would have to rotate independently of any dispensing mechanism. This meant the Stepper Motor could not be fixed to the base of the head because it would turn together. The alternative was to turn it from the top of the head, by adding an extension to the Stepper Motor spindle. I wanted to retain the removable lid to facilitate adding the sweets so this meant the base had to be removed with a tin opener. The raw edges were smoothed and sealed with hot glue to protect from cuts.

Fig 2

The next step was to plan a compartment to hold the sweets. This required a base to be fitted around 3cms from the top and sealed by the lid. I decided I only needed a simple release mechanism to dispense sweets based on 2 discs with thumbnail size holes which when fully aligned would allow them through. To see how this might work I played around with paper discs on a pencil to see how they related to each other. I concluded one disc had to move and one didn't

Fig 3

Fig 4

Fig 5

This meant I could use the base of the sweet chamber to act like a disc as it would rotate with the tin. Using the circumference of the tin, minus a small margin for the thickness I cut a cardboard disc. I then made a thumbnail hole on one side big enough for a sweet to fall through, added tabs as fixings and made a hole in the centre for the Stepper Motor spindle to attach to the lid. I then made an identical disc and glued one in place using the tabs pointing upwards so as not to interfere with any other parts.

Fig 6

Fig 7

I then made 2 cuts in the lid to create a simple flap that could be used to add sweets. The strength was only marginally compromised and remained in place. If that had been a problem then I could have added a couple of dots of glue.

Fig 8

The other disc needed to be fixed to a non- moving structure that would:

a) position it close to the moving disc so sweets wouldn't get lost in the gap

b) be hollow to accommodate the Starter Motor spindle that would pass up through both discs to the lid

c) be narrow enough not to impede the tin rotating but big enough to include a channel for the sweets to exit.

The chamber would then be fixed into the shoulder housing to keep it upright. To keep it simple I used a cardboard roll to which I glued the next disc.

Fig 9

To test the working I put the straw through the middle and inserted the roll into the tin with the straw passing through the compartment base. This tested whether there was enough free movement around the spindle and whether the discs would operate smoothly.

Fig 10

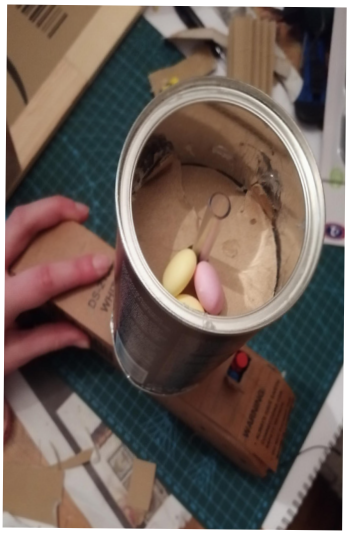


Fig 11

As the cardboard was quite rough I decided to add plasticised card washers to the opposing surfaces of the discs as a contingency. I could also spin the discs to align the holes and test how a sweet would fall when it went through. I found that sweets could slip between the tin and the tube, so I cut a flap in the tube where the holes would align, to create a phalange to scoop the sweet down the tube as it fell.

I reinforced this with glue and card. It also demonstrated that the sweet needed to be guided to an exit.

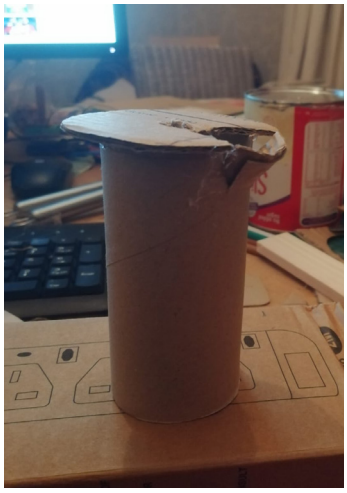


Fig 12

Fig 13

To help this work better part of the tube was cut away to create an arch for the exit and then cardboard wings inserted inside to bounce the sweets in the right direction.

Fig 14

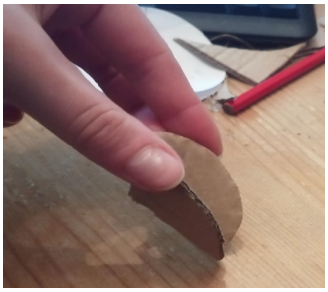


Fig 15

Fig 16

Fig 17

Until it was fixed to the shoulders it didn't matter what part of the tube was changed. When this appeared to work smoothly I hot glued a flat wooden stick inside the tube, opposite the opening, in order to attach it to the shoulders by making a small incision in the housing and inserting it.

Fig 18

To insert fully I had to make a small curved cut in the housing for the exit. This allowed it to rest on the housing and help stabilise the head.

To complete the assembly I hot glued the straw to the bottom of the lid.

Fig 19

Housing, Components & Wiring

The first step was to estimate how wide, deep and high the shoulders needed to be, relative to the head to give a good appearance.

To ensure I could fit all the necessary components in I laid them out first to test the optimum positions and get dimensions.

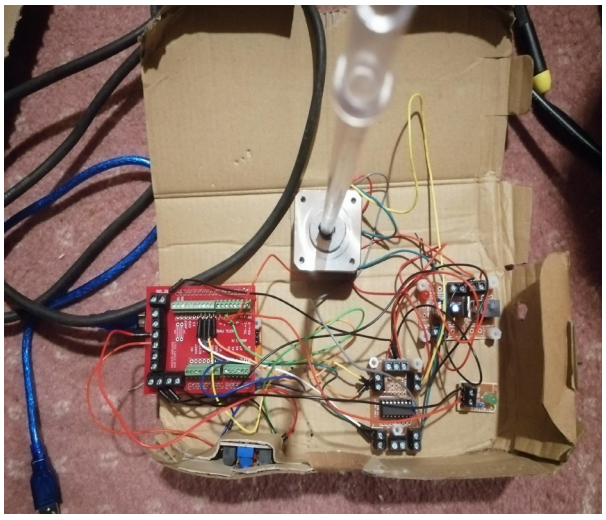


Fig 20

Using a rectangular cardboard box close in size to the footprint required, I detached the overlapped side along the length and fashioned both ends into shoulders before gluing the end sections in place.

Fig 21

This now looked like a long narrow open suitcase which could be opened back to allow me to mark up the positions for the components before attaching the boards with pegs.

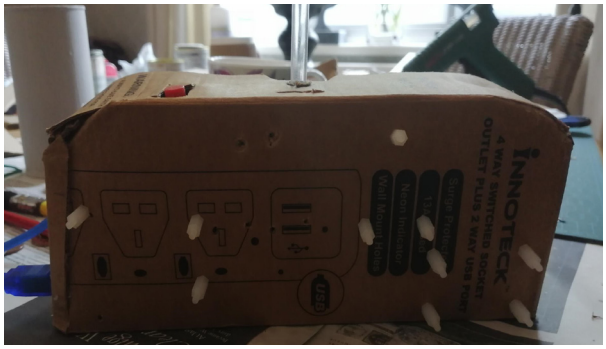


Fig 22

The Button and Potentiometer on the same board had to be fitted differently because only the button had to be exposed and the potentiometer accessed when needed. I thought the best position for this was on top of the housing where they would be seen and easy to reach. I marked the position by pressing it into the cardboard from underneath and cutting a hole just big enough to expose both components.

Fig 23

As the board didn't have any fixing holes I glued a sling of cardboard suspended inside to hold it.

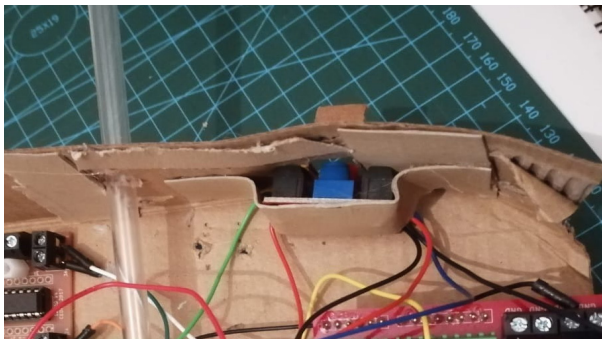


Fig 24

The final attachment were the LEDs. To provide user feedback. These were very awkward because they were not on the same board and were very small compared to the terminal blocks which meant they could not be mounted from underneath.

I decided to fix them on the front as the most visible place, disguised to look like an insignia in keeping with the soldier theme.

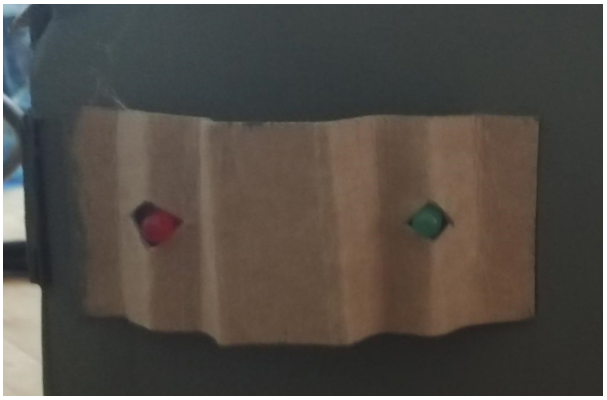


Fig 25

As these had to be fitted further away from the Arduino Board, I also had to swap out some wiring to make them reach.

The Stepper Motor was then put in the central position and a perforation made in the top of the housing just big enough to take the circumference of a plastic straw.

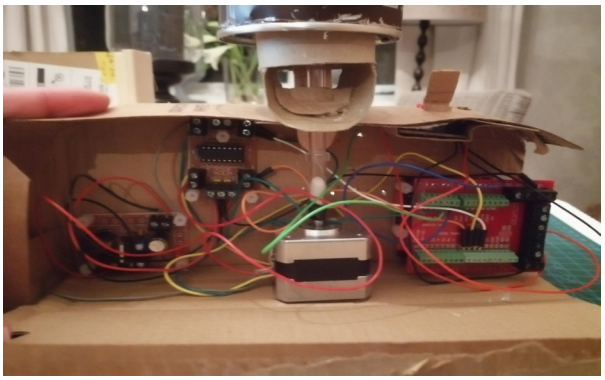


Fig 26

The end of the straw was filled with a little Blue Tack and inserted through the hole from above onto the Stepper Motor spindle.

This held it firmly in place while it was taped to the spindle. I then glued cardboard wedges around the Stepper Motor to control and lateral movement

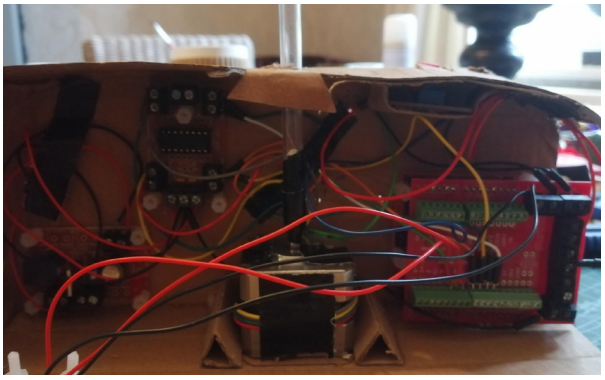


Fig 27

Issues

I wired all the components together according to the PowerPoint diagrams from last term. There was a missing Gnd wire between the Motor Drive and Arduino. The slide images of the Arduino showed it in 2 different orientations which caused confusion.

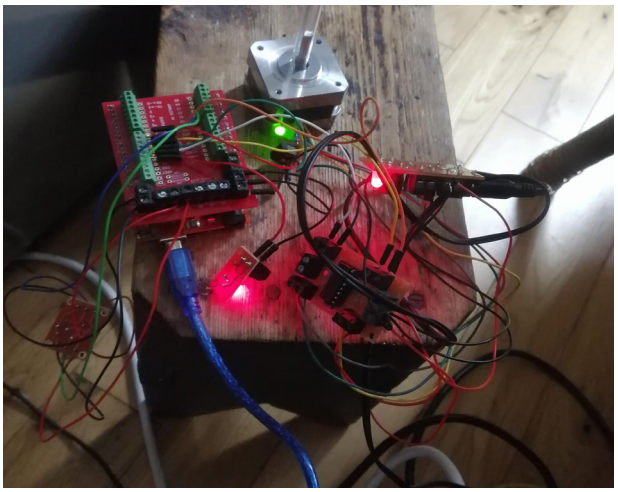


Fig 28

These were resolved and the stepper ran smoothly.

Component Access

Full access to the components via the front and side as shown in Fig 29 and Fig 30

Fig 29

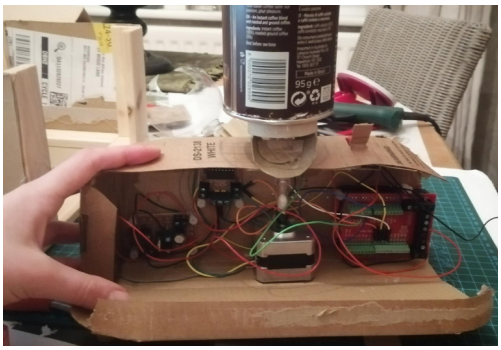


Fig 30

Coding

My starting point was to interface the components to the Arduino. I tried out small functions to make the stepper motor step, to detect the button press, and to read the potentiometer.

When I felt happy , I could use my chosen components and what I wanted to build. I made a further set of functions to define the broad functions - start the game, make the trial (which I had already written and named to test the LEDs and user response) etc. I noticed that some of these functions are a single line, I thought it would be clearer not to put every line of the programme in its own function.

I wrote separate scripts to try the button and the potentiometer, and I used Serial.println and the serial monitor to inspect the values and show me how the program was functioning.

Using the stepper code from the previous term, it initially didn't step but once rewired correctly it worked with the code.
I put the code into two functions and looped them to avoid repetition, I then added a step direction parameter using a pattern I found on Google that steps the motor clockwise and anti-clockwise, which worked, but I wondered what would happen if I wanted to make a single step rather than a step of 4 with an interval of a second, if I repeated this would I keep to the same sequence of steps as the test program or could I repeat step one? To slow the pace, should I drop all the outputs and depower the motor or keep the power and risk the motor over-stepping

The button press required two codes, one to activate the flashing LEDs which is really a 'wait for the button to be pressed' and another button press to stop the LED on the colour at the time the button was pressed and give a new command, e.g. release sweets.
I wanted to be sure a false press of the button wasn't detected so I added an inner 'while' loop to allow the button to be released but I didn't want it to wait forever so I added a pause value to return true if the button is pressed within X milliseconds and false if it hasn't, to return to the main loop if the user is no longer playing.

If they hit the button on the red light, they fail but if they hit the button on the green light, the user is rewarded, but if they don't press the button at all then the loop will repeat the cycle for 100 flashes.

For every major change, I ran a new Arduino script in the development system and copy & pasted the current code to the new script. This gave me a history of development scripts with a date and a, b, c. markers.
From the functions I developed for the components, and by typing place holders for the higher level functions such as 'make the trial', I improved the code.

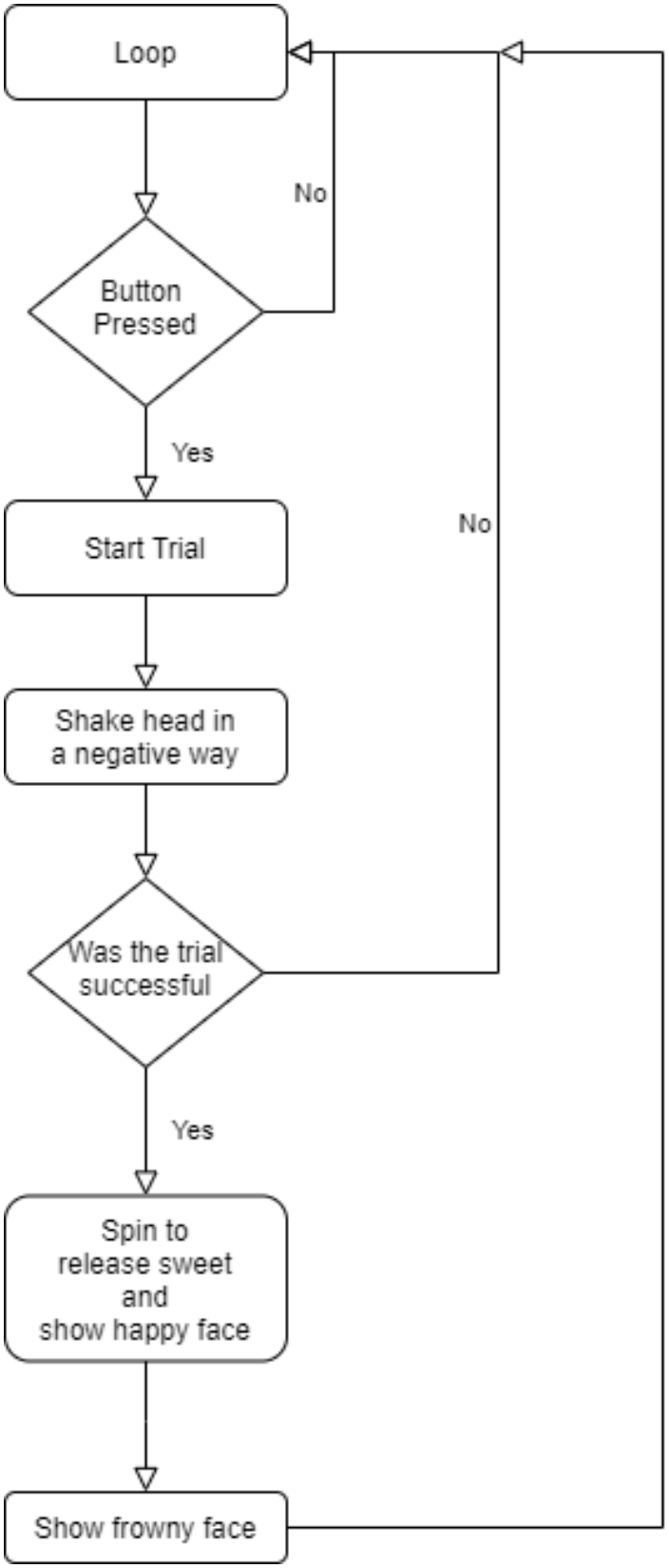
I wanted to avoid hardware reads or writes and having a read button pin input in the main loop of the code to keep it clear and so that any fixes can be done in one place.

I used writePattern to shrink repetitive lines of code into a single sentence.

Troubleshooting

I didn't realise that a wire was needed to connect the grounds of the motor controller board to the Arduino board which didn't appear on the slides. This accounted for the step motor only producing weak vibration.

Flow Chart



Aesthetics

Range of household materials used to create the aesthetics like the corrugated lapels and isignias as shown in Fig 32 and 34 and a shiny 2p coin to replicate a medal.

Paints were also used to make the access points to the machine circuitry look more discrete.

The two opposing faces are cruical to the enjoyment of the product as they offer the user an indication of a positive or negative outcome. It means the head only has to rotate 180 degrees to change this, thereby simplifying the operation of the stepper motor and the coding

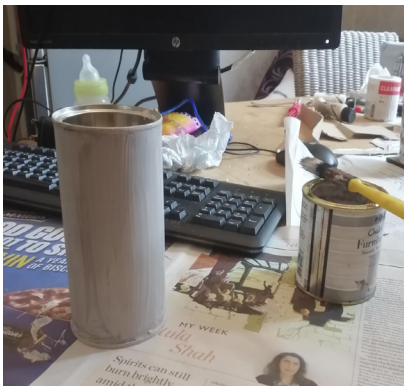


Fig 31

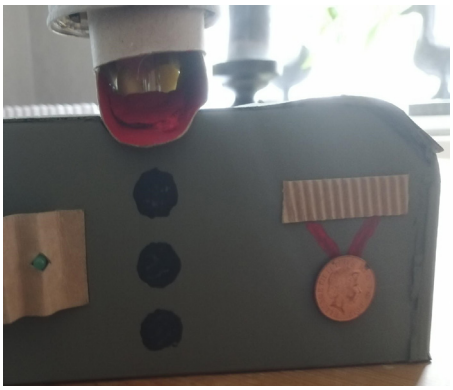
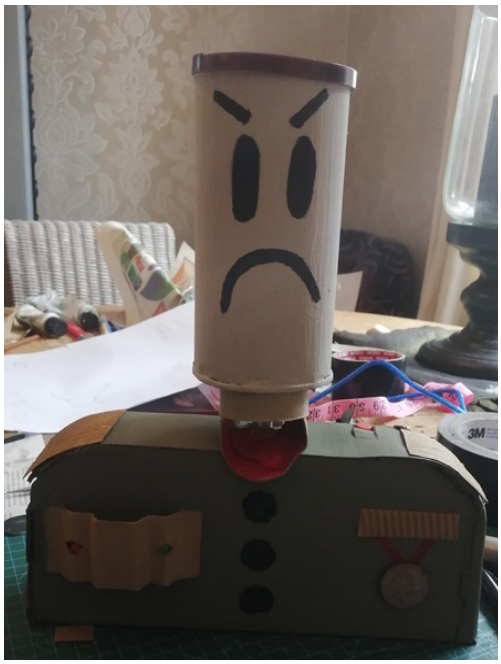


Fig 32

Fig 33

Fig 34

Finished Machine



Future Developments

In the future, I would like to build on the military theme and introduce features like text to speech so that the machine can communicate audio feedback to the user when indicating their success or failure at gaining sweets. Audio commands could include; "attttention" – to indicate the machine is on and ready to start the game, "not good enough corporal" – to indicate failure and "good work out there soldier" to reinforce the message of reward if you land on the green LED.

I feel that the cravat collar could be refined and the motor speed slowed in order to control the descent of sweets better so they land cleanly in the dish instead of flying out.

I would also introduce more flaps in the sides of the shoulders in order to allow for greater ease of access when disassembling or analysing the internal circuitry

Potentially, if the head was made bigger, then two types of treat could be offered to keep the user playing and make the outcome more random

A range of themed designs could be produced, e.g. Easter theme - chicken releasing mini eggs.

Conclusions

I felt this machine met the brief because it vends and offers an experience.

It is hard to fully gauge the strengths and weaknesses of the machine as it has had to be manufactured from quite poor materials.

The concept has a lot of strengths and engages the user and the rewards could be changed to appeal to a child or an adult.

Seeing the project finally come together with no faults and with the additional of decorative paints pulled it together, I feel it unified the design to make it feel like a real product.