Physical Prototyping of a "Treasure Hunt" Toy to Enhance Parent-child Gift-giving.

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CONCEPTION

Since working with microbits was a requirement for this project, the first step in the design process for this concept was, unusually, considering which tools were available and deriving an idea from these.

Two components were deemed notable: the rotary potentiometer from the freenove starter kit, and the microbit's radio and compass capabilities. From this, an ideation phase commenced regarding how these could be used in conjunction. Throughout this, the ideas of gamification (particularly puzzles) and designing for children were carried forward from an earlier concept in response to the design brief "Santa's secret radio".
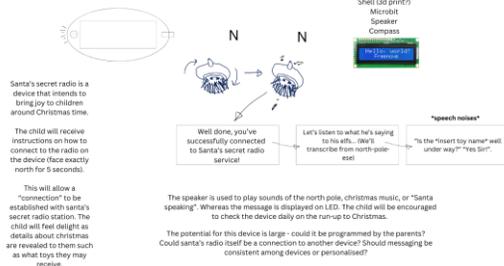
This initial idea was abandoned following a group discussion of our concepts, in response to feedback about how the compass could be used more creatively.

Indeed, the "treasure hunt toy" came about as an evolution of the "cracking the code" theme from this. I was interested in how this process could be made more complex to provide a more satisfying gamification, as well as removing the seasonal component.

To do so, I reconsidered the usage of a potentiometer. In particular, how this could be used to emulate the "cracking" of a safe as presented in films and TV. Building upon this, I conceptualised "treasure" being stored in the safe, and another "finding" step being required before the cracking game began. This two-step process was conceived to provide a closer emulation of a real-life treasure hunt to engage children's imagination, providing delight.

Regarding the "finding" step, this was an opportunity to utilise the radio and compass capabilities of the microbit. I suspected these could be combined to triangulate positions of microbits from one another.

Finally, I considered the concept altogether to find a key interaction and motivation behind this. Namely, the interaction of gift-giving which can be enhanced through gamification, especially in a child's mind, and the motivation of creating "play" between parent and child, as well as teaching delayed gratification.

STORYBOARDING

Once an idea had been conceived a simultaneous storyboarding and sketching/clarifying function process began., The former was necessary to explore and consolidate the concept, as well as communicate to others for feedback.
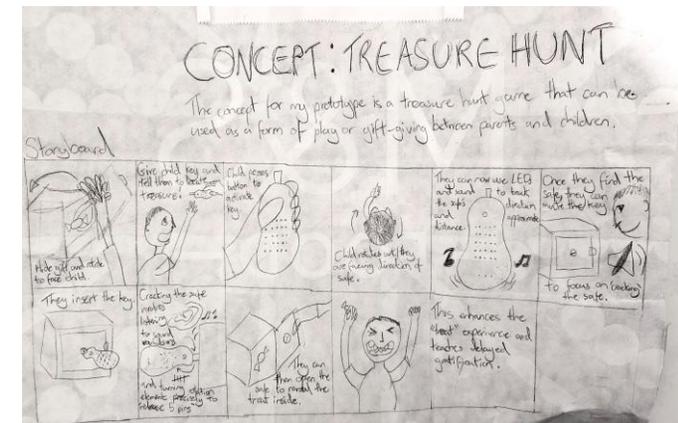
Regarding the above storyboard, the steps outlined helped to visualise how the devices would be interacted with to form a cohesive "treasure hunt". For example, details like the parent presenting the key as a matter of excitement for the child, or physically opening the safe rather than automation may be more satisfying. These details had not been considered prior but were elucidated in their

necessity to be drawn when considering the whole process.

SKETCHING AND CLARIFYING FUNCTION

In the same session as storyboarding, I began considering the devices' appearance, and the relevant details of construction using the microbit components, as well as how the game itself could be developed with the tools at hand.
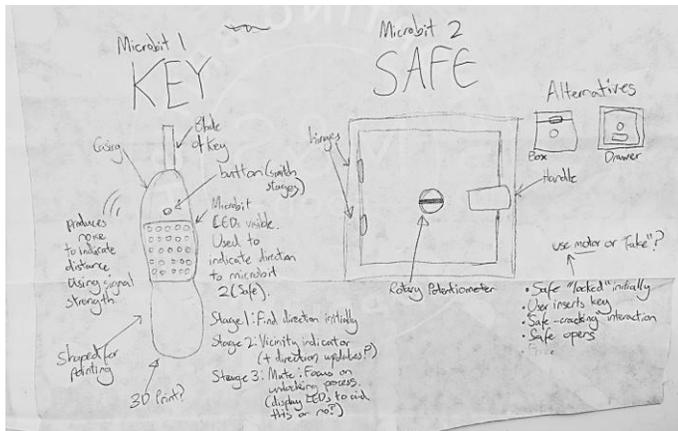

Figure 1 First sketches. The stages were added following further consideration in figures 2+3

Regarding the above sketches, these were necessary to gain a better understanding of how a synthesis between an ideal physical structure of the design, and one that could work with the requirement of microbit insertion, as well as limitations in materials available and my own ability.

Considering the key, my biggest concern was concealing non-interactive and unneeded elements from the user. As such, the salient solution was a "shell" casing which left no visible portions besides a singular button and the LED grid, which I had deemed necessary for functionality. Furthermore, the key "blade" was incorporated to allow for interaction between the key and the safe, where prior they had been visualised as two separate interactions. This allowed for a more cohesive experience. Practical considerations also included allowing room for the necessary battery pack so the microbit could function without USB power.

In addition, materials and ergonomics were examined at this stage. A rounded, 3d printed shell would allow for a superior level of fidelity to other possibilities like a wooden box, while being pleasant for the user to hold.

Finally, implementation was reiterated in this sketching process. For example, Having the microbit rotated 90 degrees in such a design would require any LED patterns to also

be rotated to achieve the desired output. Similarly, the compass itself would be at a 90 (or 270, depending on final design) degree bearing from north when the user points the key towards north, which would require compensation in the code.

Regarding the "safe", I wished to emulate the presentation of a safe in children's cartoon, which are typically round and have an emphasis on the twistable element and handle. This was realised in Figure 1, however I also included alternative designs where this may be difficult to prototype.

A primary consideration was whether to include a motor which could perhaps be used to emulate a "locking" door as the rotational element could be attached to a piece of material blocking opening. On reflection, I realised that the engine required a large 9V battery which was not included in the freenove starter kit, and which may take up undue space in the prototype. Indeed, this can be "faked" in a number of ways.

At this stage, the material of the safe was undecided. While metal was ideal but difficult to work with, plastic could be used to provide vibrant colours to engage children, while wood would allow biodegradability as insurance for loss during outdoor play.

CONSIDERING TRIANGULATION

Until this point, I had hoped it would be possible to triangulate microbits positions from one another through some method, for the "Finding" aspect of the game. My primary thinking was that a line could be drawn from both microbits towards a point representing North from their compass functionality, and then the radio used to communicate how far each microbit's direction differed from North and thus triangulate each other's position from this. In retrospect, this not a logical assumption to make, as I realised after drawing the following diagram:
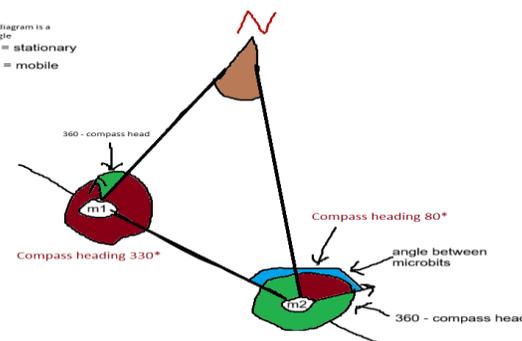

Figure 2 An initial idea for triangulation

Simply regarding this, I suspected that it would not be possible to ascertain the blue angle from the information available. Upon consulting with various peers who study mathematics-based subjects, this was confirmed, as well as the crucial point that North cannot be considered as a point on a 2d plane, and should rather be considered as a single direction for all microbits in a reasonable vicinity of one another.

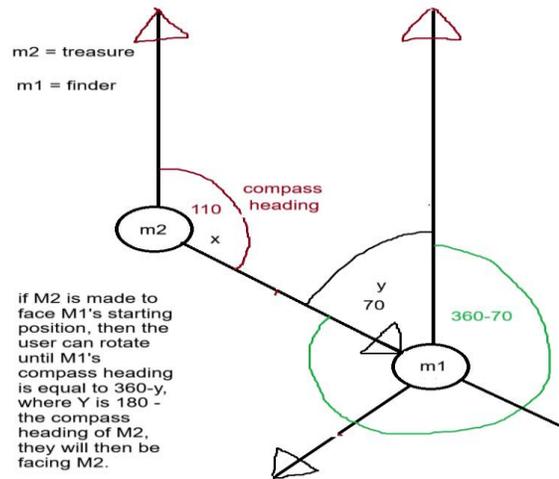Given this, I progressed to produce the following diagram:

Figure 3 Updated idea for triangulation

In this concept for triangulation, an element of "faking" has been implemented to work within the limits of the microbit systems. That is, m2 (the second microbit in the safe) must be positioned facing the starting position of m1 to ensure functionality. This is a reasonable adjustment for prototyping, since the parent-child interaction is not compromised as the parent will know where they will give the child the key (e.g. their room) and can easily ensure this.

Then, the maths to conduct this triangulation process became rather simple, as outlined in Figure 3.

Figure 4 Paper prototype – the "Safe"

Figure 5 Tying Microbit to Battery

Figure 6 Paper prototype – the "Key"

Figure 7 Interaction success!

PAPER PROTOTYPING

Although a high-fidelity prototype was the intended outcome, developing a paper prototype was both helpful insurance in the case that this development would not be possible e.g. if support was not available or due to extenuating circumstances, as well as very useful to communicate to others prior to this development, notably Ben, the MakerSpace creative technologist who I hoped would help guide the hi-fi design process. Furthermore, this additional prototyping step raised important points that were useful later. Firstly, since this session was conducted in my home, it was necessary to find the

required materials for prototyping, which required lateral thinking.

For example, after assessing desired size and shape, the carboard tube from an empty toilet roll was determined as a suitable container for the microbit to prototype the "key".

In this, the microbit was tied the battery pack using male-to-female cables from the freenove starter pack through the holes in the microbit, where there was no access to other methods of attaching the two.

The "safe" was prototyped by cutting, re-sticking and adjusting a damaged amazon delivery box that I located, then attaching the potentiometer to this. Overall, this paper prototyping required creativity, which lessened the mental burden when designing the hi-fi prototype since much consideration had already taken place.

Important points that were raised in this process included how to make the microbit sit in the shell without moving, and how to incorporate a proper hinge in a non-malleable material for the safe.

PROGRAMMING

To bridge the gap between the current static object and an interactive prototype resembling the initial conception, the Microsoft "makecode" IDE was used. Two separate files were produced to determine the functionality of each microbit, titled "Safe" and "Key". The former dealt with the "cracking" interaction, namely reading inputs from the potentiometer and guiding the user to match them to preset random values using sound, whereas the latter dealt with the triangulation process, as well as "Stage 2" in which signal strength is used to give the user a "hot or cold" finding interaction as they physically move around, and "stage 3" where the key is muted but provides LED feedback to indicate the safe being "cracked".

This programming process involved overcoming various issues to gain a greater understanding of the prototype's functionality. For example, the potentiometer value must only be updated if varying by more than 10 from the pin's previous reading, since it has some natural variability as an analogue signal that would cause unwanted sounds here. Furthermore, I realised during debugging that the triangulation algorithm varies if the safe's compass heading is more or less than 180°.

This block shifts the compass bearing to account for the microbit being skewed 90°.

This block deals with incrementing steps in "cracking process" and communicating this to the user

This block below communicates "hot or cold" to the user through sound and LEDs (Stage 2).

This block deals with setting the values to be "cracked"

This block deals with radio – communicating regularly to allow the "hot or cold" functionality, and once at the start to triangulate.

This block assesses if the user is facing the right way and communicates this. (Stage 1)

This block determines whether the user has "cracked" a code, and communicates to the user how close they are through noise.

This left block deals with triangulation.

HI-FIDELITY PROTOTYPING

Once the code had been completed, I began planning a hi-fidelity physical prototype. This primarily involved rebuilding the prior paper prototypes from more user-friendly materials, as well as dealing with any design issues that became illuminated during this process.

To begin with, it was necessary to consult with Ben, the MakerSpace creative technologist, as I had little bearing on how to progress my design, besides a rough concept of 3D printing a "key" and perhaps a box with a potentiometer cut-out.

Ben suggested that it would be suitable to 3d print the key as a shell design that could be glued together, whereas the box could be laser cut. He also pointed out that instead of a bit on the end of the key that slotted into the potentiometer, a knob could be used for precise interaction. We then worked together on a 3d model for the aforementioned shell that would fit a microbit and battery pack, which was later taped and glued together (Figure 8). During modelling, I addressed concerns such as the button being difficult to press as it was quite flat (by adding a divot) and maintaining the ability to adjust the code of the prototype (by adding a charging port). One issue I faced in assembling the key was that the microbit wouldn't lie flat due to the second button. Luckily, we were able to remove this.

Figure 8: The "Key"

3d Printing the key was ideal to achieve an ergonomic shape and precise measurement.

Although the key was smooth-sailing, perhaps due to Ben's input, the box was a more independent process with setbacks. Firstly, there was an initial problem with the concept – it would be difficult to add a hinged door to a laser cut MDF box, with this material being chosen for the aforementioned biodegradability consideration. My first solution to this was to utilise the considered alternative design of a drawer, however, this remained an issue; when using a hot glue gun to assemble the box, I realised the residual glue would not allow for a properly fitting drawer. Going back to the drawing board, I produced a different design of a "lifting panel" (Figure 9) which satisfied the requirements of an openable box, and actually allowed for better concealment of the microbit by glueing it to the ceiling of the box rather than the floor. Still, when assembling the box, I realised that the panel could be pushed inwards or outwards to open it rather than sliding it up. To address this, I laser cut two "guiderails" which were placed on either side of the panel to maintain a smooth up-and-down motion.
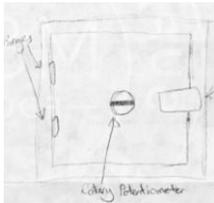

Figure 9: The progression of the "Safe" design.

SIMULATION
Once the Hi-Fi prototyping was complete, I was able to successfully simulate the "Treasure hunt" game.
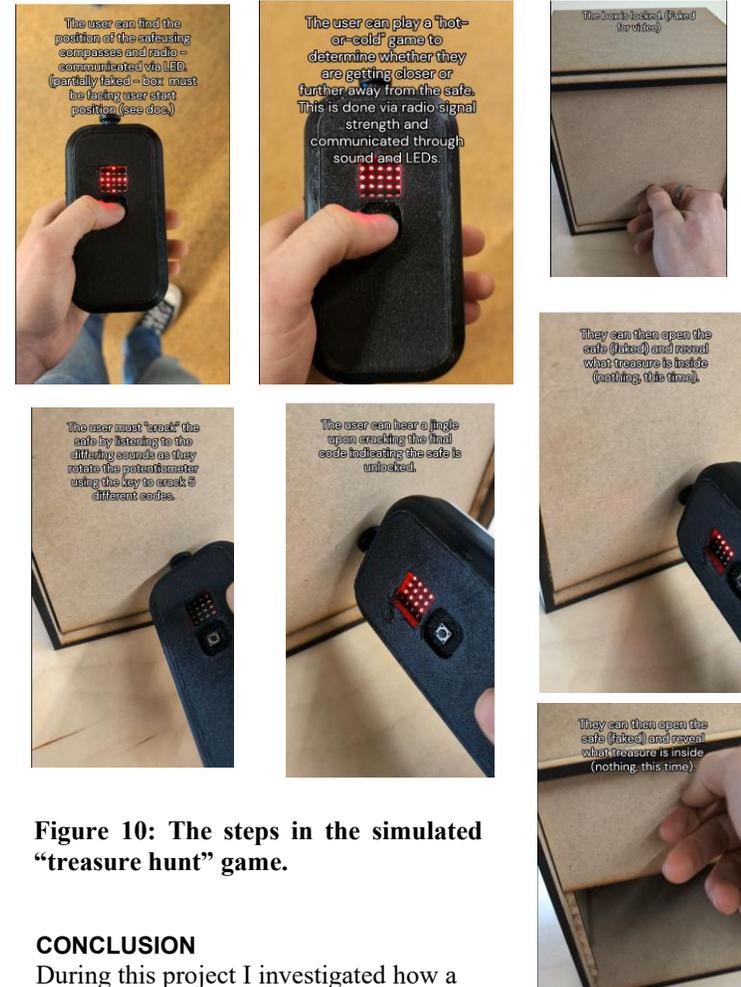

Figure 10: The steps in the simulated "treasure hunt" game.

CONCLUSION
During this project I investigated how a "treasure hunt" game could enhance parent-child gift-giving through a prototype using microbits, components, 3d printing and laser cutting.

Though this was successful, development in to a fully-fledged artefact could include increased consideration of materials and decoration to please children, better triangulation, user-testing in real-world, and custom components.