Final Report

(last update: May 23, 2020)

CollaBox Team

ENGG 4930C

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1. Background

1.1 Situation description

Caritas Lok Kan School is a special education needs school in Tin Shui Wai, New Territories, Hong Kong. It accommodates for students aged 6-18 years with severe physical and intellectual disabilities. As the school serves students with severe intellectual disabilities, all of them are assessed as SID (Sensory Integration Dysfunction) before admission. There is a wide range of disabilities including autism, epilepsy, cerebral palsy, infantile spasm to name a few. Very few students have the ability to independently carry out daily life activities like drinking, eating, ambulation and even communication. Most need assistance. Students can communicate using facial expressions, gestures and a communication book but none with words as of now.
Given the range of disabilities, the 52 students are grouped based on their abilities (physical and intellectual) into primary, junior secondary and senior secondary classes. The kids attend classes of language, physical education, math (for advanced classes), and are also given some vocational training in baking, decorating, etc.

1.2 Problems

1. There is a wide range of disabilities amongst the students so it is difficult to have a generalised form of education curriculum. Most students are accompanied by care-takers and teaching is very individual focused. Even though this ensures each student gets enough attention and a customised form of learning, there is limited to minimal student-student interaction.
2. Students have potential in being more independent from their care-takers not only for learning but also for leisure activities, despite their physical and mental constraints. Even though some of the higher ability students do play in groups, there are many more that we observed that do not interact.
3. Classroom learning might be affected by the student's lack of interest or attention. Since classroom time is limited and considering that the majority of it is required for settling down and/or taking care of medical conditions, it is important to make best use of the remaining time by grasping students' attention in class content.

1.3 CollaBox's objectives

CollaBox provides an opportunity for the students to come together and solve simple puzzles to achieve a shared reward. With this, we encourage students to play with and learn from each other and understand the value of cooperation and shared objectives. Using a game play, CollaBox retains the students' attention and trains them to be cognizant of daily life objects in different contexts, while also improving their hand-eye coordination.
The core game format is that of a matching game. Students are instructed to match pairs of objects to whatever the question cue is. Upon successfully matching the game, the story line proceeds and gives further instructions to the students. The game involves virtual and tangible rewards which maximises their interest and motivation for the collaborative game.

1.4 Major elements of CollaBox

1. Game software
2. Animations
3. Hardware (coding and building)
4. Rewards

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2. GAME DEVELOPMENT

Technology used

Game elements were fabricated on Unity. Coding in C# was managed in Visual Studio Basics.

Evolution

The ideation for the game initially involved multiplayer interaction with complex controls and a well branched storyline. However, over the course, we had to simplify the game to better fit our target.

Prototype 1.0

The biggest challenge was learning to use Unity, C# and GitHub, but the team found their pace through rounds of trial and error and with great help from the teaching team. Initially, the prototype of the matching game was made on an educational tool creation platform called Flippity. It featured multiple pairs shuffled within an interface (Fig. 1). Students would have to click two images simultaneously to indicate a 'match'. Receiving feedback from the teaching team and our partners, we decided to make two changes. Firstly, the idea of selecting two related images amongst a pool of objects might be too difficult students, which lead to the emergence of our final drag and drop model. Secondly, we were reminded that students might not be able to make sense of clipart like we do, so we decided to use actual photos of objects. When we can visit the school, we will be taking actual photos of objects they see in school to be used in the game.

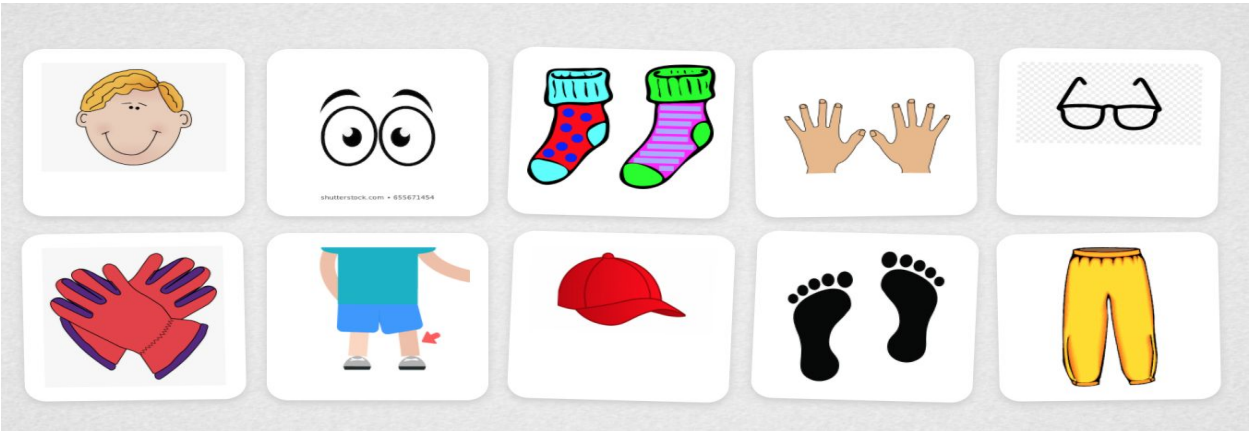

Fig 1. First prototype of the matching game

Prototype 2.0

Our second prototype was coded on Unity. Images were arranged in two columns, and students had to match the images on the left-hand-side "Questions" column to the right-hand-side "Answers" column (Fig. 2). Since the console was not fully developed at this point, students click on an image to pick it up, use arrow keys to control the position of the cursor, and click again to put the image down when they have arrived at the correct position. However, we were reminded that our target users might be confused by the concept of having to do another button to 'confirm' the match. Hence, we coded another version that automatically locks the Question image with the Answer image when they are close enough. In order to avoid making the game too lenient following the removal of the "press to confirm" key, the question image now has to exactly overlap the answer image to be told if the answer is right or wrong.

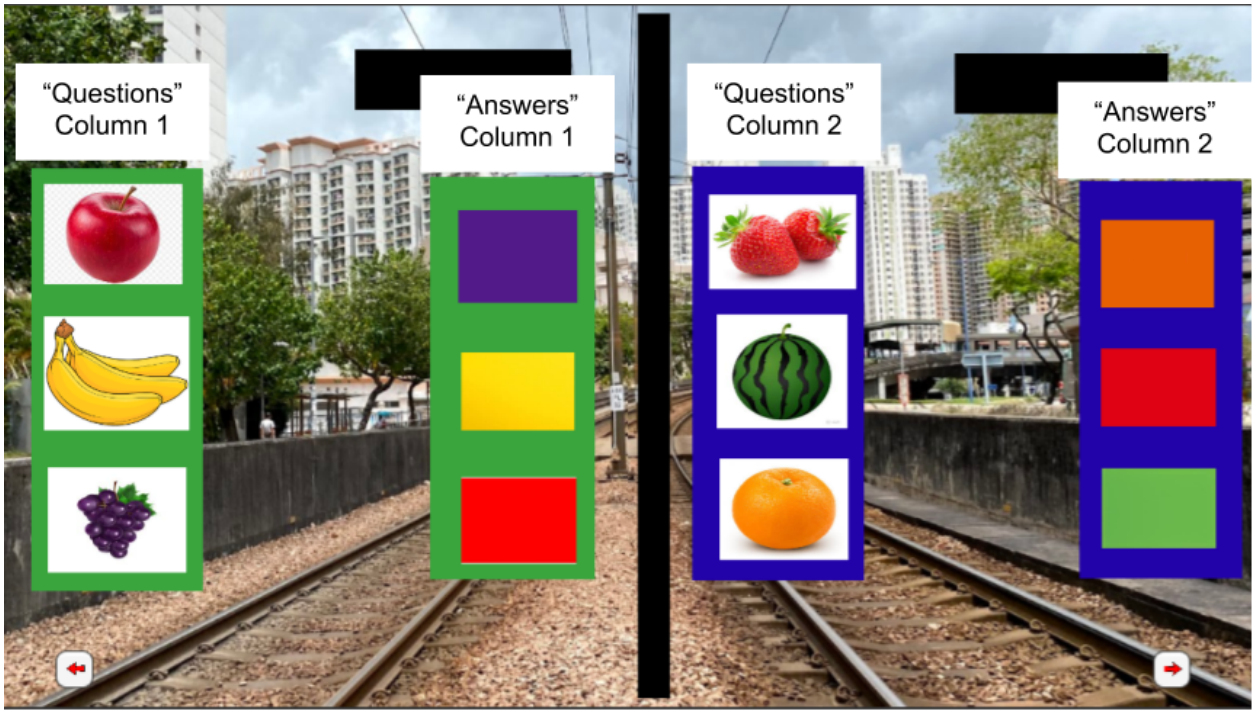

Fig 2. Question and answer columns

If an answer is wrong, the question image's alpha value decreases and appears more translucent (Fig 3).

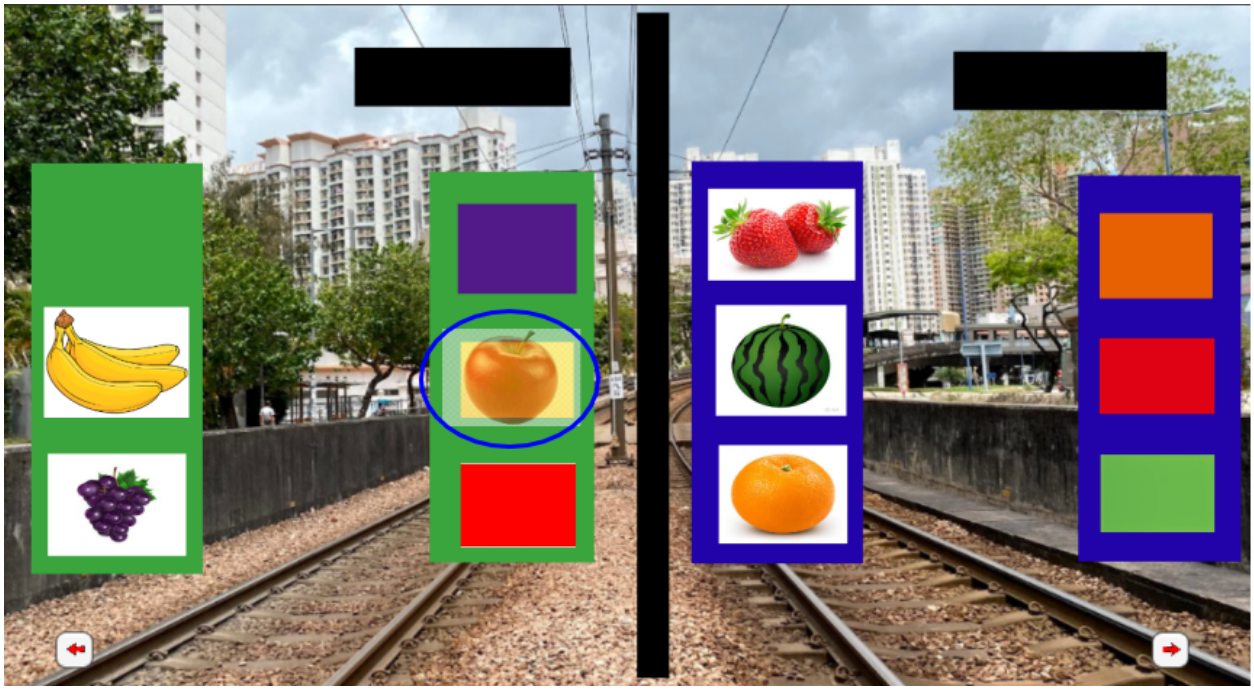

Fig 3. Wrong Answer

We were uncertain about the students' abilities and what would be appropriate for the students, so we had to communicate with teachers from Lok Kan frequently to make sure our product and address the users' needs.

One major challenge at this point, however, was that of a time lag with the joystick. Since the joystick was our main input device, time lag in its digital reaction was getting frustrating. This was fixed by using a thread function. Our team members from game development department efficiently collaborated with the hardware department to familiarise the latter with Unity platform and C# while troubleshooting the issue by making changes in Arduino and incorporating new functions in C#. [Please refer to the hardware development section of this report]

Prototype 3.0 *

The third phase of software development was focused on adding effects and stitching the graphics into the game. In the main gameplay scene, a checkmark appears when the correct images are matched. A chiming sound is played simultaneously and a star appears at the top of the screen. Pieces are contained within their field of action and cannot cross borders.

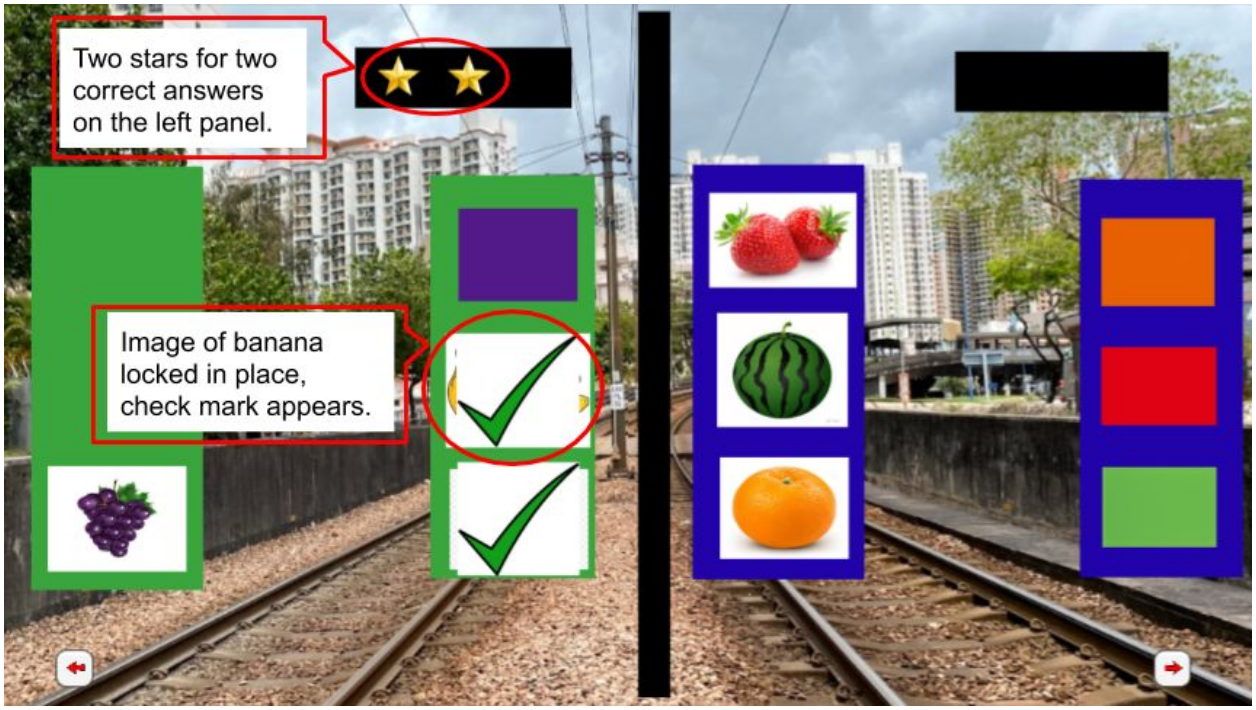

Fig 4. Checkmarks and stars

When a student finishes all three questions, a different chiming sound is played and half of an octopus appears.

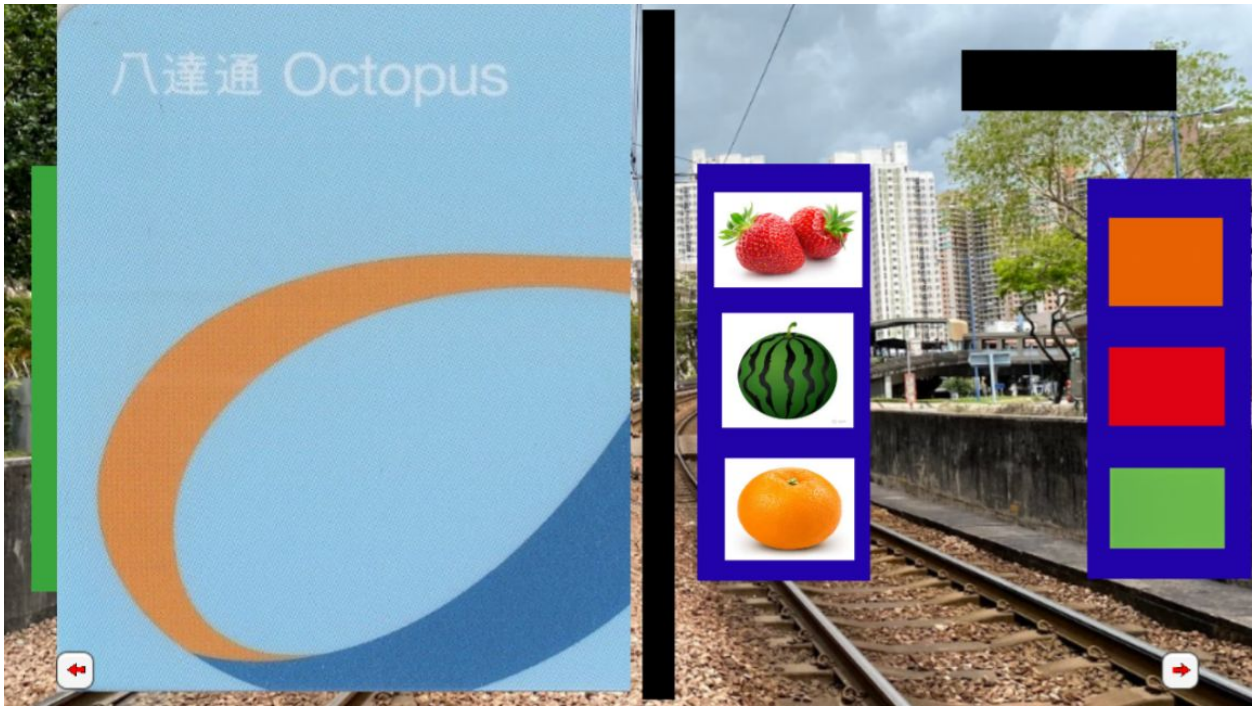

Fig 5. Half octopus

A tutorial scene is added for students to familiarize with the controls of the joystick. This scene will be shown before each pair begins their gameplay. The joystick controls the movement of the pieces smoothly throughout the game play.

The introductory video and voice overs (with Pepper, the humanoid robot, used as the narrator avatar) were also added to the game. [Refer to Animations for details]

* Prototype 3.0 is the final product as updated on 23 May, 2020. Further changes are expected to be made in near future.

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3. ANIMATION DEVELOPMENT

Technology used

CollaBox used Adobe Animate and Adobe Illustrator for animation design, together with Premiere Pro for video editing.

Evolution

Prototype 1.0

Our first idea on the game theme was having a group of monkeys trying to escape from the zoo and explore around Hong Kong, as we believe monkeys would be a cute choice of characters to be used in the game (and it is quite similar to humans, students may be able to relate to the characters). We designed our own monkey characters and animated them by putting them onto our own-drawn background to create a starting scene and an ending scene for the matching game.

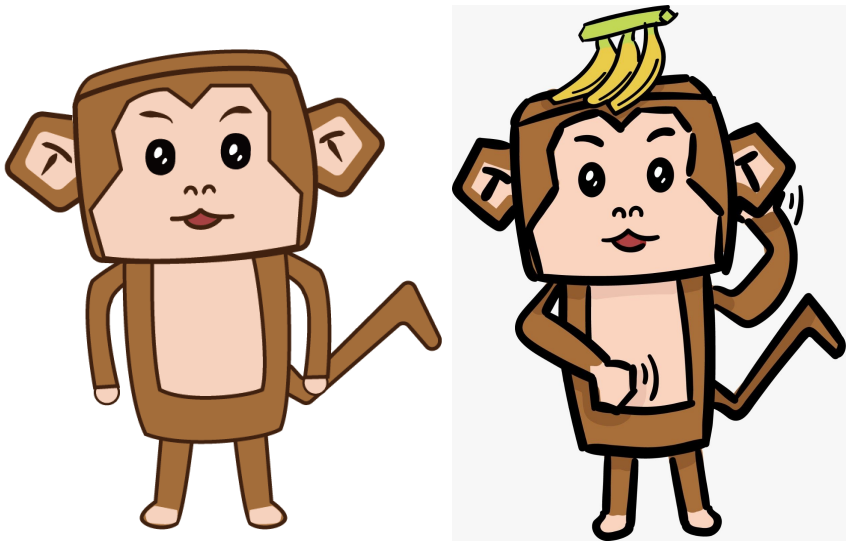

Fig 6. Preliminary character design

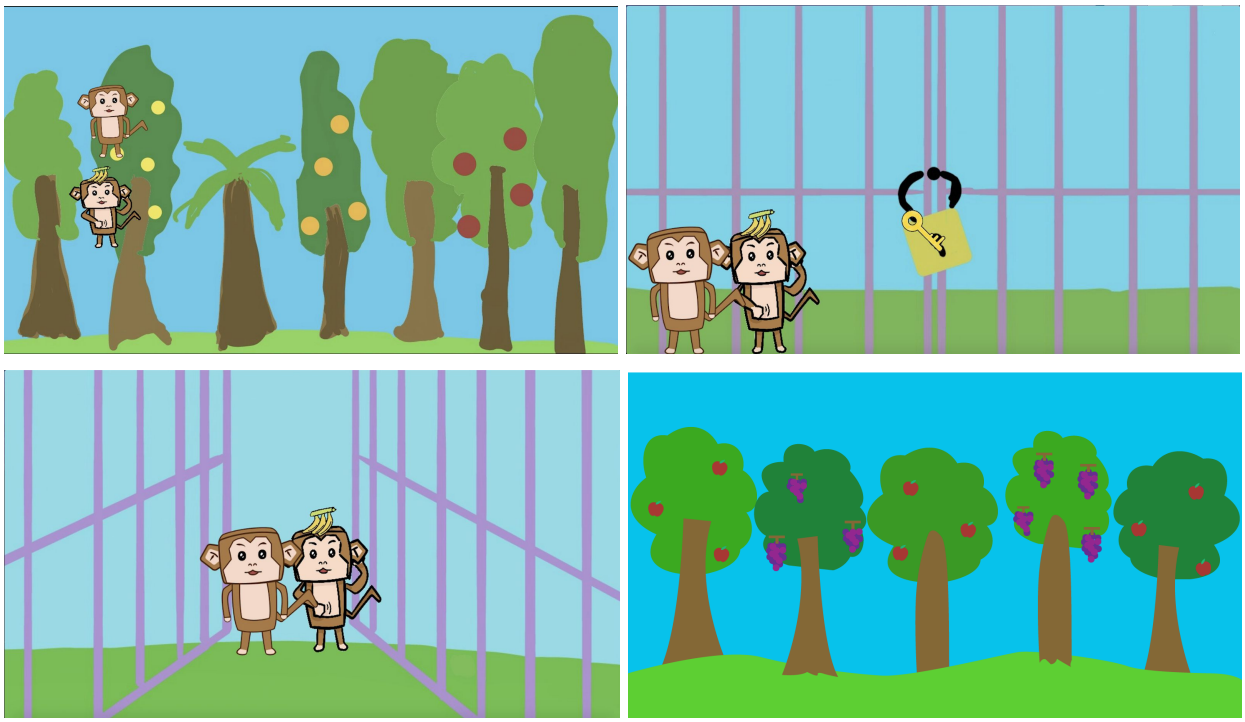

Fig 7. Screenshots of the game scene we created

Prototype 2.0

After the Internal Check we received advice that we should include more elements in the game to engage the students when they are waiting for their turn to play the game. We came up with the idea to include a progress map on screen which lets students know their progress in the game. We also drew characters other than monkeys e.g. penguins as having different animals completing their tasks in the game using their special skills can better present the concept of collaboration in the game, which assists the students in “collaborating “ with their friends.

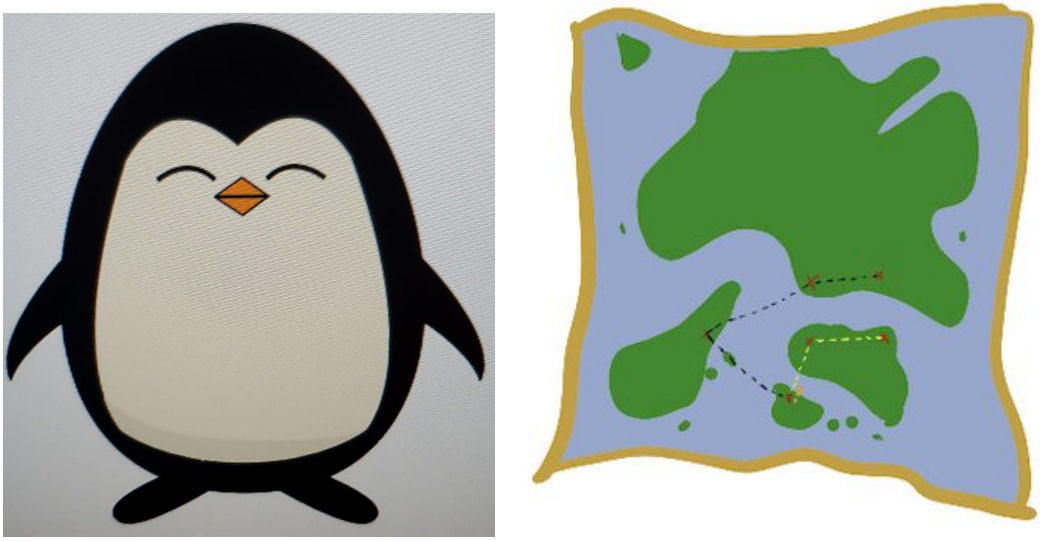

Fig 8. Preliminary animations

Prototype 3.0

After learning that zoos may be a vague concept for students to relate to (and animals escaping from the zoo might be a wrongdoings to students), we decided to drop the jungle theme for our game and instead use daily life scene in Hong Kong/items. The background of the game became travelling around Hong Kong with MTR to complete tasks in different districts, and we made animations of monkeys obtaining an octopus card and using it to get through the MTR gate.The reason why we chose MTR is because we were told that students are very excited when they get onto trains.

Fig 9. Screenshots of the animations

Prototype 4.0

We took into account the comments that students are more familiar with light rail instead of MTR, and started creating scenes that set in places around Caritas Lok Kan School. We visited Tin Shui Wai, Sham Shui Po and other places in Hong Kong to take photos that can be used as background for the game. On top of that, we designed a few more character designers as the teachers told us putting students' heads onto the animal body would be interesting and cute, which appeals to the students.

Fig 10. Screenshots of the animations

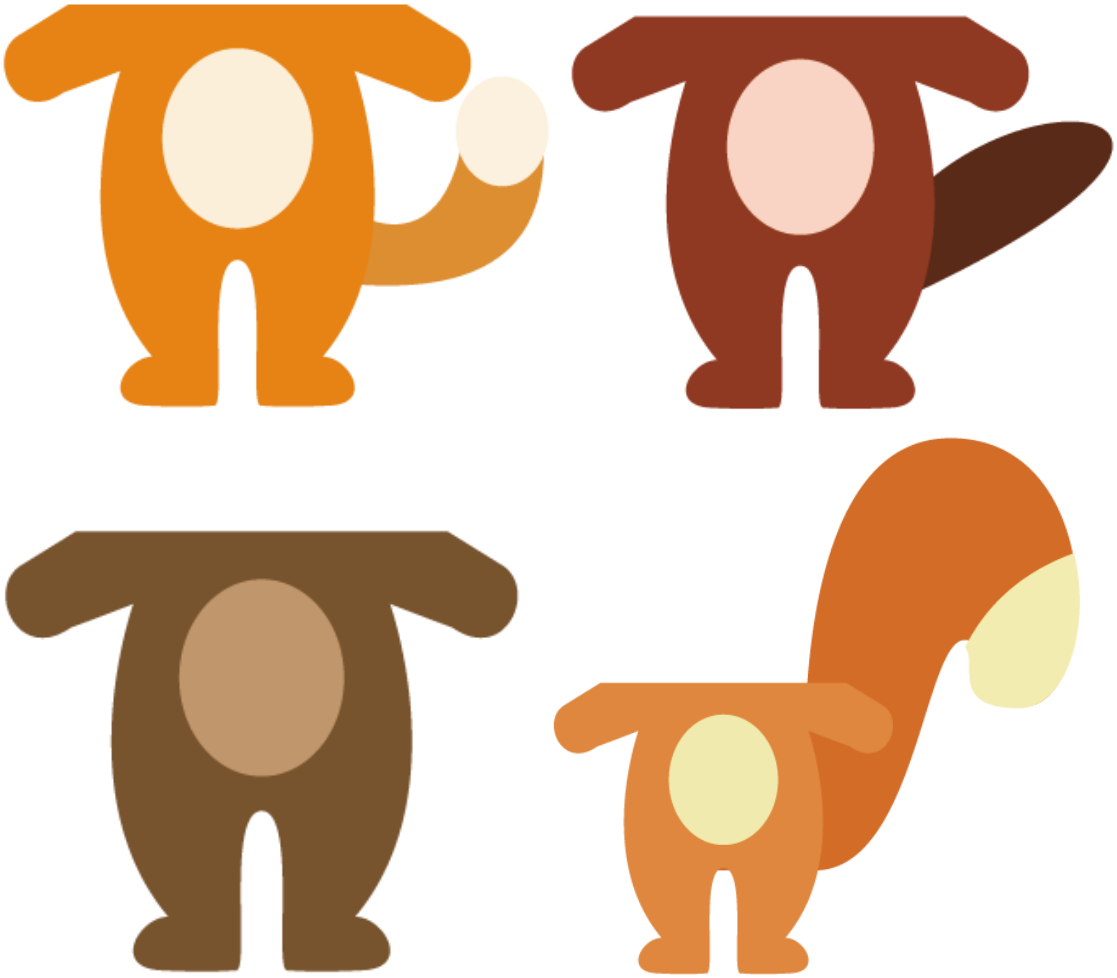

Fig 11. Character designs (animal bodies)

Final Product (current version on 21 May, 2020)

In the latest version of CollaBox, cartoon human bodies are used instead of animal bodies as teachers' final decision on design falls on human bodies, and we have attached two of our teammates' heads to the bodies to better showcase the visuals of the game. We created new human bodies designs as well as the map which shows students their location in the game. The new game background is: the characters are

going to visit the chinese teahouse for dim sum and they have to pick up students at other stations in order to have dim sum together. To better utilise Pepper, the robot the school owns, we also include an image of Pepper in the game for giving instructions to the students. As getting the audio output from Pepper would take a long time, we have done voiceover for it in the game.

One biggest challenge for our existing graphics is the aesthetic issue. We have not spent much time on polishing the game graphics so the existing version may not be as appealing as video games available on market, but we would do more studies on the use of colours and composition to improve our game graphics.

Fig 12. Screenshots of the animations

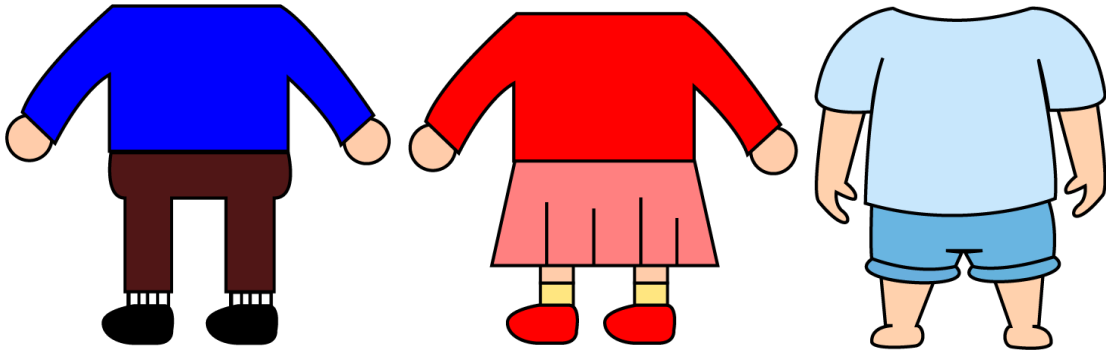

Fig 13. Character designs (human bodies)

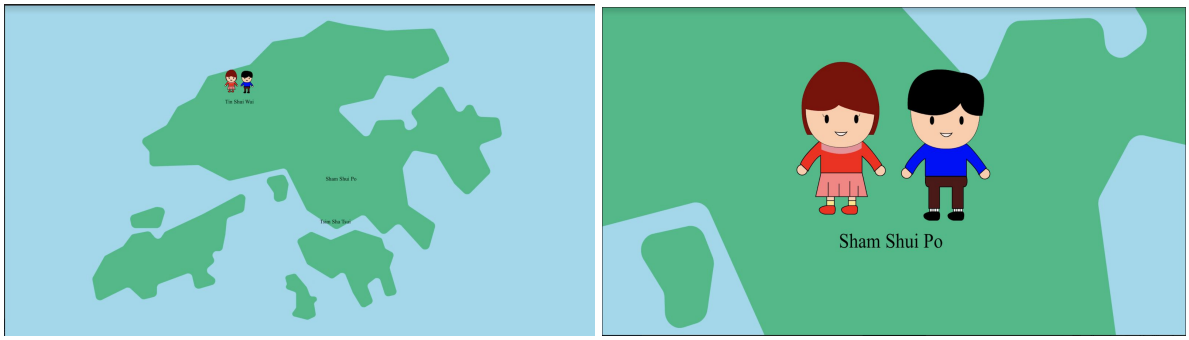

Fig 14. Progress map

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4. HARDWARE DEVELOPMENT

The hardware development includes technology used, the evolution and the final product of input device and Arduino Integrated Development Environment(IDE), a tailored input device holder InBox, and the tracks.

Technology and materials used

1. Open-source Arduino IDE for building and coding the console.
2. SolidWorks and Fusion 360 for 3D modeling.
3. Acrylonitrile Butadiene Styrene(ABS) as filament and Up Box for 3D printing.
4. Laser cutting for the track prototype.
5. Sanwa JLF Series Joystick for movement input
6. Button switches

Evolution : Input Devices and Arduino IDE

Prototype 1.0:

This prototype tested the use of Arduino IDE and ran simple code on digital inputs. A Push Button was used to simulate digital inputs and Arduino Layout. The Arduino Uno board was the first Arduino board used for CollaBox in hardware prototyping.

Prototype 2.0:

CollaBox decided to build on the Arduino board after successfully running multiple codes with inputs from a Sanwa JLF joystick. Joystick's user-friendly digital inputs simplified its communication with C# based game platform Unity. The Game code was modelled to read 5 inputs, of which 4 were directional inputs and the last was button input. The outputs were tested and displayed on the serial monitor.

Prototype 3.0:

CollaBoz finalised the number of inputs based on prototype 2.0. CollaBox had started exploring serial port communication. A simpler game for Serial port demonstration was used. Game's movement was simulated by joystick inputs.

CollaBox had been encountering the issue of time lag when producing movement across all Game objects. Even so, as Unity managed to open the serial port and process debugging, CollaBoz had proved that Unity could read inputs from the serial port and thus show potential for CollaBox Game.

Prototype 3.5:

Arduino code was modified to send dummy variables during standby to stop movement in the Game. Also, CollaBox had considered using board alternatives such as the Arduino Mega 2560 and Arduino Nano for the Final Product.

Prototype 4.0:

Unity - Arduino communication via serial port had been vastly improved. Arduino code was altered to fit the Game's design better. Moreover, serial port information was relayed to Unity. Altered codes and threading reduced time delay removed conflict among different objects in the Game when receiving information from the same serial port.

In this prototype, CollaBox was still using Touchpad or Mouse to select objects in the Game. Game works as intended with the joystick but not when built.

Prototype 5.0:

Sanwa OBSF-30 Button which wired and connected to the Arduino Uno board, was installed to the InBox and responded to simple demonstration code and generated output to the serial monitor. CollaBox will further develop buttons to adapt real game code command OnMouseDown in future prototypes.

Evolution: Joystick holder
Please refer to the "Console Design" folder under "Supporting Files" for the SolidWorks of the Joystick Holder.

Prototype 1.0
CollaBox designed the prototype two layers, which were named 'Lid' and 'Container' respectively. The prototype was objected to hosting one joystick and one Arduino circuit board only. The Lid and the Container were printed separately and can be attached and detached for joystick and board placement or maintenance. The dimension of the prototype was 140mm*120mm*50mm. Also CollaBox developed a button cap, which is in the Console Design folder.

Prototype 2.0
The prototype could host one Sanwa button and one breadboard additional to the joystick and the Arduino circuit board. The dimension of the prototype had been increased to 160mm* 130mm*50mm.

Prototype 2.1
The lid had two boss-extrudes on the bottom to lock the Lid on the Container.

Prototype 3.0
CollaBox added one layer additional to the first two layers of prototype 2.0. The third layer was named 'Base'. Epoxy would be applied to stick three plastic suction cups with the Base. The suction cups were arranged as an equilateral triangle for even force bearing and thus stabilization,

Prototype 3.1
The dimension of the 3D drawing of the prototype was increased as the space required to hold joysticks and the Arduino Board was undermined during the previous measurement.

Prototype 4.0(Roadshow)
The prototype had been closest to the joystick holder in the Roadshow in terms of appearance and functions. The previous printed Lid was found too small, and thus was enlarged to 160*140*5 and reprinted.

Prototype 4.1
M4 holes were hand drilled on the Container and the Base to hold the Arduino board with M3.5 holes.

However, after passing the M3 screws through the Container and the Base CollaBox realised that transition from Desk Mode to Relax Mode would be inconvenient as users would need to screw and unscrew the Arduino Board.

Therefore, CollaBox was going to test with M4 mounting on the Container and inverted

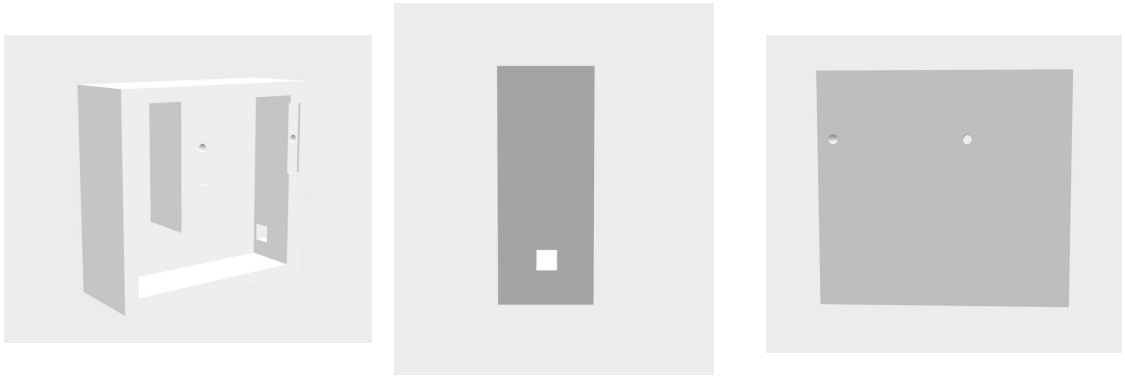


Fig 15.

Prototype 5.0

Prototype 5.0 was a drawing without the button, with a SolidWork assembly dimension of 105mm*150mm*75mm.

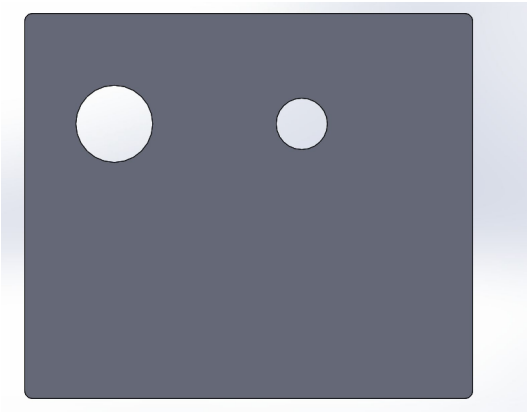
Prototype 5.0 was created during the three hour when the SLD files of previous prototypes which were saved on virtual were missing and the time when CollaBox was not deciding on whether to test the button with Caritas Lok Kan School students by May 18th,2020.

Since the files of the previous files were found later, and CollaBox decided to test the button, Prototype 5.0 was not printed at the end.

Prototype 6.0（most updated version by May 23rd, 2020 and was not yet printed)

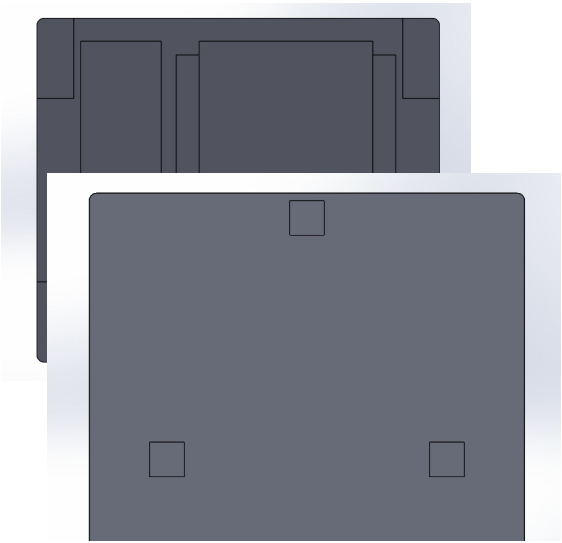
This prototype aimed at simplifying the connection and detachment process, and thus bringing convenience to the end users during change of modes, maintenance and storages.
CollaBox had thus eliminated the holes on Lid, the Container and the Base as screws and nuts were replaced by velcro, which would be applied at the four corners of the back of the Lid, both sides of the container, and both sides of the Base.

Update on the dimension:

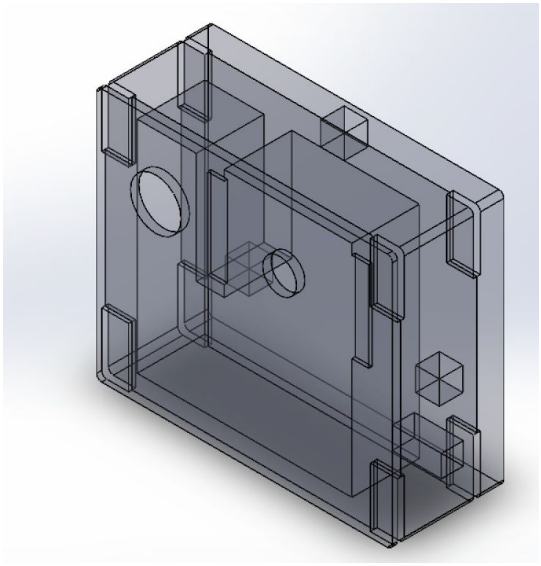


Lid:175mm*150mm*5m

Container: 175mm*150mm*45mm



Base: 175mm*150mm*16mm



Velcro **:** 35mm*16mm*2mm

Total: 175mm*150mm*66mm

Please refer to the Console Design folder for the details of SolidWorks.

Final Product and how it fits end users' need

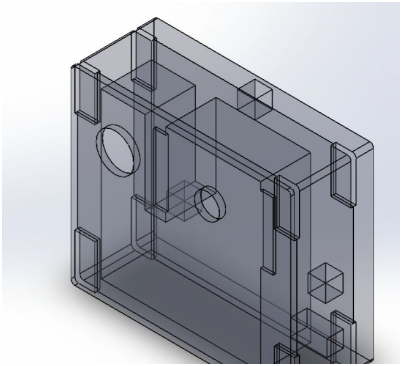
Each set of input device InBox included one joystick holder, which hosted one Arduino Uno board, one Sanwa JLF-TP-8YT-joystick , and one Sanwa OBSF-30 button.

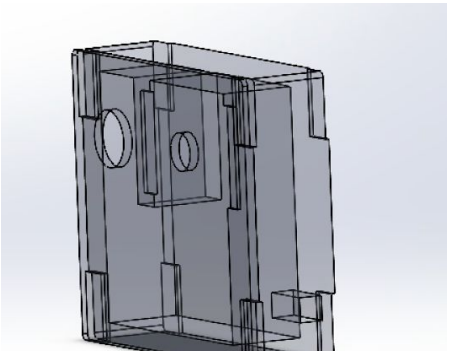
The Arduino Uno had 4 digital inputs running through to signify each direction and sent a dummy variable to stop the object selected.

Serial port information varied from system to system so has to be programmed into the unity game code. Unity utilized threads to manage different objects reading the serial port information. On unity, there was virtually no lag between input and object movement. Build settings needed to be troubleshooted.

The joystick acted as the only input device at the time of writing. The joystick had been optimised in length with a shaft extender and ball-shaped grip to support easier movement for students who have more physical challenges. The traditional joystick board design has been reduced to one button, thus reducing the number of inputs players need to work with to play the game. The dimension of the final product was 175mm*150mm*66mm.

The joystick holder could be switched between 'Desk Mode' and 'Relax Mode'. The Desk Mode contained three layers, which were the Lid, the Container and the Base(as shown)The Relax Mode contained two layers, which were the Lid and the Container(as shown). Users could easily switch Modes as layers were attached by velcro.





CollaBox had considered safety as the first priority. The enclosed design avoided users from tripping. Except one necessary USB wire connecting the laptop was exposed in the air, the wirings were stored inside the holder. Another advantage of the enclosed design was little exposure to air also reduces damage to the joystick and the boards due to dust or liquid.

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5. REWARDS AND OTHER GAME ELEMENTS

Technology and materials used
We have used toy trains and tracks, cardboard, plywood and plastic boards specifically for the rewards while Photoshop and Premiere Pro are used for both rewards and other game elements.

Evolution (tangible rewards)
Version 1.0
CollaBox's reward mechanism is divided into three groups, including individual, pair and group basis to reward students for finishing their game. In our first proposed idea, individual rewards are stickers of different train components like the train heads and windows. Pair rewards is colouring the train track we prepare in advance and the group reward is combining and running the train on the tracks.

Version 2.0
After discussion with different advisors and teachers from the school, we modified the rewards for individuals and pairs. For individual rewards it becomes stickers of things that students are fond of, while the pair rewards is assembling train tracks instead of colouring the tracks.

Although not many amendments are made to the whole reward mechanism, we have been putting effort in improving the train and train tracks. Initially we bought the light rail toy trains from MTR store and other

toy trains from IKEA, and combined them using magnet. We also applied skin to the Ikea toy trains using cardboard to “make” the look like the light rail trains.

As for tracks, because the width of the wheel of the light rail trains is different from the IKEA ones, so we added a slide shaft at the bottom of each of the Ikea trains and let it guide the trains when being put on the track. With this design feature, all we need for the track is just a line with depth on any surface. We began trying different materials for the tracks e.g. plastic board, cardboard and plywood, and turned out cardboard was relatively better out of the three options. Yet, we did not manage to run the trains smoothly on the cardboard tracks so we abandoned these ideas afterwards.

Fig 16. Toy trains we bought from MTR and IKEA

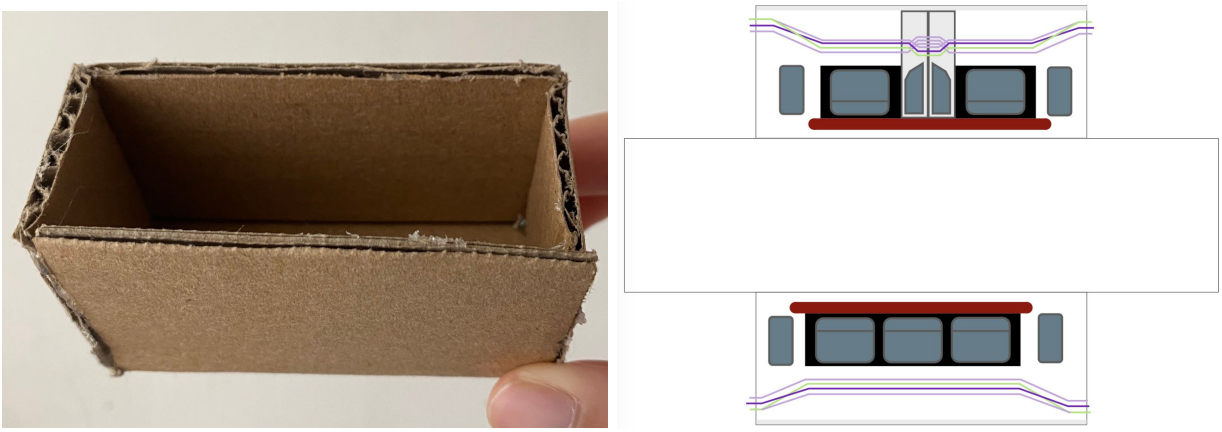

Fig 17. Cardboard and design made for the “light rail train skin”

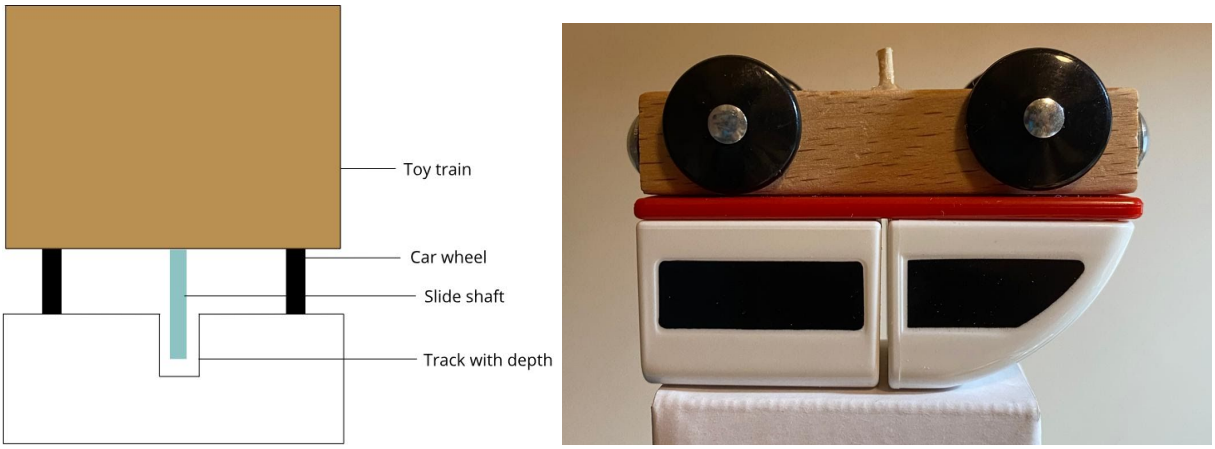

Fig 18. How the slide shaft works

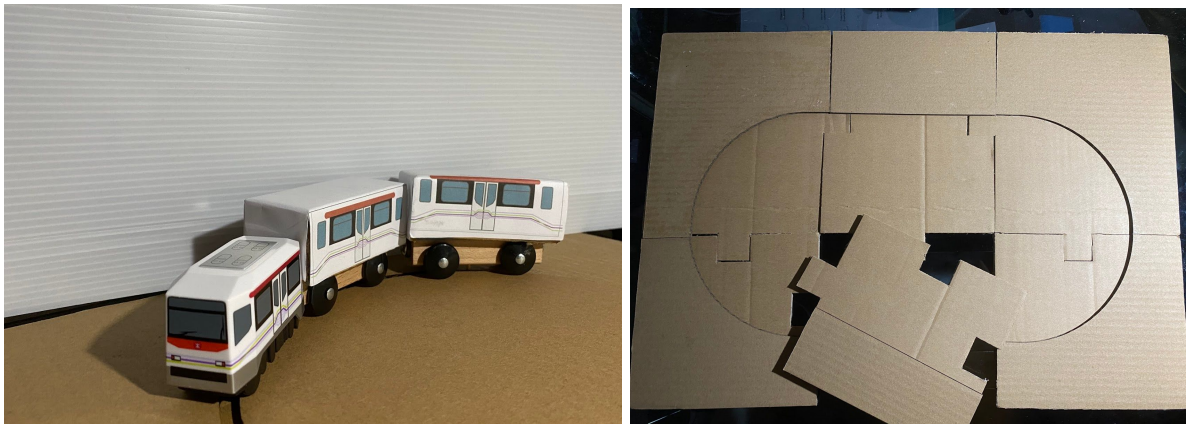

Fig 19. Complete toy trains with tracks

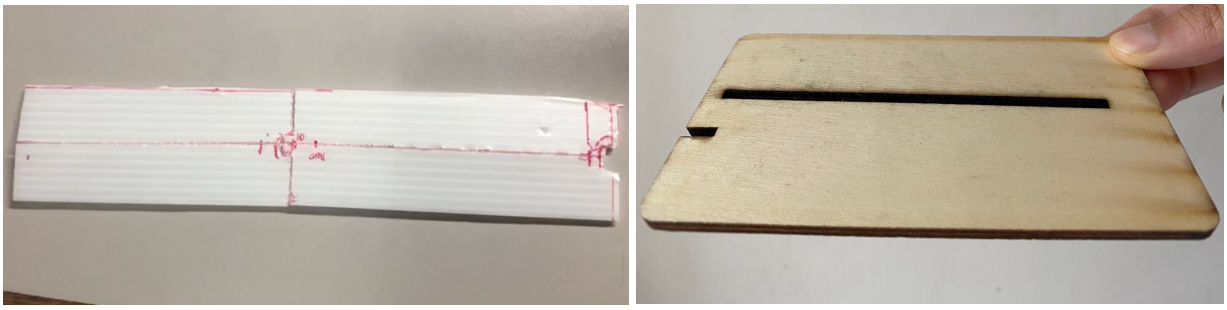

Fig 20. Plastic board and plywood track prototype

Final Product (current version on 21 May, 2020)

Tangible rewards

Stickers of trains or characters students like are kept for individual rewards, while the pair rewards is modified to optimise to the classroom settings where students will be testing the game in June: the pair of students will be assembling train tracks until they reach the area where the next pair of students are sitting, assuming they are sitting at a straight line. The group reward would still be combining the train compartments and running the whole train on the track.

Fig 21. The trains and train tracks we bought from TaoBao

Intangible rewards

For every correct matching pair a student creates, he/she will be rewarded a virtual golden star, and when he/she completes his/her own side of the game, he/she will obtain half of the octopus card (as mentioned in the Game Development part). When the pair of students complete their game, their halves of the octopus card will combine to form a real octopus card, and the students would use it to travel to another place and pick up other students.

Other game elements: slideshow

To engage students who are queuing for the game, we have created a slideshow which shows photos of places where the students would be visiting in the game. Students can make use of this chance to explore different parts of Hong Kong. Our teammates are the photographers of those photos as this minimises any possible copyright issue. The slideshow is expected to be shown on a projector in the classroom so that all students would be able to enjoy it.

Fig 22. Screenshots of the photo slideshow

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6. Users' Feedback

CollaBox had been constantly communicating with Caritas Lok Kan School. Since November 2019, CollaBox has been collecting users' feedback, updating project progress, and exchanging opinions mainly

with Caritas Lok Kan School's teacher Miss Grace Kwong by emailing, campus visiting, Google Hangouts and Zoom Meeting. CollaBox had conducted a game test with young children aged from 3 to 6 for a simulation by March 30th, 2020. Details may be referred to supplementary document First Internal Check: Users' Feedback:
https://docs.google.com/document/d/1tKucsLT2DGrifjrzYiNPOdQFT-WDYhLmNnL05w6dijQ/edit

Feedback from Lok Kan has been collected for a variety of elements. For the input device, except the necessary USB wire connected to the laptop, CollaBox had wires all included in the InBox to protect end users from the tripping concern. CollaBox also provided two InBox modes: Desk Mode and Relax Mode, which allowed students with different physical needs or levels in terms of arm extension and muscle power to control the input device with comfort. CollaBox also had prepared a detailed user manual, in both Chinese Language and English Language, and an interactive tutorial session for students to understand and familiare with the use of joystick and button.

For the game format and content, CollaBox switched from consecutive clicking to dragging images as the students might have trouble understanding the concept of matching things by clicking. We also brainstormed question types with the teachers, and came up with ideas such as clothes to body parts, whole fruit and cut fruit, and types of food to shops (eg. hamburgers to McDonald's). We also decided to use change scene buttons instead of automatic jumps, according to their preferences.

In terms of graphics and the storyline, the theme of light rail trains has been chosen as the teachers mentioned that the students were very interested in the light rail trains. Apart from this, the goal is set to be dining in chinese teahouse as the teachers pointed out students love having dim sum. CollaBox also switched from using animals as characters to using photos of the students together with cartoon human bodies, as the teachers found human bodies more relatable to students. Most background in CollaBox are photos of the actual scenes as teachers agreed that photos would be a better representation of the places instead of manually-drawn pictures.

As for the reward mechanism, CollaBox switched from using stickers related to trains to stickers of characters that students like as the teachers told us students are delighted with stickers. Originally CollaBox was also stuck between whether having toy trains or assembly wall for the pair and group reward, but after considering the complexity and the monetary output which are also the users' concern, trains and tracks are selected eventually.

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7. Evaluation of Final Product

The final version has gone through a series of iterations that make our product specifically cater to the interests and abilities of students at Lok Kan school. The game is also able to engage students outside of school hours without less manpower required compared to traditional classroom teaching. Students will also be able to engage in collaborative games, encouraged to collaborate with a shared outcome. The game also provides an opportunity for students to make connections of facilities and objects around them.

Students will be able to benefit from the local setting of the game. The spirit of "travelling" also enriches students' life experiences, as they might not have many chances for so due to their disabilities.

However, CollaBox does have a few limitations. It is uncertain whether the students from the lower ability class could benefit from the game, and this would be one of the directions for further development. The current model also only features one laptop in use, which would mean that there would be waiting time for other students. The team will try to incorporate multiple device communication later. Currently our tangible reward mechanism is also heavily reliant on the facilitator. We acknowledge that this is rather inevitable for safety reasons, but we will look at alternatives.

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8. Implementation

8.1 Big goals for the coming months

- School visit by team members to try out the full game with students (probably in June)
- Open up multiplayer function in the matching game that allows different pairs of students to play simultaneously (publisher-subscriber model)
- Have two forms of output (one on laptop screen and one on projector) within the same Unity programme, to display the progress map and increase engagement
- Sync the Unity programme with Question Bank where we store questions of different categories, so that teachers can select the question types they want for the matching game
- Modify the game to make it suitable for students of relatively lower ability

8.2 Timeline

TIMELINE

This coming week

- Return the laptop back to Caritas Lok Kan School
- Send the controllers, train, tracks and user manual to the school for user pilot test
- Collect feedback from the students and teachers after the test

June (after examination)

- Improve the product according to feedback from the school
- Develop more levels for the game (different themes for matching game, more places to visit, diversed difficulties for the matching game)
- Further polish the UI (give complete set of animations, take photos around Hong Kong. animate the chatacter movement)
- Decide the ideation for reward mechanism (the allocation of reward, proof of logic)
- Complete the whole game with every part linked (animations, matching game, reward mechanism)

Early July

- Send the complete set of game to the school for user testing (most ideal situation: our team can test the game with the students in Lok Kan directly)
- Open multiplayer option
- Have two seperate output for the same unity code (one on laptop, one on screen in classroom)
- (Optimise the game to suit classroom environment if we can visit the school)

Mid-July

- Investigate on the incorporation of PEPPER into the game (feasibility, man power required, control panel)
- Design possible output on the classroom screen other than progress map and photo slide show
- Improve product according to user feedback

Early August

(we are not sure if any student will be staying in dormitry in summer)

- Design avatar for every student in Lok Kan (or the students with higher ability first)
- Add options in the game starting scene for avatar selection (choose specific avatar when a particular student is playing)
- Add options to select total number of players and number of levels

Mid-August

- Develop more game levels for question bank
- Rabdomise the questions played in the matching bank (connection with question bank)

September

(uncertainties exist and there may be change on team members working on the project)

- User test with the school and improvement on product
- Constant updates for game levels
- Use themes that are more extraordinary (e.g. Amazon rainforest) for the game

October

- Start working on games that would cater the lower ability group of students (simplify the matching game we are having/consider other types on games maybe on iPad)
- Continuous contribution to the question bank

This is the end of the Final Report.