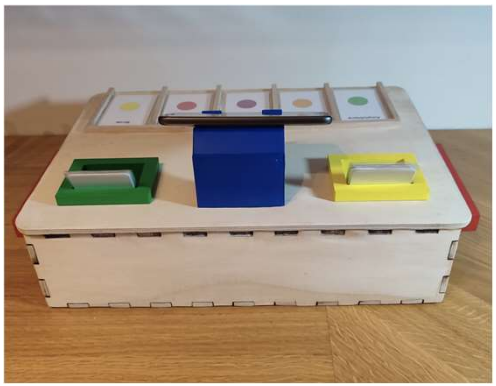
Design & Technology NEA Portfolio



Candidate Number:

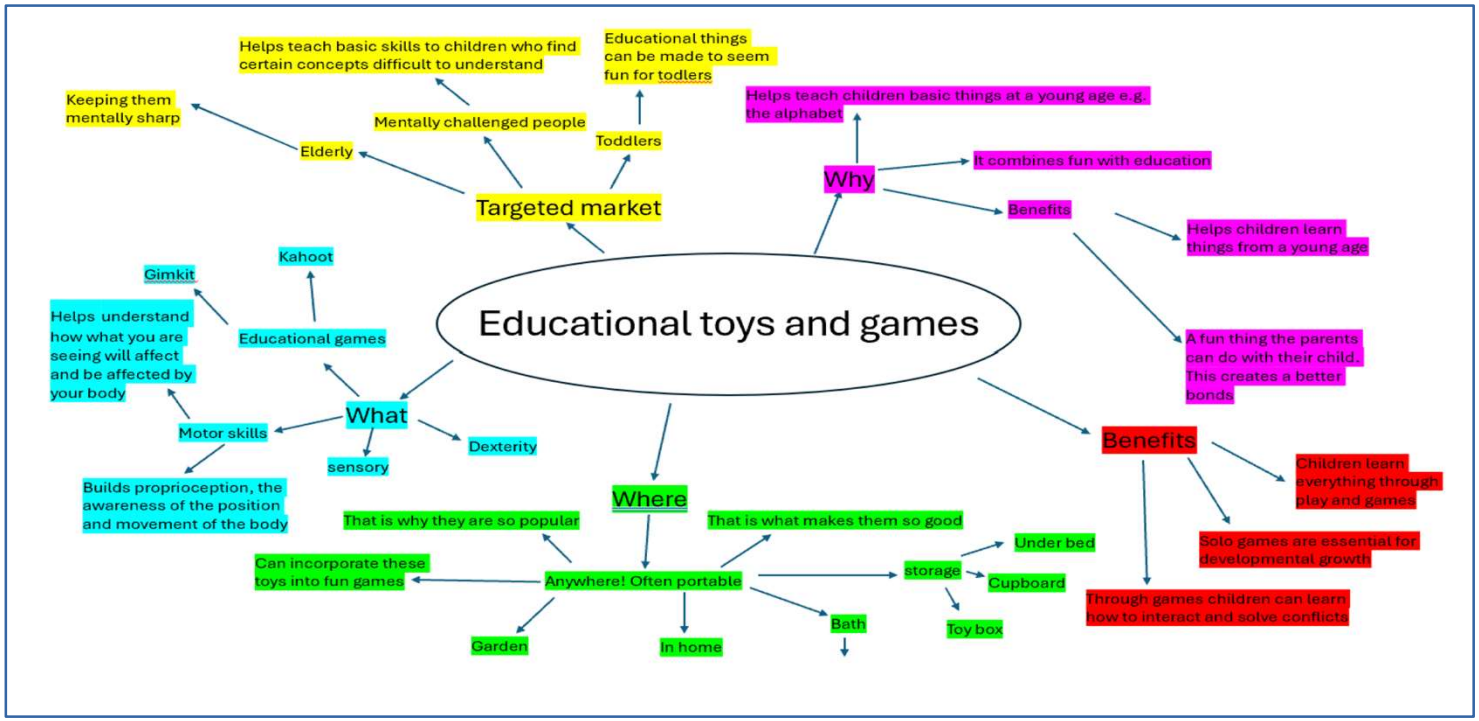
Centre Number:

1. Context

Chosen context: Educational Toys and Games

Why I chose the contextual challenge

- My next-door neighbour is a retired school teacher. I thought that she would have some really good ideas about the types of educational toys that weren't available and that she would be an enthusiastic client. (When I asked her she was!).
- I think it would be exciting to try and design and make a toy which doesn't exist on the market today
- This contextual challenge has a lot of scope. For example, the type of toy / game, age group, whether it is aimed at a group with specialist needs, the types of materials that could be used in construction, etc.



Design Opportunity 1

- A lot of toys and games only have a single purpose. This means that the toy / game only has one level of difficulty, only focusses on a certain type of question or topic, etc. and that it may quickly become redundant. Research shows that by the **age of 5**, a child will have owned **190** toys! This is far more than I would have estimated.
- An opportunity that I thought of therefore was a toy that has more that this one 'single purpose'. For example, extending a wooden sorting toy to add different types of animals. Being able to add to a game extends its lifetime and usefulness and reduces its impact on the environment.

Design Opportunity 2

- Some educational toys provide feedback whereas others don't. For example, a shape sorter provides instant feedback - you will know because the shape will either fit or not fit the hole. Whereas with a maths calculator game, where you chose the input numbers, does not provide feedback without an adult's help. This means that you will not know whether the answer is right or wrong.
- The opportunity is a game that provides feedback on whether you got the answer right or wrong as well as telling you some background information on the topic, e.g. how a maths problem is solved.

Design Opportunity 3

- Some toys are physical games that are made out of wood or plastic whereas some games are fully digital meaning that that they are all played on electronic devices. Both types have their benefits.
- The opportunity is to make a physical game that has digital elements and allows children to interact with technology. Because it is physical it can test things such as dexterity and motor skills. The digital aspects enrich the toy through sound, video etc. Research shows that children play with interactive toys on average for **10 mins longer** in a session than non-interactive toys.

2. Client Profile and Needs

In this section, I will focus on who the client is and what their job is. I will also be asking a series of questions to do with educational toys and which ones have proven to be the most useful when teaching and which ones they were lacking.

Name:
Family: Husband
Job: Teacher
Age: 60+
Lifestyle: Retired
Hobbies: Arts and Crafts (Painting)
Working Location: N/A

Q1. What school did you work at?
"I have worked at a number of schools, including... and .. Infants School, but I spent the most time working in a Montessori school."

Q2. What is a Montessori school?
"It's a type of school where the focus is on hands-on learning."

Q3. What was your role there?
"I have had a number of roles during my years of teaching including a directress and a lecturer."

Q4. What age of children did you teach?
"I focused on teaching nursery, aged 2-5, but also taught children aged 5-7."

Q5. Which types of educational toys did you use as a teacher?
"When I was teaching, we taught concepts in multiple stages. An example is using a spoon to pick up marbles out of a container and putting them in another container. The next stage would be something that needs more precision, for example using a screwdriver on a screw or operating a pair of tweezers."

Q6. Which educational toys did you find useful as a teacher and why?
"Colourful wooden blocks with letters on them were particularly useful. for example, given a picture of a pig, the child would then have to find the letter blocks with the phonetic alphabet. As teachers we particularly liked toys which went from concrete to abstract ideas – this gives young children a lot to think about."

Q7. Is there anything special about Montessori toys?
"Yes, absolutely. All Montessori toys are designed to support learning and play at the same time. They are generally very hands-on as well as this is a crucial part of the Montessori teaching method".

Q8. Can you give me examples of educational toys the school was lacking?
"I would say helping children understand money in today's world. Previously, I would use coins to teach the concept of money, but the world is starting to become all digital and the use of cash is starting to die. Another example is teaching the children that the earth is round but when it is taught in school it is represented as flat e.g. map. Another example I can think of is teaching about mechanisms. For example, understanding what the different parts of a car engine do."

Q9. What type of educational toys did the children particularly enjoy?
"Wooden ones, such as wooden blocks. The children preferred this over Duplo as wooden blocks were more versatile, and you could put them anywhere whereas in Duplo all of the pieces have to connect. When we introduced Duplo to the classroom we found that the children still preferred the original wooden blocks. It gives them more opportunities to be creative and to explore ideas."

Q10. What things would you like to see in the product I am making and why?
"A toy that enables further learning or reinforcing something they have already learned."

Q11. What would you like the children to learn in the educational toy that I will be making?
"I personally think that an educational toy that could teach children about real world concepts would be a great thing to base a toy on. For example digital money or contactless payment."

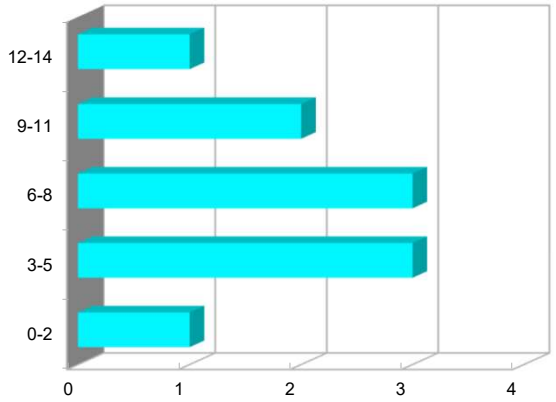
Summary of Client Needs

- Toy or game that can reinforce existing knowledge and also allow the child to learn new concepts.
- Help the child to learn in multiple stages (increasing difficulty).
- Brightly coloured, made of wood.
- Should teach the child about real-world concepts.
- Suitable for either nursery or 5-7 age group.
- Teach about technology that is used in the real world.
- Toy must support play and learn at the same time.
- Ideally would be a toy which is currently lacking or unavailable in the market.

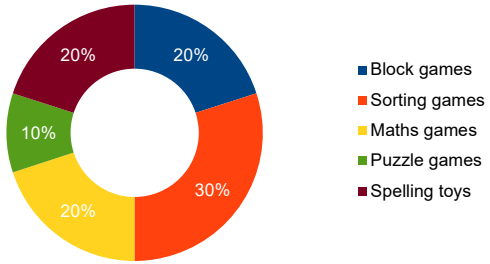
3. Survey

As well as interviewing my client I decided to interview the parents of young children to get their opinions on educational toys. I created a survey consisting of 6 questions and asked these questions to 10 parents. I have presented the results below as a set of graphs.

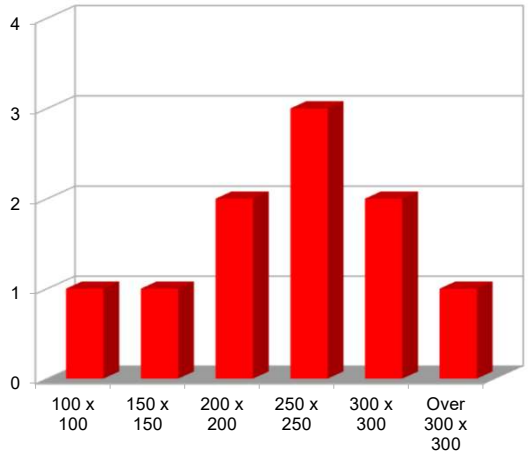
How many educational toys do you buy a year on average?



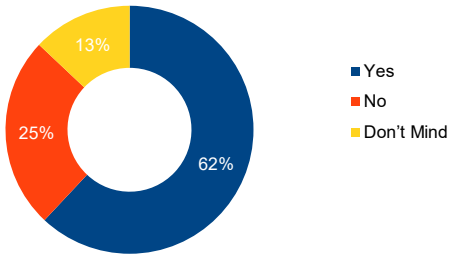
What is your child's favourite type of educational toy?



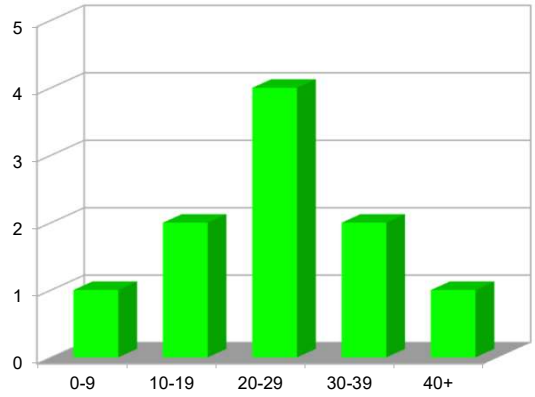
What should be the maximum size for an educational toy (width x height)?



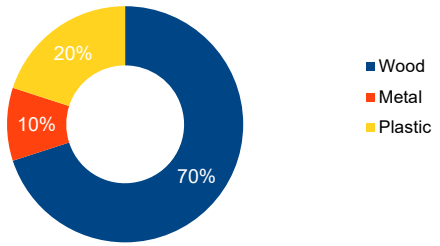
Is it important that educational toys teach children about the real world?



What is the most you would spend on an educational toy?



What is your preferred material for an eductional toy?



My research highlighted that parents overall prefer wooden toys, sized at around 250mm x 250mm. The average amount parents are willing to spend on a toy is £20 - £29 and most buy between 3 and 8 such toys a year. Sorting and maths games were amongst the most popular.

4. Work of Others

I decided to investigate the work of two companies (Alessi and The Soft Brick Company) as I thought they may provide inspiration for my designs. Alessi is an Italian design company that specialises in homeware and kitchenware. It is known for its innovative designs. The Soft Brick Company is a UK company that makes soft play areas for children. It achieves this using a range of colours, shapes and textures.

Alessi





Feature	Comments
Aesthetics	Alessi is known best for its innovative designs. Many of its designs contain humourous, cartoon faces and a mixture of primary and secondary colours. They also use a variety of different materials and textures. Alessi ultimately takes products that already exist and makes them more aesthetically appealing.
Cost	Expensive to buy (this is because limited numbers of each item are often made). The original retail price for the Philippe Starck juice squeezer was £80 and an original is now selling for upwards of £1000!! Many people now make copies of it due to the rarity of the item.
Customer	Alessi produces lots of different types of items, however they generally focus on kitchenware and homeware. Their products are also for people who are looking for a more creative version of a product that already exists and are willing to pay the premium.
Environment	Alessi focuses heavily on using recycled materials where possible. This means that they are as environmentally friendly as possible with the products that they produce.
Size	Their products vary in size depending on the role of the item is. The 'citrus squeezer', for example, is tall and thin so you can put your glass under it (and ultimately get your juice). A smaller product sold by Alessi would be the egg cup & spoon which is the perfect size to rest an egg.
Safety	All of Alessi's products do not have any toxic chemicals in the plastic / materials used to make their products. This means that there is no risk of inhaling / touching anything harmful that could make you ill etc.
Function	Alessi focuses on homeware and kitchenware therefore each product has a different function. It is important to note that Alessi focuses as much on the aesthetics of their products as how they actually function. This is therefore the reason why the people who buy Alessi products often display them rather than use them.
Materials	Alessi products are generally made out of recycled plastic. Some items however feature stainless steel for blades etc.

The Soft Brick Company





Feature	Comments
Aesthetics	The company creates play equipment that is very colourful and contains images of animals, faces, nature etc. The colours that the company uses are primary meaning that they are bold and striking.
Cost	The company sells full playsets but also individual parts (meaning you could make your own). Neither of these options are particularly affordable though (a 10 piece brick kit is £270!!!).
Customer	The customer of the toy will vary as the equipment could be used in a school environment, at home and in a garden centre. This means that the potential customer could be a teacher, parent or garden centre owner. The user of the toy however would always be a child.
Environment	The company uses recycled foam within their play sets. They also use recycled plastic to make the balls in the ball pit. Overall, the company is as environmetally friendly as possible.
Size	The company sells a variety of different sized playsets from a very large one (for garden centre play areas) to a small one (for in a bedroom). They also sell individual parts if you only want to buy a specific type of block, pit etc.
Safety	Their products are very safe as everything is made out of foam and has a soft spongy outer coating. The outer coating is also really easy to clean and therefore protects the child from catching germs. For the outer coating no harful chemicals are applied to the exterior so when the child plays/ teethes with certain objects they do not fall ill.
Function	The play areas made by the company only have one purpose, which is to entertain the child. The company does this well by including stackable items, foam animals and lots of different contrasting colours.
Materials	Their play area is primarily made from foam and a smooth outer surface. Their are also small amounts of plastic (eg the balls in the ball pit).

I will use the work of Alessi and The Soft Brick Company to inform my design. In particular, I will implement Alessi's use of colour and creativity. I like their items that contain two or three colours as I found that they were the most visually appealing. I also liked Alessi's use of faces and nature in their designs, so I may try and implement some into my design. Finally, I also like 'The Soft Brick Company's use of shapes, particularly the mixture of angular and rounded edges. I will aim to use these principles to inform my design also.

5. Product Analysis

I studied 6 different educational toys to understand the types of toys that are out there and the features they have. I have used ACCESSFM to analyse these products

	Talking Flashcards (Secondary research)	Tree labelling toy (Primary research)	Picture, object, word match (Primary research)
			
Aesthetic	Very colourful. Cute and easy to understand pictures. Lightweight due to plastic material.	Not particularly colourful. Heavy to hold. Nice wooden texture. Pattern of a tree painted on the wood.	Multiple colours, children are drawn towards games with animals. Light, plastic cards. Sharp edges, so not nice to hold. Smooth texture.
Cost	£12.99	£5.75	Free. The cards were hand-made by a teacher.
Customer	Parents will buy for children to use.	Adults or teachers will buy for any age group.	Parents or teachers will buy for young infants.
Environment	The reader is made out of plastic which is not great for the environment.	Wooden. It is a very durable toy meaning that due to its materials should last a long time.	Sheets of paper laminated in plastic. This would be better for the environment if it were to be done virtually.
Size	The reader measures 100mm x 90mm.	The jigsaw measures 240mm x 240mm.	80mm x 100mm.
Safety	Large with soft corners so no safety issues.	Cards have sharp edges so may possibly lead to cuts.	Small object so could ingest. Cards have sharp edges so may possibly lead to cuts.
Function	How to pronounce the name of the thing in the picture. The child inserts a card and the device tells you what the card is and something about the object.	The toy on the left is a jigsaw to show which parts of a tree go where. The toy on the right is a game that points to a certain part of a tree and you must name that point.	This is a game where you have to match the photo or model to the word on the card.
Materials	The reader is plastic. The cards are made of cardboard.	The jigsaw is made of birch plywood and the cards are made of cardboard.	Cardboard (laminated) and ceramic
Positives ✅	A toy you can use on your own, instead of needing to ask someone how to pronounce a word. I like the fact that it is good value and comes with a large number of cards for the child to play with. Being able to hear the noise the item makes (e.g. animal) is also great to help with learning.	Strong board – made out of wood. Will not break easily. I think that one of the strengths of this game is it is actually two games in one – a jigsaw and a card game which tells you more about parts of a tree. Putting these two games together should extend the game's life for a child.	Progressive levels – first learn how to pronounce letter. Then learn how to pronounce the word. The learn which photo matches each word. Then learn how to pronounce each word. I like the fact that this game can be put together cheaply – that means it will be accessible to a wide audience.
Negatives ❌	Does not look particularly strong meaning that the client may need to buy more than one eventually. I don't like the fact that It is not possible to add additional cards. I think this will limit the lifetime of the toy. It is also not possible to use the toy for a range of age groups.	Strength + Storage. The stubs on the tree jigsaw may snap off. The cards may get bent or lost as they do not have any sort of container. Compared to other toys and games I have looked at, the aesthetics are poor – the colours are muted and may not appeal to a young child.	Difficult to store – the pieces of paper could get lost easily. It is hard to store without having a separate box for the cards. Because it is hand made this game doesn't look particularly professional – I prefer the aesthetics of some of the commercial games I have reviewed.

5. Product Analysis

	Wooden shape sorter (Secondary research)	Montessori sorting toy (Secondary Research)	Kid's Payment terminal (Secondary Research)
			
Aesthetic	Colourful. Animals in games interest children. Magnetism was also meant to interest children. Wooden texture.	Colourful, heavy, wooden texture. Rounded corners on the box.	Made out of plastic, light, feels cheap, not particularly colourful.
Cost	£4.99	£12.97	£15.78
Customer	Parent or teacher buying for child.	Parent or teacher buying for child.	Parent or teacher buying for child.
Environment	Wooden, durable. Recyclable No plastic parts – good for the environment.	Wooden, strongly built, will last a long time. Recyclable. No plastic parts – good for the environment.	Made of plastic, my crack if dropped by a young child.
Size	210mm x 100mm	290mm x 100mm x 70mm	110mm x 80mm x 50mm
Safety	Small pieces could get ingested.	No hazards as pieces are large.	Large object so no hazards.
Function	2 games - magnet fishing and chosing the correct shape the fit over the hole.	One game is to match the shape to the hole. The other game is to match the colour.	Insert a list card at the top of the machine. Number you have to pay comes up. You then insert your card and pin.
Materials	Wood	Wood	Plastic, with electronic components.
Positives ✅	Multiple games within the board – magnet fishing, hole matcher. I like the fact that this game tells the chlid immediately whether they are right or wrong (the holes in the pieces will either fit or not). That means they can learn on their own. The shapes that come with this toy look quite thick so they could probably also be used for building and stacking. That would extend the lifetime of the toy. At £4.99 this toy is very good value.	2 stages – match the shape to the hole then colour matching. Contains a box so none of the pieces get lost. I like fact that this toy includes the names of the shapes. That means the child can learn about the shape, what it is called and how it is spelled. The natural wood, use of colour and contoured shapes means this toy embodies the Montessori design principles.	Represents a real-world transaction. The card machine looks like a real one and you can tap or insert your card to pay, like on a real one. This is getting the child use to what they will see in the real world. This toy could be used in a variety of different games, e.g. a shopping game where one child is the customer and the other child is the shopkeeper Has the contactless symbol on the side. This is a useful addition as it features in shops all over the world.
Negatives ❌	This toy contains lots of small parts. I think it could really be improved if it came with a wooden storage box to keep the parts together and prevent them from getting lost There is nothing in the game which tells the child the name of the shapes they are manipulating – I think that would be an area of the design to improve.	Generic concept – been seen and made before. This toy doesn't have any handles to it may be awkward to carry araound. It also appears to have a sliding lid which may fall out. It is a shame that it cannot be extended to sorting other types of items.	Does not stand alone as a toy. To turn it into a game you would need to add items that they can purchase etc to make it more interesting. I think this toy could be improved if it came with a storage box for the machine and the additional parts (credit cards, etc) Plastic – may look out of place in a Montessori environment.

6. Social and economic impact

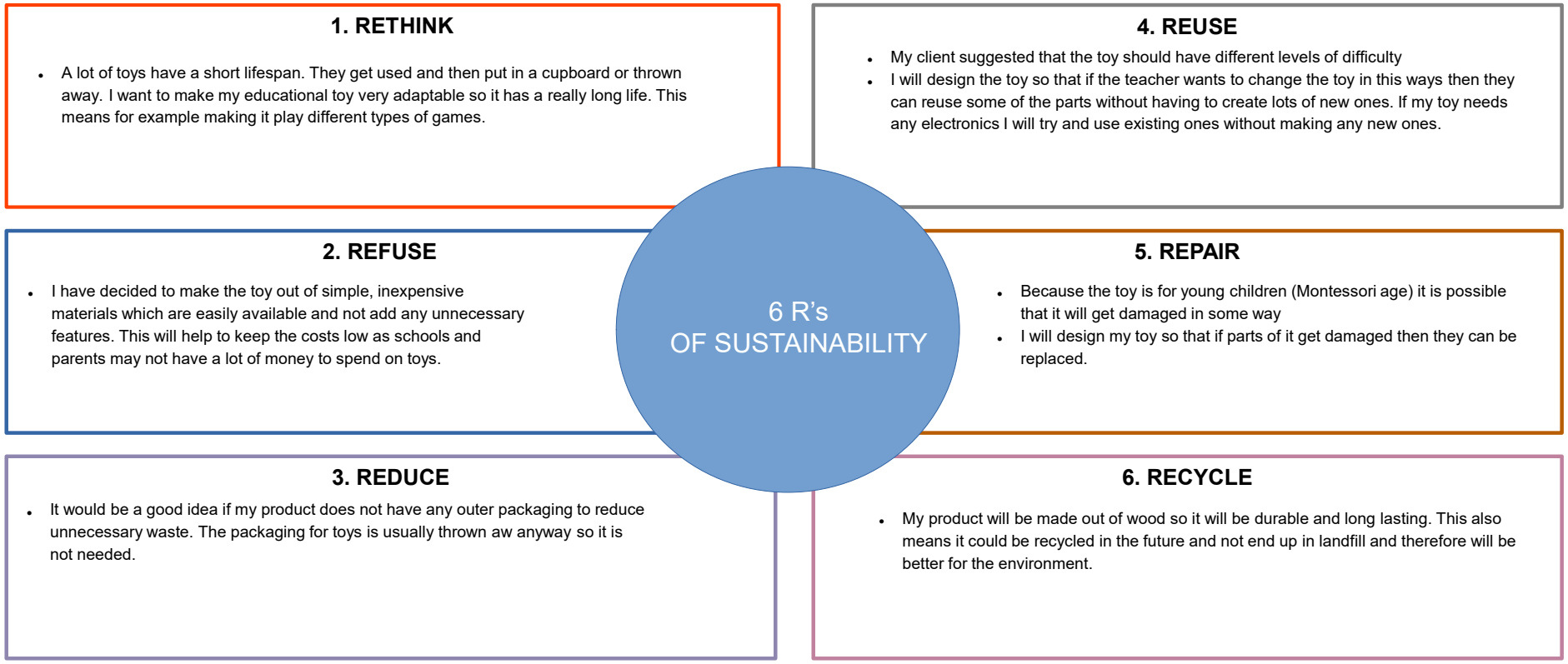
On this page I will be explaining the ways in which my product would have an impact socially and economically.

Social Impact

- My toy will impact society in a very positive way by helping children to develop a variety of different skills. This includes dexterity, cognitive, motor skills as well as their ability to understand concepts in the real world. These concepts will depend on exactly which design I choose.
- My toy will also encourage social interactions as it will be possible to use it alone or with a teacher / parent / guardian. This will help the child to bond and form relationships as they are using the toy.
- The toy I choose to build will be highly educational in nature and will bridge the gap between play and learning. Depending on the design I choose, this will help the child develop skills such as literacy, numeracy and thinking / reasoning.

Economic Impact

- I plan to design a toy which addresses the 6 R's (see below). There is a growing demand nowadays for toys which are eco-friendly and sustainable as people better understand how their choices affect the planet.
- One of my goals is to build a toy which is highly innovative. Ideally I would like to create an educational toy which addresses gaps in the market and could be manufactured and sold worldwide. Creating a new type of toy would help the economy in lots of ways, e.g. jobs in manufacturing, sales and distribution.
- As part of my research I wanted to understand how much people earn on average and how much more expensive life has become. This is important because parents and schools may not be able to buy toys if they are too expensive.
  - Average income for a family in the UK is £35,000 (Office of National Statistics).
  - Total inflation over the last 5 years is over 20%. This is significantly higher than the previous 5 years.
  - On average UK households spend £4.90 a week on toys, games and hobbies. This is approximately £255 a year.



7. Design Brief and Specification

Overview

- There aren't enough educational toys that reinforce real world ideas such as the Water Cycle which is taught in Geography lessons. My aim is to create a unique product which teaches children new skills in imaginative ways, can have different levels of difficulty and will introduce children to technology in the real world. This requirements are based on what I learned during my client interview.

Target Audience

- Young children and parents.
- Parents who want to follow 'Montessori' teaching techniques.
- Schools and nurseries.

Budget

- I will aim to keep my product as affordable as possible. I want to sell my product for £30. I would like a profit margin of 50% on each product that is produced.

Deliverables

- By the end of this project I will produce the following deliverables:
  - Final working prototype.
  - Final isometric drawing.
  - Final orthographic drawings.
  - Project plan and workshop storyboard.

Specification

Code	Category	Specification Point (requirement)	Justification
AS1	Aesthetics	The product will be colourful.	Children are more interested to play with the colourful toys than plain monochrome toys. These toys tend to use very bold primary and secondary colours. This is particularly true with very young children who find bright colours appealing.
AS2	Aesthetics	Should have a similar look and feel to other Montessori toys	Simple vs complex. Use natural materials (e.g. wood, fabric, cloth and glass). Visually appealing and welcoming. Use texture and shapes to capture a child's imagination. This is important as the toy should not look out of place in the typical Montessori classroom.
CO1	Cost	The cost of my product will be £30.	The toys that I have looked at, without any electronic features, ranged from free (making them yourself) to £12. The toys with electronic elements often cost more money and the electronic products I looked at were roughly priced at £20-30. I am planning on incorporating some electronic elements into my game therefore I will price my toy around the £30 mark.

7. Design Specification

Code	Category	Specification Point (requirement)	Justification
CO2	Cost	Once the product has been purchased there shouldn't be a need to buy other parts	It should be possible for a teacher or parent to extend the toy without having to buy any new parts. They might be able to do this, for example, by printing their own elements. This is very important as it will help to extend the lifetime of the toy.
CU1	Customer	My target market is schools and parents. The user of the product however would be children up to 7 years old	My client explained that the age range for Montessori toys is between nursery age and 7. It should be possible to change the toy so it can be used for different age groups. This is particularly importaant is it means it will not be necessary to buy different toys for different age groups – instead buy one toy and customise it. This saves on cost (fewer toys to buy) as well as storage space.
EN1	Environment	The toy should have recyclable elements	The toy should be made out of recyclable materials so it doesn't end up in landfill. This is important as the toy should not negatively impact the environment.
EN2	Environment	The toy should not have any unnecessary outer packaging	This will help to reduce environmental impact. External packaging is not needed as the toy will be safely stored in a classroom or cupboard at home.
SZ1	Size	No larger than 400mm x 400mm, No smaller than 150mm x 150mm	It has to be big enough for the child to use but it has to be small enough to be portable and to be stored. This is important for storage but also usability for the child. If it is too small they may struggle to manipulate it; if it is too large they may not be able to pick it up and move it around. This will discourage them from playing with it.
SF1	Surface treatments	Rounded corners and no coatings containing harmful chemicals.	Rounded corners mean that there are no opportunities to cut yourself. Because younger children put everything in their mouth I will not be adding any surface treatments that could be dangerous for a child.
FN1	Function	They toy will incorporate electronic elements	I will do this as it makes the toy more engaging to young children. This means that I could use audio, video and lights. These features must serve a purpose though and not be a novelty. I will be doing this because research shows that toys with interactive elements can hold a child's attention for longer than those without.
FN2	Function	Offers different levels of difficulty	Different levels of difficulty means that it will work with more age groups and it will also make it possible to change the difficulty level for a particular age group. This means that the teacher can easily adjust the toy without having to buy lots of toys for different age groups.
FN3	Function	Teaches real world concept	The toy should cement / reinforce real world concepts. My client said that this is something Montessori schools do and this is important to the way they teach. All Montessori toys are designed with an educational element – this is an important part of their philosophy.
FN4	Function	Provides feedback	The toy should provide feedback so that the child can learn on their own, i.e. without a parent or a teacher. This should mean the toy will get more use as the child will not need to wait for an adult to help them.
FN5	Function	The joints and build must be strong	May be used in rough environments so may be dropped, thrown and stood on. The product needs to be strong enough to withstand this treatment. Making the product robust means avoiding having to buy a replacement (this will save money and reduce waste).
FN6	Function	The game can be added to and extended	This means that the child will not need so many toys and have multiples games within this one toy. This is good because it means that it will not take up as much space in the classroom or at home.
FN7	Function	Parts can be replaced if damaged	If you can replace parts of the toy that have broken it will extend the lifetime of the toy. Again, this means fewer toys been thrown away which reduces the environmental impact.
FN8	Function	Be easy to clean	Because my toy is aimed at younger children it should be easy to clean. Being easy to clean should also make it more hygenic and minimise germs.
MA1	Material	The toy will be made out of wood.	Wood means that the toy will be durable and will last a long time. Plastic toys can be more flimsy and often easily snap and break more often. Ergonomics - Wood also feels nicer in your hand than other materials and often the corners are rounded meaning that there are no sharp edges on the toy. By making it in wood this means that it will be good for the environment due to its long life.

8. Design Ideas

Design 1 – Musical blocks

In this design the child can make lots of different sounds using different instrument blocks. The child gets a set of these blocks and can then chose one or more to put on the board. They then press play to hear all of the instruments being played as a song (FN3). They can then add/ remove blocks to hear how the tune changes

Inspiration: In this toy some of the blocks make noises and some of them don't. In this example you cannot put them together to play together. This makes them very limited.

Inspiration: I took inspiration from this toy because it is quite versatile and has multiple games within one toy.

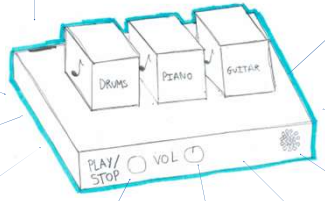
2 games: Building pictures + singing

Need all 4 blocks in place to play a nursery rhyme

speakers

Hinge - so you can store the blocks underneath

Could add handle to make more portable



Board identifies blocks as they are placed on it

Comes with a variety of other instrument blocks

Plays all blocks that are placed on the board

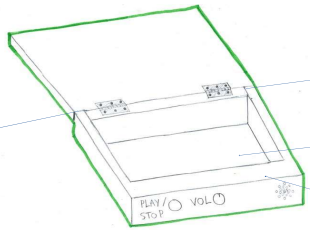
Speaker to play the sounds of the musical instruments

Make attractive by using bold colours (AS1) and instrument pictures on blocks

Play/stop button to start and stop the music

Volume adjusting dial

You could even have a speed up/ slow down knob here



Recessed to accommodate the hinge

Storage for the music blocks

Game lid has two hinges

Compartment so you can store electronics

Design 2 – Interactive jigsaw

This idea is based on a jigsaw however instead of just having one background there are multiple you can chose from. You can do this by taking out the printed background and sliding a different background into the frame. The child then places pieces in the right place on the jigsaw. Speakers in the build will then say whether the piece is in the right place or not.

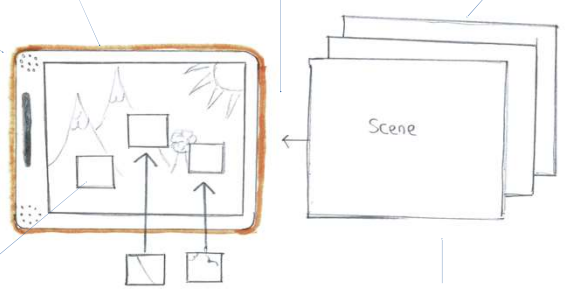
Inspiration: I took inspiration from this toy because it allowed the child the change the jigsaw background. It also has a speaker so it can tell you about the pictures (FN4). It is quite limited though because it only has two backgrounds and you cannot make your own.

Chunky wooden frame suitable for a child's hands (SF1, MA1)

Scene inserted at the side

Multiple different scene sheets are provided and new ones can be printed and added (CO2, FN3, FN6, FN7)

Speakers for providing feedback



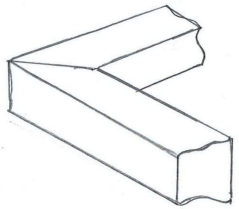
Handle for the board so it can be easily transported

Need to determine how secure pieces in place. Magnets?

Puzzle pieces being placed on the board

Scene cards would need to be laminated to make them durable and last a long time

mitre joint



I have chosen to use a mitre joint for this toy as it is visually appealing. It will look a bit like picture frame. Need to think about whether it will be strong enough (FN5)

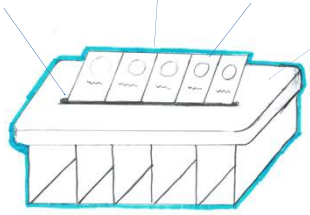
8. Design Ideas

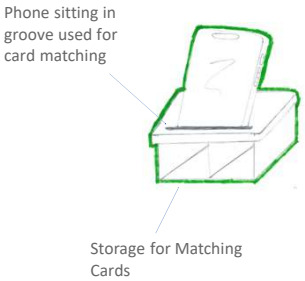
Design 3 – Interactive card matching

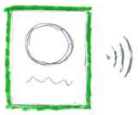
This game is like a traditional matching box but it has an interactive element. It consists of matching cards, category cards, a phone stand and a matching box. It also requires the use of a mobile phone. The idea is to take a Matching Card and place it in the box under the correct Category Card. If you do not know you can tap the Matching Card on the back of the phone and that tells you the category it corresponds to (FN2, FN3, FN4). The phone plays a video to tell you more about the item you are matching.

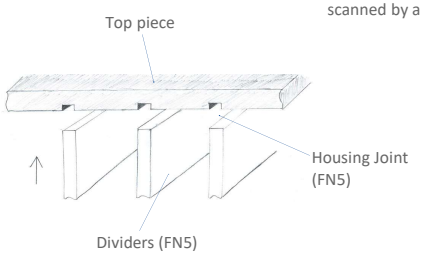
Inspiration: Good example of a traditional sorting box. Can be used to sort colours or shapes.

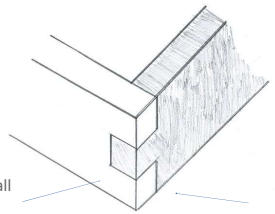
Inspiration: This toy can read cards and play a corresponding sound. It uses barcodes







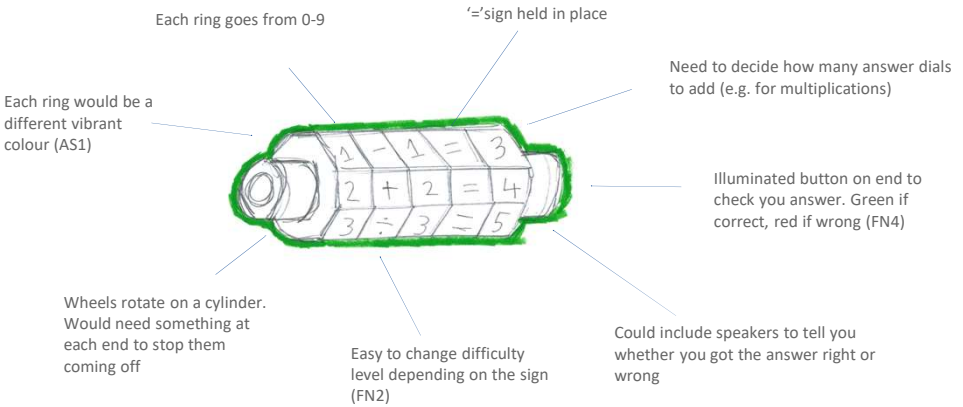




Design 4 – Interactive maths toy

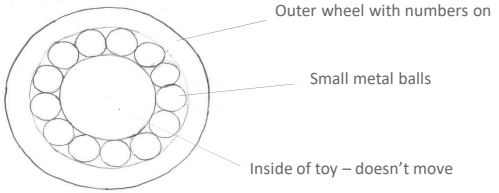
In this game the child rotates the wheels to input a sum. They then set the answer using the wheels on the right. There are already some games like this on the market but they generally only do add and subtract and don't give any feedback. In my version the game would light up to tell you whether you got the answer right or wrong.

Inspiration: I got my inspiration from this toy. It's very cheap and basic though. The wood looks rough, the numbers are printed cheaply and it has no colours at all. Also, the child does not know whether they got the answer right unless they ask a teacher.



The toy would also come with cards with sums on that you have to input and solve. The stacks of cards would be categorised into easy, medium and hard. This would allow you to answer questions that are gradually more and more advanced.It would also work for different age groups that way.

A ball bearing would allow the wheels on this toy to move smoothly and easily. It will improve the ergonomics



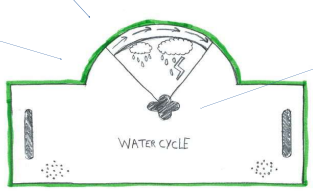
8. Design Ideas

Design 5 – Water cycle wheel

This toy is designed to teach children about the water cycle (FN3) which is a topic that is taught in geography. The water cycle demonstrates how water comes from the sky, enters lakes and rivers and then ends up in the sky again via evaporation.

Inspiration: This basic wooden jigsaw depicts the water cycle but it is static so may not engage a child for very long

Inspiration: This paper model was built by someone on YouTube. You can turn it to see the water cycle stages. Because it is paper it would be very flimsy



Arrows show which direction the wheel can be turned

You turn the wheel in the direction of the arrow. Each time it clicks you see a different part of the water cycle

Uses a **ratchet** mechanism so the wheel stops at the right place

Dial to turn wheel

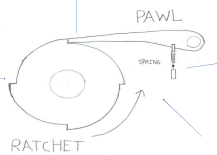
This toy would have handles so it could be easily transported

The main toy would be made out of natural wood (not painted) but the water cycle pictures would be bright and colourful (AS1, AS2)

This is another interactive design so it would have speakers to talk to you about each part of the water cycle

You can increase the number of notches to increase the number of stops the wheel would make

Stops the wheel rolling back



Spring applies pressure downwards on the pawl

Job is to make it click over once and then stop until the wheel is turned again

Design 6 – Smart Home

This educational toy teaches children about the concept of a smart home. Part of my client's brief was to teach children about the real world (FN3). My toy would involve a miniature sized house and would have cutaway walls to show what happens when you press the different buttons on the control panel. I believe this is a very innovative solution – I haven't seen a toy like this in the shops.

Inspiration: I took inspiration from this toy because it has different rooms, figures and moveable furniture in it. However, it is very basic and doesn't have any electronic elements.

Carry handle

Model representation of a house

Brickwork effect adds realism

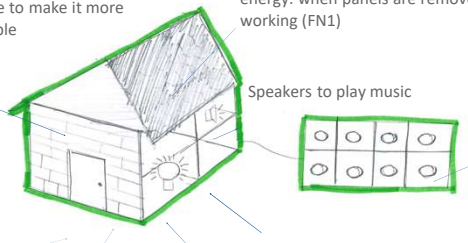
Bold primary and secondary colours, appealing to children

Bolts for self-assembly

Exposed natural wood

Lots of cutaways so the child can see and move things inside of the house

Making a larger version of this toy with interactive parts would be more interesting to a young child



Think about adding a handle to make it more portable

Solar panels to show energy source – teaches about renewable energy. when panels are removed, smart home functions stop working (FN1)

Sensor switches light on if movement outside when dark

Speakers to play music

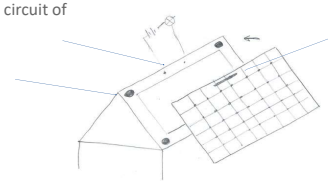
Board with all of the different buttons to operate functions such as lighting, sound, alarm, etc

Door – makes noise if the alarm is set

lighting

Cutaway so you can see inside

Brickwork to look like a real house



Contacts for circuit of house

Removal solar panels are attached to frame using magnets

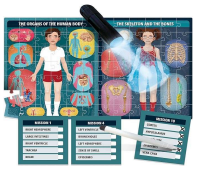
Metal strip on solar panels acts like a switch to complete circuit for house. Removing the panel turns off the smart home

8. Design Ideas

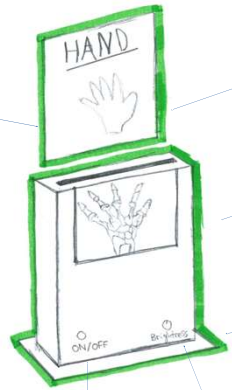
Design 7 – X-ray machine toy

In this toy the child has a set of cards representing parts of the human body (FN3). They place these in the scanner so they can see what the bones look like in the hand, leg, etc.

Inspiration: This toy has cards showing parts of the body that have been x-rayed. There are only four cards though and you can't see what the body parts look like before they have been x-rayed.



Inspiration: This game is a jigsaw of the human body but also allows the child to x-ray the body using a special torch



Picture card pushed into slot. Top of card sticks out so it can be removed

Picture card of body part to scan (e.g. hand). Either use chip or barcode

Small electronic screen to show x-ray picture

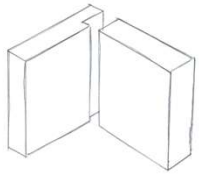
Picture cards are scannable. Small computer inside the scanner reads the card and displays the corresponding x-ray picture on a screen (FN1)

Sturdy wooden base prevents the scanner from toppling over

Can be extended by making new picture cards and putting new x-ray images on the scanner's computer (CO2, FN2, FN6)

Switches on / off like a real x-ray machine

Control brightness of screen like real x-ray machine



Rabbet joint

Corners of x-ray toy could be held together using a Rabbet joint. It is strong and visually appealing (FN5)

Side panel

Design 8 – Air traffic control toy

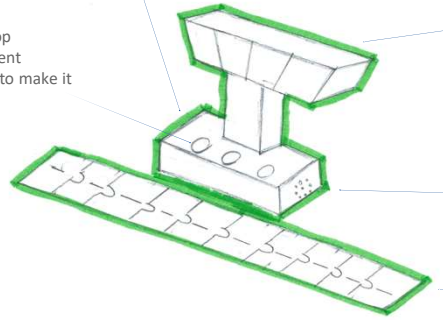
This toy is a wooden air traffic control tower and a take off and landing strip (FN3). The idea is that the child presses a button on the control tower and it gives the child instructions about how to fly the plane. For example, it can tell them to take-off, land, do a loop, etc. It could also tell them how they are flying, tell them to avoid objects, etc.

Inspiration: Both these toys are wooden models of an airport. They are made of natural wood and are brightly coloured. They are quite limited though because they only come with one plane and don't have any electronic elements.

USB slot for adding new sounds (FN1)

Made out of natural wood with some brightly coloured parts (AS1, AS2, MA1)

Buttons to start and stop instructions. Play different instructions at random to make it more interesting

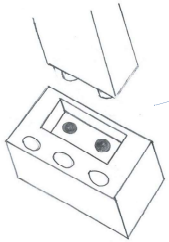


Wooden air traffic control tower

Speaker for listening to instructions

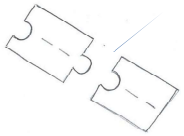
Runway Made as jigsaw pieces for easy storage

This toy would work with any existing toy planes in the classroom so I wouldn't create any new ones as that would be unnecessary and wasteful. (CO2)



Dowel joints hold air traffic control toy together for strength (FN5)

Base of air traffic control toy



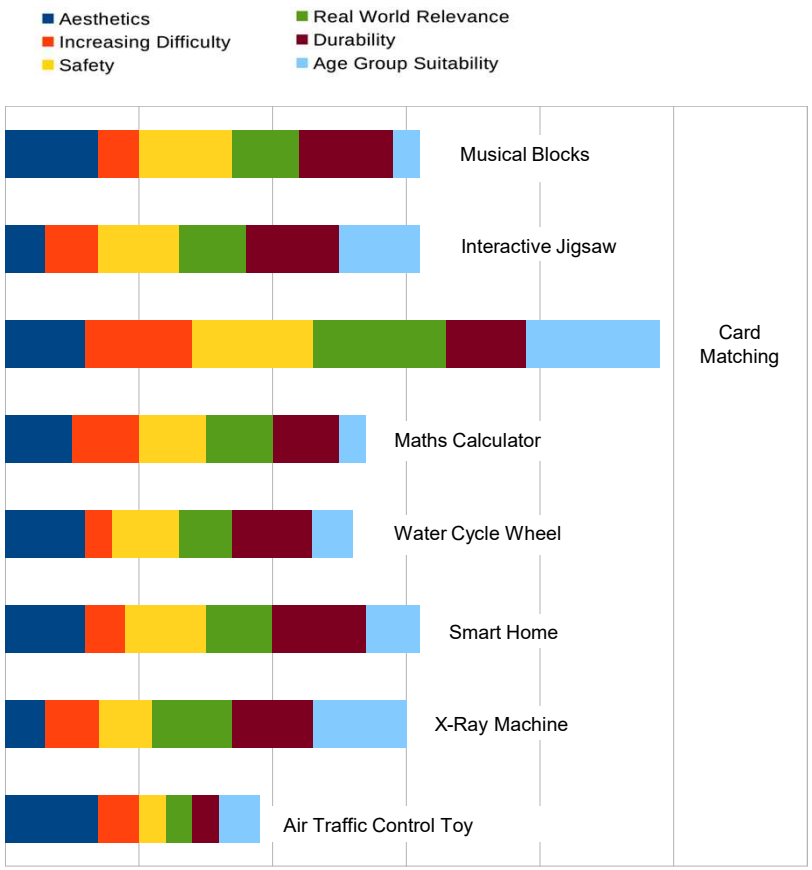
Tab

Runway pieces can be disassembled for easy storage

9. Design Ideas – Client Feedback

I discussed my design ideas with my client and asked her to score each one based on a set of criteria – the results of this are presented below in a bar graph and also in a table. My client provided a lot of constructive feedback and came up with a number of comments and suggestions which I hadn't thought of. She also provided me with detailed comments on each aspect of all my designs but I haven't included them here as I felt a summary was more useful.

Design	Aesthetics	Increasing difficulty	Safety	Real world relevance	Durability	Age group suitability	Overall score and comments
Design #1 Musical Blocks	7/10	3/10	7/10	5/10	7/10	2/10	31/60 Could be colourful and quirky; teaches how a song is arranged Limited scope and stages of difficulty Could cause chaos if all kids doing the same in the classroom!
Design #2 Interactive Jigsaw	3/10	4/10	6/10	5/10	7/10	6/10	31/60 Backdrops could reflect real world situations Effectively just a virtual jigsaw. How to make the design more interesting?
Design #3 Interactive Card Matching	6/10	8/10	9/10	10/10	6/10	10/10	49/60 Self-correcting toy; can handle lots of topics; multiple age groups Perhaps need to make the design more interesting. Drawers?
Design #4 Interactive Maths Calculator	5/10	5/10	5/10	5/10	5/10	2/10	27/60 Similar solutions exist in the market place so perhaps not as creative as some of the other ideas
Design #5 Water Cycle Wheel	6/10	2/10	5/10	4/10	6/10	3/10	26/60 Innovative - not really a product out there like it Limited scope. How to add other cycles? (e.g. butterfly)
Design #6 Smart Home	6/10	3/10	6/10	5/10	7/10	4/10	31/60 Looks appealing; can teach children about solar power Difficult to make look different to a regular dolls house
Design #7 X-ray Machine	3/10	4/10	4/10	6/10	6/10	7/10	30/60 Could teach a range of ages with different levels of difficulty Looks quite robust Short lived in learning
Design #8 Air Traffic Control Toy	7/10	3/10	2/10	2/10	2/10	3/10	19/60 Unique and appealing design No levels of difficulty Durable? Runway tab pieces might snap? Where do you store the runway pieces when not in use?



Summary

I will be going ahead with Design 3 – Interactive Card Matching. Both my client and I came to this conclusion for a number of reasons:

- it will be able to teach a wide range of concepts.
- it is self-correcting which means that the child does not need rely on a teacher to adult to aid their learning.
- it can be used to target a wide range of age groups.
- it can teach real world concepts.

My client also suggested that I could improve this idea by making the design more interesting and visually appealing – I will investigate this in the following pages. I will talk to my client again when I have refined the design to see what she thinks.

10. Research – Card Scanning

In my design for the Interactive Card Matching toy, I had the idea that the child would be able to scan a card using a phone and then decide which category the card belongs to. In this section I have recorded the research I did into the different ways I can use technology to achieve this. I looked at QR Codes, barcodes and NFC tags.

QR Codes

A QR code is a 2D barcode that stores information in a grid of black and white pixels.They are typically scanned using a smartphone or a camera. People use QR codes for lots of different things, e.g. advertising, marketing, product information, etc.

Barcodes

A barcode is an image made of vertical lines which can be read by a smartphone or a special scanner. Like QR codes, they contain information (e.g. about a product). Barcodes are commonly found on goods in the shops such as supermarkets.

NFC Tags

NFC tags are small chips that can store and transmit data wirelessly. NFC stands for Near Field Communication. NFC tags have lots of uses including contactless payment and hotel room keys.

Initial Testing

I decided to test scanning QR Codes, Barcodes and NFC Tags on my smartphone to understand how they work. I also wanted to understand the key differences and similarities between these approaches.

Approach
For my testing I used two different Android apps: 'QR and Barcode scanner' and 'Tasker'. ('Tasker' was for testing the NFC cards). I printed out QR and barcodes from the internet.

Type	Observations
QR code	• Compatible with phone – scanned ok. • Had to ensure the phone was a suitable distance away from the QR code before the scanner was able to read it. With the phone on the stand if was difficult to get the QR code in front of the camera. • Probably too slow and fiddly for a children's toy • Cards would need QR codes printed on them which would make them less appealing to children.
Barcode	• Compatible with phone – scanned ok. • Had to ensure the phone was a suitable distance away from the barcode before the scanner was able to read it. Same behaviour as QR code. • Probably too slow and fiddly for a children's toy • Cards would need barcodes printed on them which would make them less appealing to children.
NFC tag	• Compatible with phone – scanned ok. • Able to read with a simple tap – more straightforward than QR codes and barcodes. • No issues trying to manoeuvre the card in front of the phone as NFC doesn't use the phone's camera • Need to ensure you tap the NFC card at top of the phone – this is where the reader is.

Further testing - NFC Cards

I decided to run some tests with different types of NFC tags (credit card, coin, sticker) to confirm that they worked ok with my phone. I have recorded the results in the table below.

Type	Image	Observations
Credit card size		• Compatible with phone – scanned ok. • Scanned reliably when held close to the phone. Occasionally needed a second attempt to get the phone to recognise the card.
Coin size		• Compatible with phone – scanned ok. • Quite often would need a second or third attempt to get the tag to scan. I did some research and discovered that this can be the case with the smaller tags.
Sticker		• Compatible with phone – scanned ok. • Same behaviour as coin tags (above).

Scanning - Conclusion

My tests with the NFC tags were quite surprising. I expected all three types to scan reliably but that was not the case. The larger credit-card size tags worked well (sometimes needing a second attempt to get the scanning to work). The smaller tags were far less reliable. I have therefore decided to use the credit card sized tags as the smaller ones would get very frustrating. I don't know whether my phone is partly to blame for the scanning problems – it is an old Android phone. I did some research on the internet however and there are a lot of people who have described reliability problems with the smaller tags.The bigger tags contain a bigger antenna which allows them to work more reliably. It is also necessary to tap the card at the very top of the phone – I will have to add something to the toy which tells the child where to tap as it is not obvious.

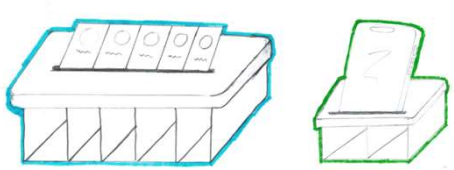
Conclusion

I have decided to use NFC tags as a way of scanning the Matching Cards. This is because they work simply by tapping the phone. QR code and barcodes require the use of the camera on a smartphone – that is more cumbersome as you have to hold the QR code or barcode a particular distance away from the phone so the camera can scan it. I have also decided to use the credit card style of NFC tags as my research showed that they were much more reliable.

11. Development of Chosen Design – Sorting Box

In this section I will be developing my chosen design – Interactive Card Matching. I will firstly review my client feedback as well as my own observations I will then look at different aspects of the design and propose a number of improvements and refinements.

Initial Design – Interactive Card Matching



My Observations

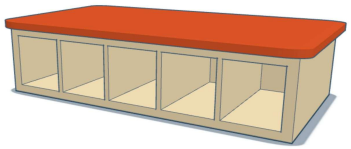
- Does the phone stand really need to be separate? I will look into streamlining my design by combining the main sorting box with the phone stand / card storage.
- I need to think about the best way to present Category Cards to the user of the toy. Would it be better to have them flat or standing up?
- I need to think about the best place for the Matching Cards. In the phone stand, on the desk or add to the sorting box?
- Which way round should the phone go? Landscape or portrait? I need to consider what would work best for showing videos.

Client Observations

- The design needs to be more aesthetically appealing. Think about colours, shapes, etc. to make the design more interesting.
- Consider adding drawers. This would have two benefits – firstly, somewhere to store the cards when not in use. Secondly, for younger children the addition of drawers may make the toy more interactive and appealing.
- How will the toy be transported? Does it need handles?

Design Alternatives – Drawers vs Open front

1. No drawers



In my original design I had open compartments for the Matching Cards. The idea was that once the card had been matched (using the phone), it would then be placed into the corresponding slot. I discussed this design with my client and also reviewed it myself. I came up with the following pros and cons.

Pros

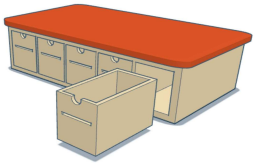
- Simple design, straightforward to build
- Possible to see the cards once they have been matched. They can be taken out and inspected

Cons

- Slots only a little bit wider than cards so may not be easy to remove cards
- Cards would fall out if the toy was picked up and carried or tipped forward
- No easy way to store cards when the toy is not in use

In conclusion, this design had too many cons so I have decided to discount it,

2. Small drawers



Drawer too small to collect / remove cards

During the initial interview my client said that the design needed to be more interesting and that drawers would be useful. I created a prototype for one drawer out of cardboard (with vinyl wrap).

Pros

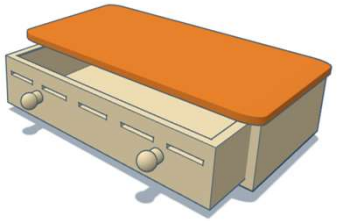
- Cards are kept separate after sorting
- Drawers can be used as storage when toy not in use
- More interactive design (children may find drawers more of a novelty)

Cons

- My scale prototype made it clear that the drawers were too small for a hand to reach in and remove the cards

In conclusion, the idea of having several small drawers is not practical as it is too difficult to remove the cards after they have been sorted. I have therefore decided to discount this design.

3. One large drawer



My final design alternative is to have one wide drawer. The drawer would need to have a number of slots on the front so the child can push the cards through once they have been sorted.

Pros

- Easy to collect the cards once they are in the drawer.
- Drawer could be used to store all game parts when not in use.

Cons

- Dividers in the drawer would again make it difficult to collect the cards so these must be omitted.

I also realised that there is nothing to stop the drawer falling out - I will refine this part of the design later if I choose this option.

Conclusion

I believe the single drawer (without dividers) is the best design as it is the most functional. I plan to discuss this with my client and confirm this decision.

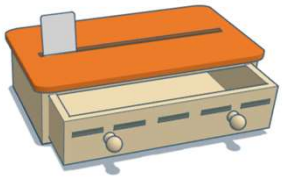
11. Development of Chosen Design – Sorting Box

Design Alternatives – Category Card position

In this section I am exploring the different ways of positioning the Category Cards. I thought it was important to create prototypes so I could test the ergonomics in each case.

1. Groove

I experimented with different gaps when I was building this prototype. A 3mm gap allowed the cards to tilt back by 80° making them easy to see.



Pros:

- Cards can be made to tilt backwards more by routing a bigger groove
- Simple to make

Cons:

- No way to ensure the child aligns the cards with the drawer slots – this may cause confusion
- Cards may easily be knocked out of place as not secured into position
- No room for phone in this design

2. Recess

The prototype highlighted that it would be difficult to lift the (thin) cards out of the recesses – this could be very frustrating and discourage children to use the toy.

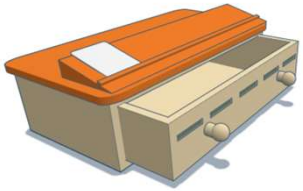
Pros:

- Aesthetically pleasing
- Cards would be kept in place and aligned with drawer slots
- Very obvious where cards need to be placed

Cons:

- Thin cards are too difficult too remove from recesses. Unfortunately that limitation means this design needs to be ruled out

3. Slope with lip



This prototype successfully tilted the cards forward but I decided that it wasn't really necessary and having the cards flat would be better.

Pros:

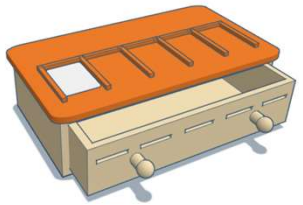
- Practical – the cards are raised so they are easier to see.
- A lip prevents cards from sliding forwards

Cons:

- Similar to Design #1 – cards not necessarily aligned with drawer slots; cards easily knocked out of place
- Not as aesthetically pleasing as Design #1 and Design #2 – wedge shape spoils the look of the toy

I decided to rule this design out as it would spoil the aesthetics and isn't really necessary.

4. Retainers



For this prototype I built a small raised retainer for the card. It was very easy to slide the card in and out and it stayed in place nicely

Pros:

- Cards can be very easily slid into place and removed in the same way
- Cards align with slots in drawer
- Cards cannot easily be knocked out of position as the retainers prevent this from happening

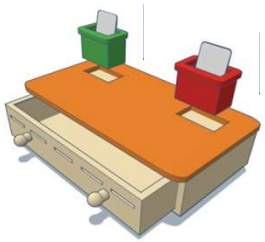
Cons:

- Nothing obvious. I would need to think about how to make this solution more aesthetically pleasing though

Design Alternatives – Storage for Matching Cards

My original design had two elements – the main toy (sorting box) and a separate phone stand (which also had space for card storage). As I developed the design I realised the separate phone stand was probably not necessary – the phone could be mounted on the sorting box instead. This also means the phone will be directly in front of the child and not off to one side, thereby making it easier to see.

Without the separate phone stand however there was no longer any storage for the Matching Cards. To address this problem, I evolved the design of the sorting box to include 'card buckets'. These are recessed, allowing the cards to stand up and be easily accessible to the child.



Card bucket prototype

Pros:

- Cards are more accessible than if they were in a separate stand
- Can have two buckets (may work well for left and right-handed children)

Cons:

- Nothing obvious.

The functionality of this prototype is better than the separate phone stand idea as the cards are closer to hand and only one physical toy is required.

Conclusion

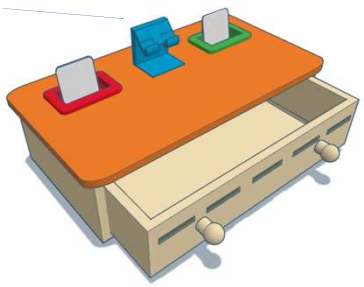
I have decided to combine the sorting box and phone stand into one, simpler design. This means it will be possible to position the phone directly in front of the child and have the Matching Cards accessible to their right or their left. The Category Cards will sit in small retainers which will align with the drawer slots and stop them being knocked out of place. I will review these design changes with my client during our next meeting.

11. Development of Chosen Design – Sorting Box

Design Alternatives – Phone stand

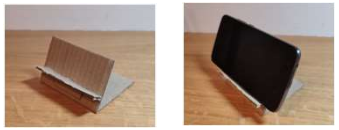
In this section I am looking at different ways to position the phone. I created a number different prototypes as there are lots of different factors to consider. For example, the dimensions of the stand, the material I should use, how far it should tilt back, whether it needs to be raised so the screen is easily visible, and whether the phone should be in portrait or landscape. Below are phone stand examples that I researched on the internet. I was specifically focused on comparing the material, colour and ergonomics.

Phone stand position



1, Initial prototype

My initial prototype worked well. The dimensions were good (90mm x 35mm) and the phone was stable but I discovered some shortcomings. Firstly, the phone tilted back too much to be comfortable for the user to see (approximately 40°). Also, the 'clips' holding the phone were too large and obscured the screen.

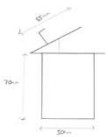


2. Second prototype

I developed a second prototype to address the shortcomings of the first one. This time, I adjusted the tilt on the phone stand to 60° – this made viewing the screen more comfortable. Secondly I removed the clips that were obscuring the screen. Unfortunately this then mean that the phone slipped off the stand too easily I also realised I would need to develop a mechanism for holding the stand in place.

3. Final prototype

I developed a final prototype to incorporate everything I had learned so far. This prototype had a very small lip to stop to phone slipping. It also had a base which could fit into a recess in the sorting box. The idea was that this would be held in place in a similar way to the card buckets.



Conclusion

I have decided to develop a phone stand which tilts back at 60° – this seems to work best for being able to easily see the screen. The stand will have a small lip so the phone does not slip off the stand. In terms of width, 90mm is wide enough to accommodate modern phones (which a are generally quite large). The phone stand will sit in a recess just like the card buckets for the Matching Cards.

Design Alternatives – Carry handles

My initial design for this toy didn't have any handles at all which I realised isn't very practical. In this section I have therefore explored adding some handles so the toy can be easily transported around. Again, I developed prototypes to get a better idea of ergonomics and dimensions.

1. Cutaway handles

To start with I thought simple cut away handles might work best – one on each side so the toy can be easily picked up and carried. I found an example of this in an Ikea storage box when I was doing some research.

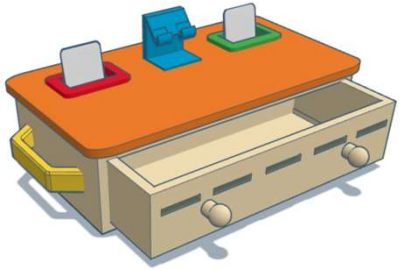
Ikea storage box with cutaway handles

This approach would have worked well with the original design but does not really work now since I have added a drawer. (The cutaway for the handle would need to extend into the drawer). For that reason I quickly discounted this approach and did not create a prototype.

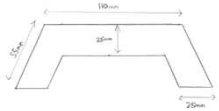
2. Physical handles

Once I had decided that I needed physical handles I did some research on the internet. I investigated colours, materials and finishes

I modelled my preferred design out of foam core board. After a couple of attempts I was able to create handle that was big enough for adult hand to grip. I think that this handle would be most suitable to be made out of wood and to be painted colourfully to match the Montessori aesthetics



Foam core prototype handle



Conclusion

I decided that physical handles would work better than cutaway handles as the design for my toy has a drawer. I prototyped a simple handle design and tested the dimensions to make sure it was big enough for an adult hand – anthropometrics. Before finalising this design I will speak with my client as she may have a preferred design.

11. Development of Chosen Design – Themes and Cards

Design Alternatives – Themes

At this point in the project I had to decide what theme to use for the toy. I did some brainstorming and came up with a number of different ideas which I then evaluated.

Theme	Details	Comments
Animals and continents	Sorting animals according to the **continent** they live on	Good idea but there are 7 continents. Because of the size of the toy I can only have a maximum of 5 categories. I therefore decided to reject this idea.
Classification of animals	Sorting animals according to their **classification**	Good idea and would work with 5 categories (mammals, fish, amphibians, reptiles, birds). Videos could demonstrate how the animal moves, hunts, sleeps, etc
Recycling	Sorting pictures of items (e.g. cans, bottles) into different coloured bins	Relevant and educational – a good idea. Videos of cans, bottles, etc wouldn't teach the child much about those items though because they are static. In fact this could be achieved with simple cards and wouldn't need a phone. There are already games on the market which do this.
Basic shapes	Sorting every day items according to their shape, e.g. clock = circle, slice of cake = triangle, etc	Good for very young children. Similar comment to Recycling solution above – videos may not add anything.
Flags, countries and continents	Matching a country (from its flag) to the continent the country is in.	Probably too difficult for the age group (up to 7 years) – therefore doesn't meet requirements.
Household items	Sorting household items according to the room they belong in, e.g. oven = kitchen	Good for very young children. Videos could show how they household items work, e.g. taking food out of an oven. Definitely a theme to consider choosing.
Vehicles	Sorting vehicles according to their type, e.g air travel, road, water, etc	Another good idea and the videos could show the various vehicles moving and even what they sound like. This is a theme I think could work well.

I realised that there were lots of options for themes – the best ones were ones where a) 5 categories could be created and b) a video could teach the child something new about the item before matching it. In the end I decided to use the theme of 'Classification of animals' although there are other good ideas which I could use to make additional sets of cards in the future. One of the good things about this toy is that it can be easily extended.

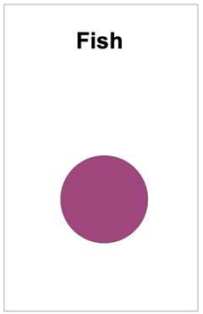
Design Alternatives – Card designs

Once I had decided on my theme I needed to design the Category Cards and Matching Cards. To do this I created some prototype images in Powerpoint and then evaluated them. One of the most difficult things I had to work out was what to put on the Category Cards. For example, should this just be the name or a picture? What pictures should I use to represent Amphibians, Fish, Reptiles, etc? How would the child be able to match what they saw on the video to the correct category?

Design Alternatives – Category Cards

Pros
- Simple design

Cons
- Requires the child to be able to read
- No colour - unappealing



Pros
- Simple design, adds some colour
- Easy to add dot / spot to video to help matching
- Has written word to help with reading

Cons
- Colourful enough?

Pros
- Colourful, attractive
- Has written word to help with reading

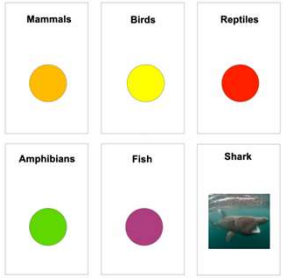
Cons
- Confusing? Does this represent one type of fish or the category fish?

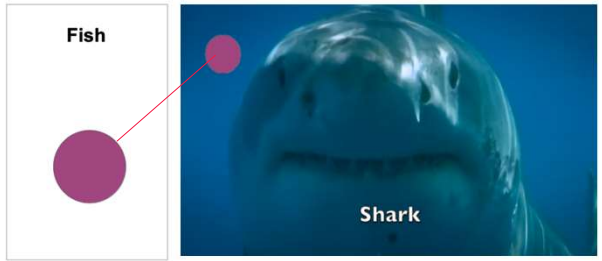
Pros
- Colourful
- Has written word to help with reading

Cons
- Confusing if the fish being matched does not appear on the card?

Design Alternatives – Matching Cards

The Matching Cards were easier to design than the Category Cards because all they needed to show was the animal along with its name. I wanted to be able show my client what I thought the Category Cards and Matching Cards would look like. I therefore created 5 Category cards using different colours and 1 Matching card (a Shark).





On the category cards and on the videos there will be a coloured dot to help the child make the match,.

Conclusion

I chose the theme of 'Classification of animals' as this met the brief – it was relevant and educational. It would also allow me use videos to show the animals in the wild which would help the child with their learning. I chose a simple design for the Category Cards which included a coloured dot. I will put this same coloured dot on the video so the child can match up the animal to its category.

11. Development of Chosen Design – Joints, Mechanisms. Materials and Surface Treatments

In this part of the project I decided to do some research into how I would construct my toy, what materials I would use and what surface treatments I would apply. In each case I have considered the alternatives and explained what I think would work the best.

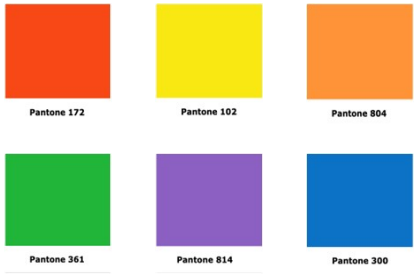
Choice of wood

	Wood	Cost (£/m2)	Observations
	Hardwood	£150	Hardwood has lots of advantages. They are generally very durable, unlikely to splinter and often have a very attractive grain pattern. The major disadvantage is cost (in my brief I said I would make the entire toy for less than £30). For that reason I decided not to use hardwood.
	Plywood	£15	Plywood seems like a good option for this project. It is available in various stock forms, it is very strong (due to the way the plys are laid), it generally doesn't warp very much and it is quite affordable. The edges of plywood aren't very attractive so I will need to consider how to deal with this.
	Softwood	£25	Softwood is often used in toy making. They are generally easy to work with and not too expensive (compared to hardwoods). Materials such as pine aren't available in all the stock forms as say, plywood, so I think plywood would be the better option.
	MDF	£10	MDF is sometimes used in toy making but it doesn't have any grain so the aesthetics would not be right for this project. The Montessori toys that I have researched all seem to have a natural grain. For that reason I have decided not to use MDF.

Colours

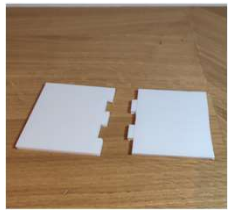
I knew from my research into Montessori toys that they always use bright colours. Specifically they seem to use either primary or secondary colours. Some of the most common colours used appear to be reds, yellows, oranges, greens, purples and blues.

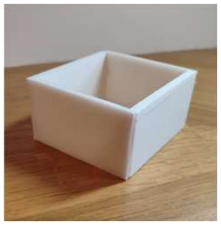
During my research I learned that there are different systems people use to identify specific colours. One of these systems is called Pantone. There is another one called RAL. I have selected some Pantone colours on the right that I think may be good options for my project. I will apply these with either a brush or paint.



Joints

I decided to use foam core board to test out a number of different ways of joining the parts of my project together. I cut these out with a scalpel and then assembled them by hand. The rabbet joints and finger joints are good options for joining the sides of the toy together. For the base I experimented with using a recessed bottom. Having experimented with the different options I decided I wanted to use finger joints. The are strong and have good aesthetics.





Testing rabbet joints using foam core board

Testing drawer-bottom recess design

Testing finger joints using foam core board

Surface treatments

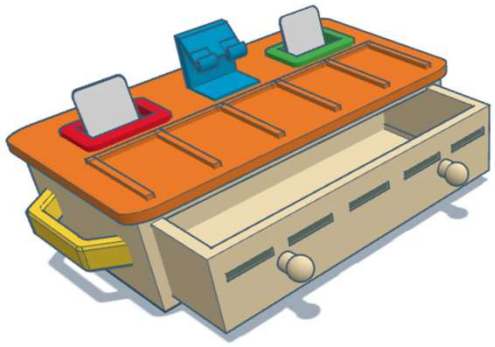
I was very surprised how many there were for wood. I wasn't sure what they would look like when applied so I used all the ones available in the workshop and applied them to pieces of scrap wood. I think the look of natural wood is most suitable for my project as this is what most Montessori toys look like. I therefore decided I did not want to use any stain. There are a number of options for a clear coat but clear varnish seemed like the best as it is commonly used for toys and easy to get hold of.

Conclusion

From my research in this part of the project I have decided that I want to make my toy out of plywood. I will be using finger joints to assemble the main toy and drawer as they are strong and aesthetically pleasing. In terns of surface treatments I will use clear varnish for most of the toy. For those bits that need to be colour, I will use bright colours similar to the ones I looked at above. These will either be spray painted or brushed on.

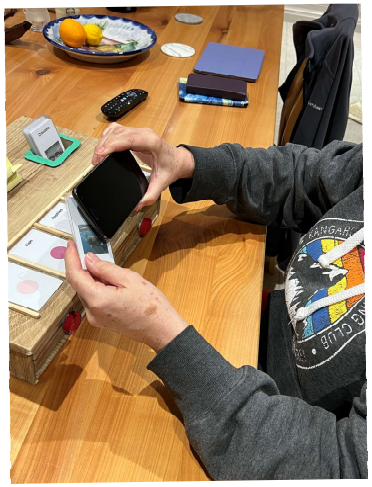
12. Model – Client Feedback

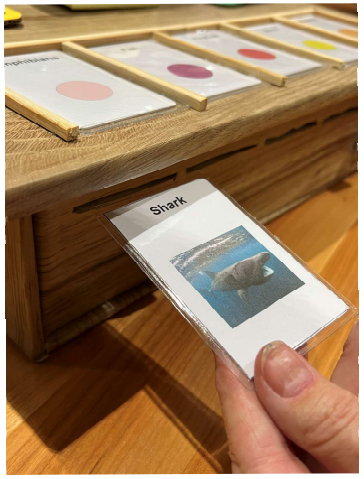
Recently after finishing my model I visited my client and got some feedback. Specifically, I wanted to understand what she liked about the model and what she thought could be improved I went round to her house to ask her a series of questions on the aesthetics and functionality of the model. I will then use this feedback to refine my design.

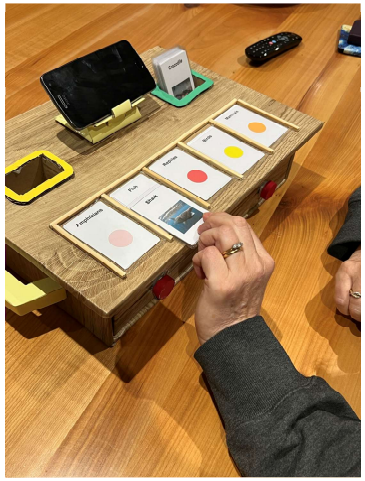


A. CAD model

B. Model – foam board / cardboard







Things my client liked:

- My client thought it was great - “I loved it”.
- Looked engaging, she was very keen to use it!
- Overall aesthetically appealing.
- Really like the modularity (in regards to topic changeability and number of category changeability).
- Use of colour (mostly natural wood with hints of primary colours).
- Thought having 5 categories maximum was ideal number.

Suggestions for improvements:

- Overhang of the top. My client said that I should reduce the size of it and move the drawer slots down. This means that you could fully see where you are putting the card.
- Taller drawer slots. This would make it easier to insert the card into the slot.
- A locking mechanism would be good as that would stop the drawer from falling out.
- My client also said that having dividers in the drawer would be good. I have evaluated this idea and. came to the conclusion that there would not be enough room to put your hand it and retrieve the card.

Conclusion

My client was overall very happy with my design and loved it even more when seeing my model built and in the flesh. My client especially loved the aesthetics and in particular the use of colours and layout of the model. My client suggested some specific improvements which I will try and include in my final design.

13. Manufacturing Specification – Cutting List

Carcass

Part Name	Part	Material for final design	W x H x D (mm)	Quantity of this part I need	How it will be cut
Side Panel	A	Plywood	260 x 90 x 6	2	Laser cutter
Back Panel	B	Plywood	380 x 90 x 6	1	Laser cutter
Base	C	Plywood	380 x 6 x 260	1	Laser cutter
Top	D	Plywood	380 x 6 x 260	1	Laser cutter
Handle	E	Ash	110 x 30 x 30	2	Cut by hand
Drawer stop	F	Plywood	50 x 10 x 9	2	Laser cutter

Drawer

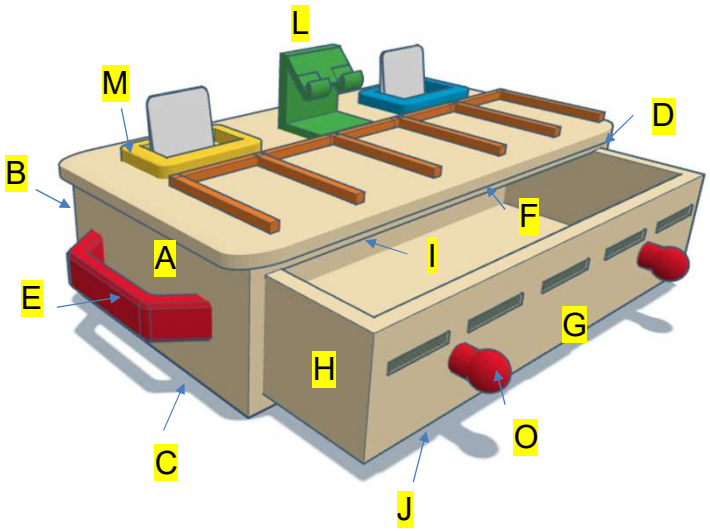
Part Name	Part	Material for final design	W x H x D (mm)	Quantity of this part I need	How it will be cut
Front	G	Plywood	348 x 88 x 6	1	Laser cutter
Side Panel	H	Plywood	189 x 88 x 6	2	Laser cutter
Back	I	Plywood	348 x 88 x 6	1	Laser cutter
Bottom	J	Plywood	378 x 6 x 189	1	Laser cutter

Accessories

Part Name	Part	Material for final design	W x H x D (mm)	Quantity of this part I need	How it will be made
Phone stand	L	3D filament	90 x 50 x 70	1	3D Print
Bucket	M	3D filament	85 x 50 x 55	2	3D Print
Drawer knob	O	Ash	30 x 30 x 30	2	Wood lathe

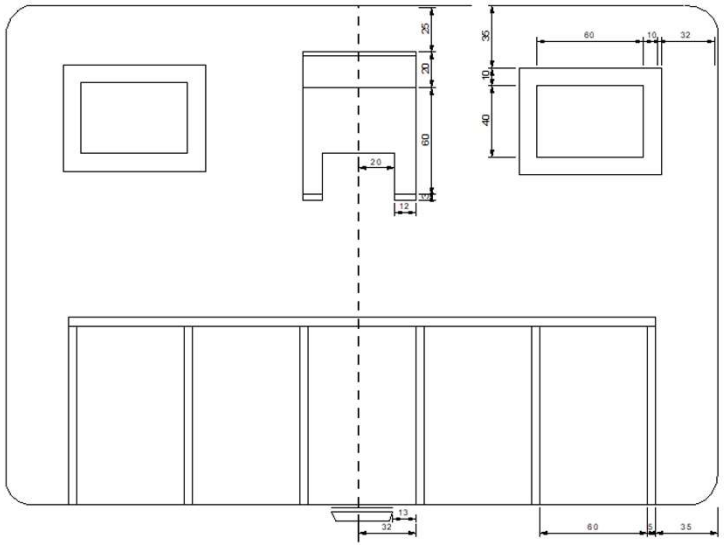
Media

Part Name	Part	Material for final design	W x H x D (mm)	Quantity of this part I need	How it will be made
Animal video	P	N/A	N/A	10	Apple IMovie
Category card insert	Q	Card	54 x 85	5	Powerpoint + inkjet printer
Matching cards	R	Card	54 x 85	10	Powerpoint + inkjet printer

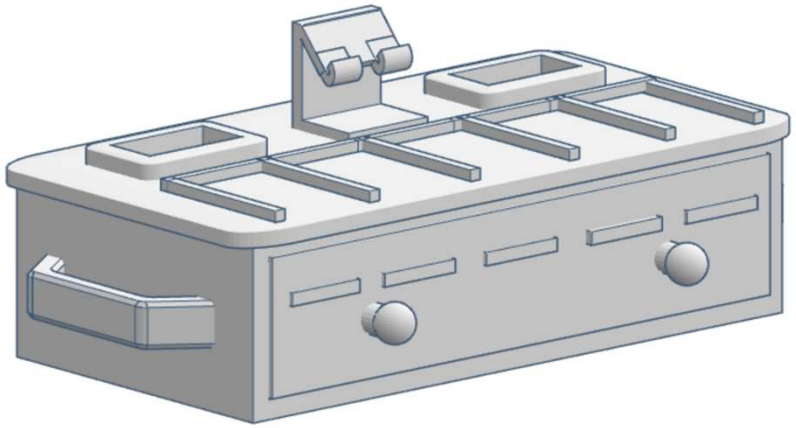


14. Manufacturing Specification – Technical Drawings

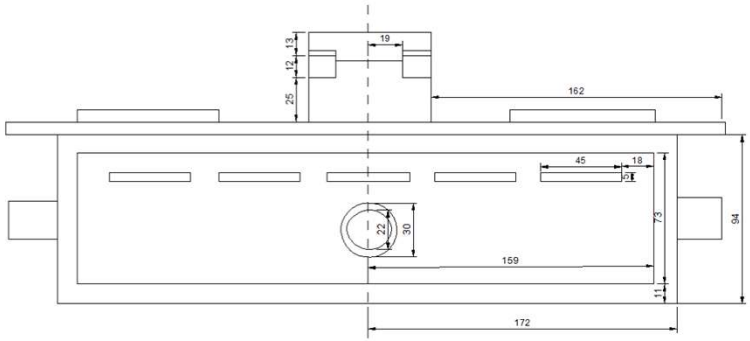
3rd Angle Orthographic view - Top



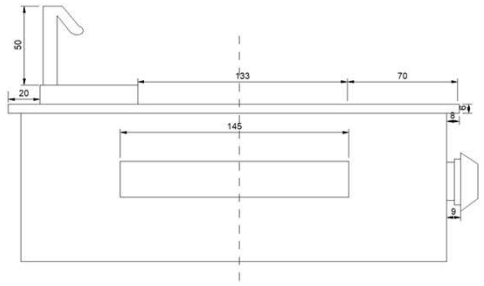
Isometric view



3rd Angle Orthographic view - Front



3rd Angle Orthographic view - Side



*All measurements in mm

15. Manufacturing Plan – Gantt charts

On this slide I have included my original manufacturing plan and my actual plan. I would say overall the build went to plan but there were some changes I had to accommodate during the build. Firstly, I discovered that some parts of the build required me to **iterate**. For example, when I first cut the side panels they splintered so I had to do this again. Another example was recutting the drawer panels when they did not fit the first time. Fortunately I had enough time in my plan to accommodate this. Secondly I realised that some things were going to take more time than I had allowed for on the plan. The main example of this was the videos – making 10 videos was very time consuming. Finally, I had to speed up quite a lot towards the end of the build in order to get everything done.

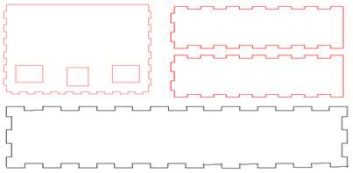
Planned

Actual

16. Workshop Storyboard - Carcass and Drawer

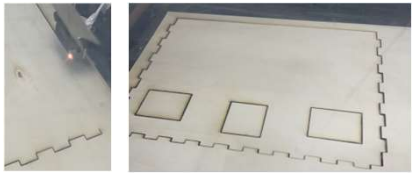
Key: Quality Control Health and Safety Design Change

1.



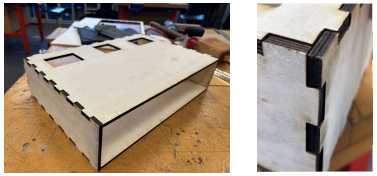
I used Techsoft 3D Design to create the shape of the panels that will form the carcass of my toy. I then sent over these designs to the laser cutter to be cut. To ensure the tolerance was good I factored in the kerf of the laser.

2.



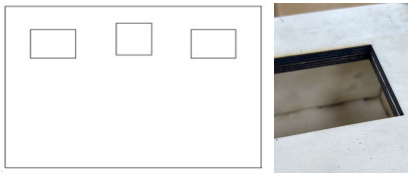
The panels were then cut out of 6mm plywood. When using the laser cutter I turned on extraction to remove any harmful fumes. I then took them out of the laser cutter, removed the cut out parts that I do not need.

3.



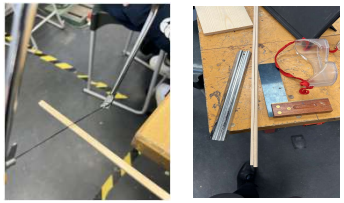
I then assembled all of the pieces that had been cut and made sure they fitted into place. I was especially pleased as this was the first time I had ever done finger joints and they fitted first time.

4.



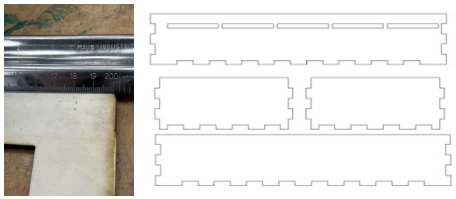
I then laser cut the overhanging top and made sure the holes for the buckets and phone stand aligned with the holes in the top of the carcass. They fitted however I did not glue them together in case of a problem later on in the build process.

5.



Next, I cut some some square wooden dowels to be the frame around the category cards (retainers). I used a junior hacksaw to do this and kept my fingers clear of the blade. To ensure that the quality was good I used a clamp to hold the dowel down which ensured that the cutting line was straight. Before cutting I marked up the cutting line which also ensured the accuracy.

6.



Then I used Techsoft 3D Design to create the drawer. To ensure that I would not need to recut I double checked all of the measurements and then cut it with the laser cutter when I was certain.

7.

When taking my drawer parts out I noticed that there were 2 large areas of splintering. I therefore decided that to ensure the quality of my drawer was good I would recut that side. The second attempt was more successful.

8.

I then used an electric belt sander and a handheld sander to remove the burn marks from the wooden parts. This made it look more aesthetically appealing. To improve the ergonomics, I also used the electric sander to create radius corners on the overhanging top. This made them have a smooth and nicer feeling edge. I used a mask and made sure that I did not put my fingers anywhere near the sanding belt.

9.

To begin making the drawer knob I started off by marking where I wanted the start and end of each gradient to be using a pencil. I then started at one end of the wood and worked my way down. I used different gradient tools depending on the curvature I wanted on the drawer knob. Finally, I took the drawer knob off and sanded any imperfections in the wood. I decided in the end to modiy my design as one drawer knob was sufficient.

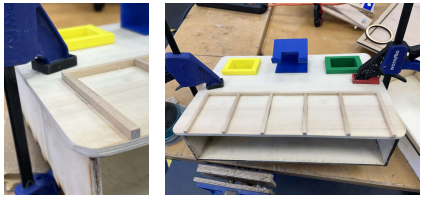
10.

Next I drew on where I wanted the drawer stops to be. Before gluing them down I double checked the measurements with a ruler. I then used PVA glue to securely fix it in place.

11.

I then glued all of the main carcass panels together. I clamped all of the panels so they would be stuck together securely. Once clamped I removed any excess glue with a damp paper towel. I did this to improve the quality of the product.

12.

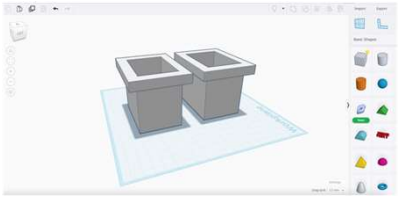


Finally, I used quick-release clamps to hold the top of the toy in place as the glue was drying.

16. Workshop Storyboard - Accessories & Assembly

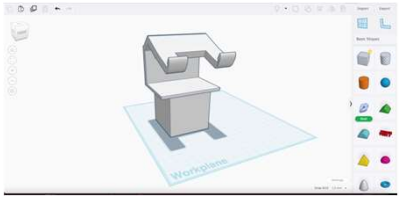
Key: Quality Control Health and Safety Design Change

1.



To design the card buckets I used some 3D design software called Tinkercad. I copied my measurements exactly from the design specification to ensure accuracy.

2.

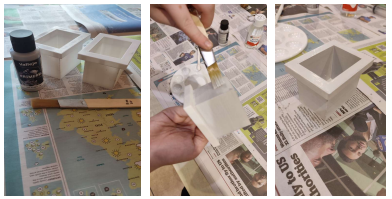


I also used Tinkercad to design the phone stand.

3.

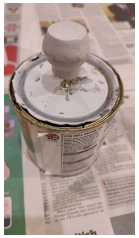
Next I sent my Tinkercard designs to the printer for printing. The 3D printer was operated in a well ventilated part of the workshop.

4.



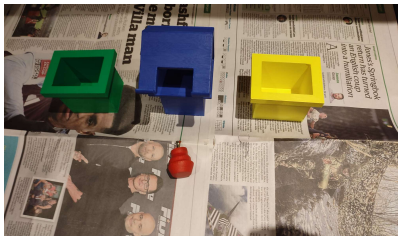
The next step was to apply primer to the printed parts to prepare them before adding coloured paint. Without the primer there was a chance that the coloured paint would not adhere properly

5.



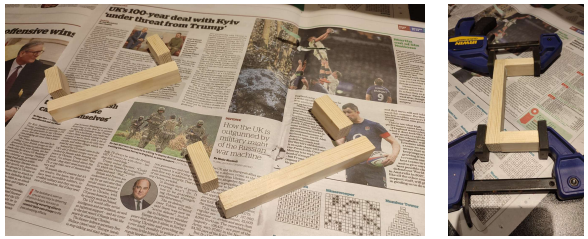
I also primed the drawer knob before painting.

6.



Next I used different coloured acrylic paint as a surface treatment for the accessories / printed parts. I realised that I would need to add several coats of paint so the colour would appear solid and not streaky

7.



My next step was to make some wooden handles for the toy. I did this by measuring some pieces of pine and then cutting them with a tenon saw. Once I had cut the wood I glued and clamped the pieces to form handles. Because I was short of time I decided to make a simpler handle than my original design showed.

8.

I then sanded, primed and painted the handles, ready to be attached to the toy.

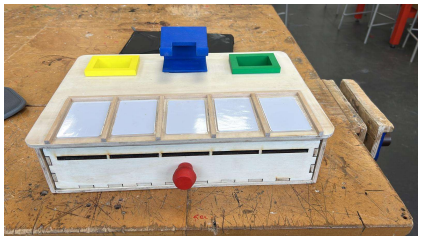
9.

I then applied two coats of clear varnish to the toy to protect the wood.

10.

Next I created the drawer insert. I cut a piece of cardboard to the same dimensions of the drawer and then I wrapped it in felt. The felt was fastened down using strong tape.

11.

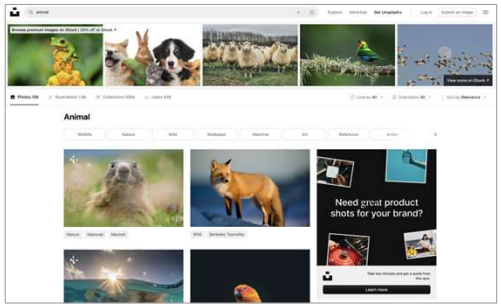


Finally I assembled all the parts to create the final toy, Once I was happy that all the accessories were in place I glued and clamped the handles which was the last stage. I carefully measured and marked where the handles would go to ensure they would be level.

16. Workshop Storyboard - Category cards and Matching cards

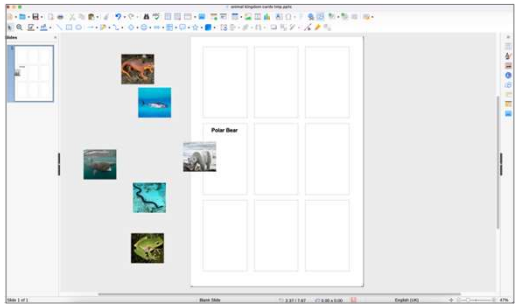
Key: Quality Control | Health and Safety

1.



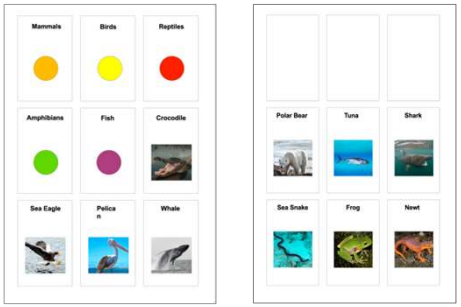
For this part of the project I needed to find some animal images for my cards. I used a website called 'Unsplash' and downloaded 10 pictures.

2.



Next I created a powerpoint presentation and created outlines for each card. I then copied in the images I had downloaded.

3.



I put a caption on each of the cards and printed them on A4 paper.

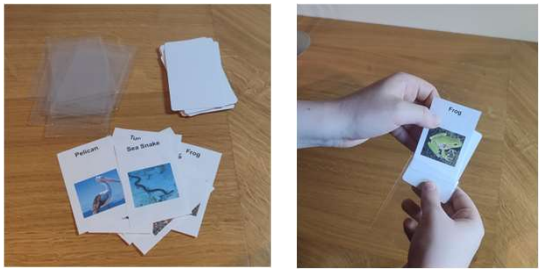
4.

Once the images had printed I cut them to size using a paper trimmer. I used the guard to ensure my fingers were nowhere near the blade.

5.

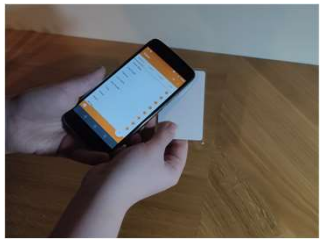
Next I measured the paper inserts to ensure they had been accurately cut. I used a tolerance of 1mm. Some of the them were not within this tolerance so I printed and cut new ones.

6.



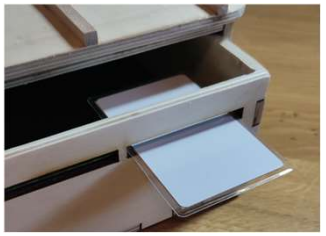
The final part of making the cards was the assembly – I put each NFC card and paper insert into a plastic sleeve.

7.



My first test of the cards was to ensure that the phone could still read them through the plastic sleeves

8.



I then made sure that the cards would fit through the slots in the drawers.

9.

I did another test to ensure that the cards would fit into the retainers on the top of the toy.

10.

My final test was to make sure that the cards fitted ok in the buckets.

16. Workshop Storyboard - Videos and mobile phone programming

Key: Quality Control Health and Safety

For this part of the project I had to create videos for the 10 Matching Cards. I will describe here how I did if for the Frog card, but the idea is the same for all the other cards.

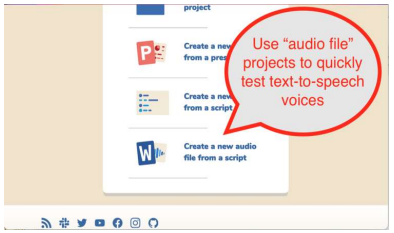
1.

To start with I found a video of a frog on YouTube which I could edit and make shorter. I decided my videos should be about 15 seconds long so the child does not get bored.

2.

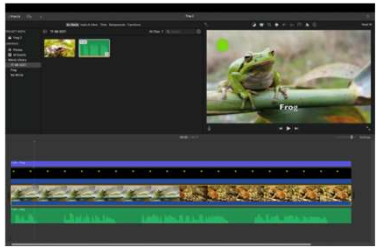
I then created in image of a green spot in Powerpoint.This will be added to the video to tell the child that a frog is an amphibian (the green spot is also on the Category Card).

3.



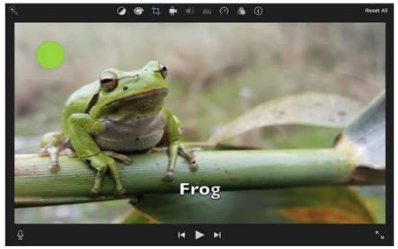
Next I used Google to research some facts about frogs and used some software called Narakeet to convert these facts into an audio file.

4.



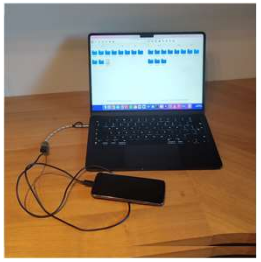
I then used Apple iMovie to combine the YouTube video, my audio file and the green spot. I shortened the video so it was between 10 and 15 seconds.

5.

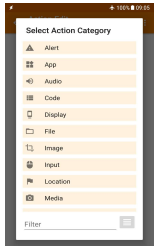


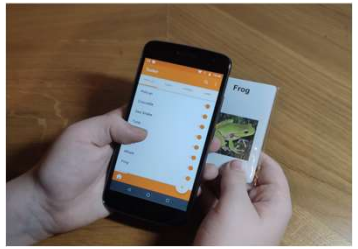
The next step was to add a title to the video so the child could read the word ‘Frog’. I then used iMovie to create a final video with all the parts together.

6.



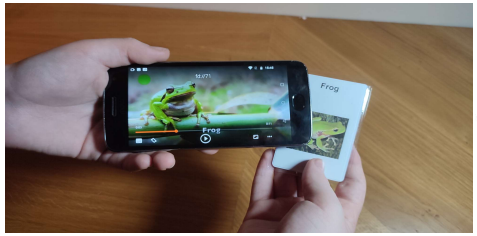
Once I had the finished frog video I connected my laptop to the mobile phone and copied the file over.





I then programmed the NFC card to play the frog video when the user taps the card on the phone. I used some software called Tasker to do this. Each card has a unique number so when Tasker sees this number it knows which video to play.

8.



Once I had finished the programming I tapped the card on the phone to make sure it played ok and I could hear the audio.

Audio narration

“This is a frog. A frog is a type of amphibian.

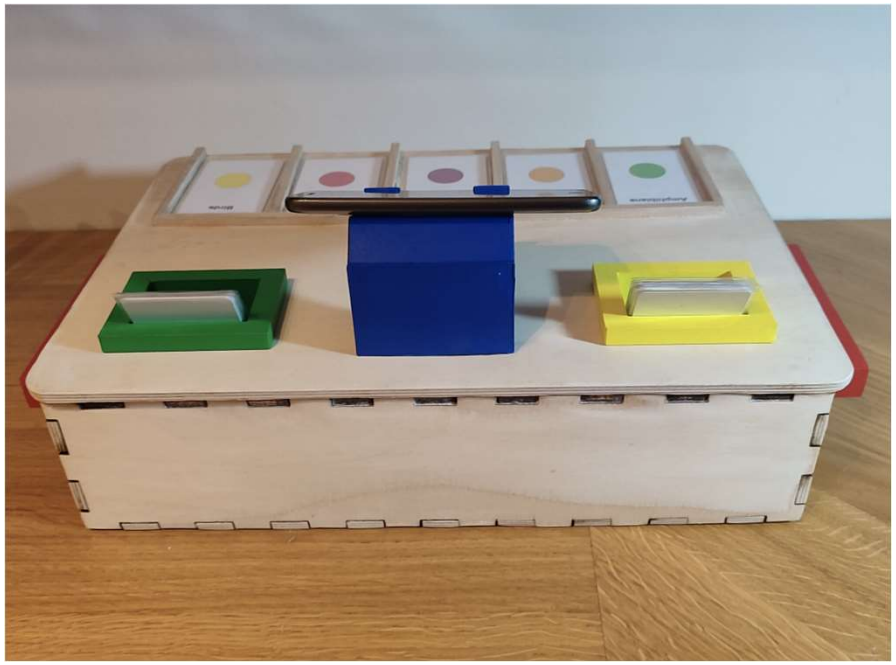
Did you know that a group of frogs is known as an army?

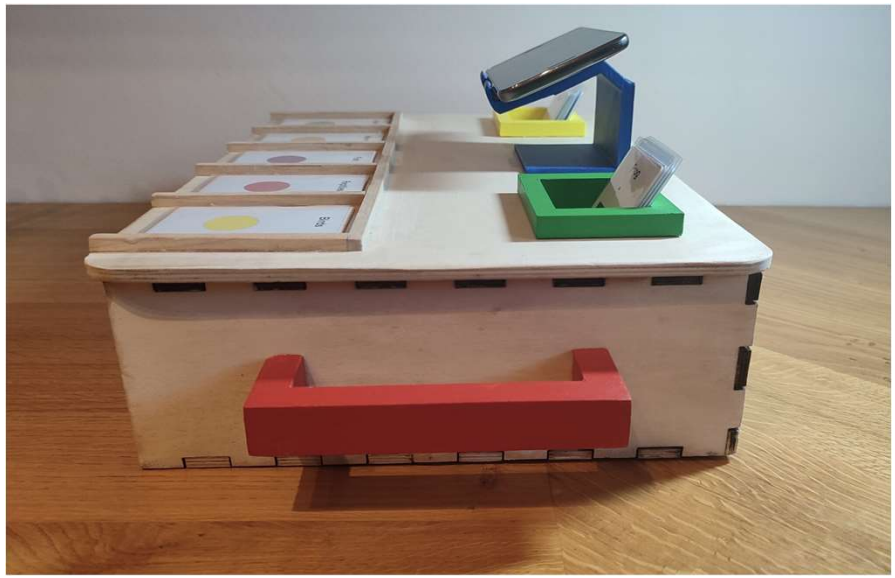
Some frogs live for over 20 years!”

9.

The final stage was to create 9 more videos for the other Matching Cards. The crocodile and tuna videos are shown above.

17. Final Prototype





17. Evaluation Against Design Brief and Specification

Code	Category	Specification Point (requirement)	Achieved?	Evaluation	Improvement ideas / modifications
AS1	Aesthetics	The product will be colourful.	Y	In the end I think I managed to capture the Montessori aesthetic very well by using bright primary and secondary colours and varnished, wooden parts. I also made the category cards and matching cards colourful by using photographs. These characteristics would make the toy attractive to a young child.	If the toy was being used by older children / students, it might be a good idea to make the accessories (buckets, phone stand, drawer knob) all the same colour so it seemed less childlike and therefore more attractive to them.
AS2	Aesthetics	Should have a similar look and feel to other Montessori toys	Y	Overall this design goal was achieved successfully by using natural materials (wood) and carefully choosing colours. The use of colour is described in AS1	Quite a lot of the Montessori toys I looked at during my research had a lots of rounded corners. My toy has a rounded top but some of the other parts could be less angular and more rounded to be more consistent. For example, I could make rounded handlles and a more curved / rounded phone stand.
CO1	Cost	The cost of my product will be £30.	(Y)	The wood I used cost approximately £8, the paint £10 and the NFC cards £5. Total = £23 approximately. There would also be a small cost for printer ink, screws, glue, etc. This would be very small so I have estimated as £2. The toy can be made for under £30 but there would only be a £5 profit.	I could improve my toy by finding ways to make it more cheaply. Firstly, buying all the materials in bulk would reduce the cost of raw materials. Secondly, I could use larger sheets of plywood and cut out several drawers, carcases, etc from each one. Finally, I could look at using coloured PLA (for 3D printing) which would avoid the need for most of the paint. I would need to investigate all these options to generate the 50% profit margin I was hoping for,
CO2	Cost	Once the product has been purchased there shouldn't be a need to buy other parts	Y	This design goal has been met. The only reason you would need to buy spare parts is if you wanted to expand the toy with more category cards and matching cards. This would involve buying more NFC cards and sleeves.	N/A
CU1	Customer	My target market is schools and parents. The user of the product however would be children up to 7 years old	Y	I have demonstrated that my toy would work for children of about 4-5 years old (this is due to my choice of animal matching cards). I have also explained how it could be used for much older children by adding new sets of cards.	With more time I would have created additional sets of cards and videos to show the toy working for different age groups.
EN1	Environment	The toy should have recyclable elements	Y	The main toy is recyclable as it is made out of plywood. The accessories were 3D printed using PLA which can be recycled. Because the accessories are made out of PLA that also means they are biodegradable.	N/A
EN2	Environment	The toy should not have any unnecessary outer packaging	Y	I didn't create any packaging at all for my toy. If it were a commercial product it would need packaging to store the main toy along with accessories (buckets, phone stand, cards, etc).	I would make a simple cardboard box for the toy which would be fully recyclable and included no plastic parts (inserts, trays, etc).
SZ1	Size	No larger than 400mm x 400mm, No smaller than 150mm x 150mm	N	My toy is slightly narrower than 400mm without handles and approximately 60mm wider with handles. I realised that in my specification I did not include a maximum height – if it is too tall to be easily stored (e.g. in a cupboard) then the phone stand can be removed.	If height is an issue, the phone stand can be removed. One improvement would be having a compartment in the drawer to store it.
SF1	Surface treatments	Rounded corners and no coatings containing harmful chemicals.	Y	There are round corners on the toy (on the top). The varnish and paints that I used are non-toxic.	N/A

17. Evaluation Against Design Brief and Specification

Code	Category	Specification Point (requirement)	Achieved?	Evaluation	Improvement ideas / modifications
FN1	Function	They toy will incorporate electronic elements	Y	This design goal was achieved as the toy needs a mobile phone to work properly.	One improvement would be to include a bigger screen so that the videos are easier to see. This could be achieved by using a bigger phone or adding a built-in screen.
FN2	Function	Offers different levels of difficulty	(Y)	In the end I only had the time to create one set of cards and videos so the toy only offers one level of difficulty.	With more time I would create different sets of cards based on other topics and aimed at other age groups.
FN3	Function	Teaches real world concepts	Y	I think the choice of Animals was a good one as it is a real world topic. My client confirmed this choice when I spoke with her.	I would make sure that the other videos and card sets I created were also based on real world topics.
FN4	Function	Provides feedback	Y	I think this deisgn goal has been met in a number of different ways. Firstly, the audio tells you what category the item belongs in via an audio track. Secondly, there is a coloured dot on the screen which also helps you match the category.	One improvement would be that the toy would give you additional feedback when you put a card in a drawer slot. It could make a sound to confirm whether the child has put the card in the correct slot or not.
FN5	Function	The joints and build must be strong	Y	The toy is robust which means it should last a long time in the classroom. In the end I made it out of 6mm plywood as that is what was available. In my original design I wanted to use 9mm plywood to make the toy even stronger.	Use thicker (9mm) plywood for carcass to improve the toy's strength and durability.
FN6	Function	The game can be added to and extended	Y	This design point has been met. It is easy to extended the game by adding new cards and videos.	One improvement would be to share vidoes and card images once they have been created. This would allow other people to download them and use ones that have already been created. It would also be possible to sell cards and videos. Another improvement would be to provide some software to create the videos as it currently takes a long time to assemble the different bits.
FN7	Function	Parts can be replaced if damaged	Y	All of the following could be replaced if they got broken (or lost): buckets, phone stand and drawer knob. This should extend the lifetime of the toy as sometimes small parts can get lost in a classroom environment.	N/A
FN8	Function	Be easy to clean	Y	The toy is easy to clean with a damp cloth as it has been varnished. The accessories can also be removed and cleaned if necessary. The drawer can also be removed to be cleaned if necessary.	N/A
MA1	Material	The toy will be made out of wood.	Y	The main toy and drawer are made out of wood. The accessories however were 3D printed using PLA.	N/A

18. Client Testing and Final Interview

At the end of the project I decided to conduct one more interview with my client. I wanted to ask her a series of questions about the toy and also get her to test it. My client really liked the final prototype and she came up with a number of improvements which I could make.

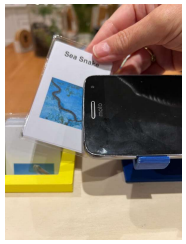
Testing Set-up

It was really easy and straightforward to set the toy up, but I did have to tell the client where to place the buckets, phone stand, category cards and matching cards. Once explained to the client it was very easy to insert the buckets and phone stand into the top of the box; sliding the category cards into the retainers; placing the matching cards into the buckets; and placing the mobile on the phone stand.

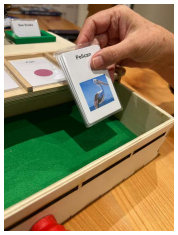
I think that it would be beneficial to include an instruction booklet with the toy.

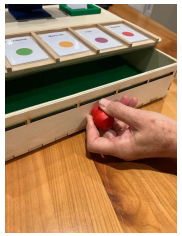
Testing Matching

It was a very simple process to take a single card out of the bucket and to then match it to the correct slot. With children who may not know to which category the matching card belongs, it was easy to place the matching card behind the phone. I did have to show my client where to place the card for it to be near enough for the phone to read the card, but after that it worked really well. In the testing process the matching card (in this case the sea snake card) when placed behind the phone played the recording highlighting some key facts about the sea snake and identifying the correct category.



Resetting





In terms of re-setting it was very straightforward to remove the phone from the phone stand, the unused cards from the buckets, the category cards from the holder and the matched cards from the drawer.

The drawer moved smoothly in and out of the carcass. It would be easy for the children to operate this.

Testing Portability

The handles make it easy for the toy to be moved around. The buckets and phone stand need to be removed first. This is because as they are not fixed in place they may fall out when transported around. The matching and category cards can be stored in the drawer.

The drawer seems well fitted, but to improve the design it would be good to have a mechanism which prevents the drawer from sliding out when it is being carried by the handles.

Q1. What is your overall impression of the toy?

"I love it. It's got a really nice, smooth finish with no sharp edges. It also looks really robust. Being lightweight means it's also really practical. I'm pleased that you kept with the natural wood. Overall I would say it's a clean, tidy looking design".

Q2. What do you like most about the toy?

"The thing I like most about it is how much learning you can get out of it - it is accessible and really easy to use."

Q3. Do you think the toy would work well in a Montessori classroom?

"Yes, I definitely think it would work well in a Montessori environment. Montessori toys don't generally use a lot of technology but I think they need to because it is the way of the modern world. This toy uses technology in a healthy way, i.e. not just playing a game".

Q4. What would you change?

"I would think about making the phone holder moveable, i.e. being able to tilt it backwards and forwards."

"I would also think about making some more of the corners rounded to make the make the lines a bit smoother."

"Finally, it would be useful to have compartments inside the drawer for storing the cards, buckets and phone holder, etc so the toy can be easily stored and all the separate parts can be kept together in one place".

Q5. Final comments

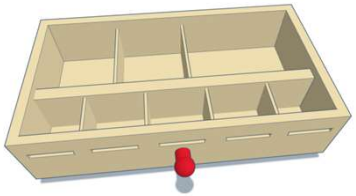
"I could really see it being used for lots of different purposes, e.g. countries within continents, different types of birds, mammals, etc. I think there is a lot of scope here. The beauty of this toy is that you could buy this as the starter pack and then to extend the play you would only need to purchase other categories of cards. You could also adapt the categories to reflect the age and ability of the children."

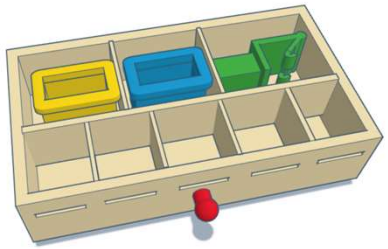
"I would definitely buy it for my Montessori school!"

19. Proposed Modifications

On this slide I have explained the modifications that I would make to my design. This is as a result of my own testsing as well as feedback from my client.

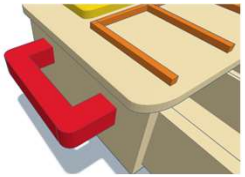
1. Drawer Inserts





One of the improvements that my client suggested was to add inserts to the drawer. This would be beneficial for a number of reasons. Firstly, it would be possible to remove the accessories (i.e. phone stand, buckets) and store them in the drawer when not in use. Secondly, it would be possible to store sets of cards inside the toy as well. In terms of making the drawer dividers I would either vacuum form them or use 6mm plywood.

2. Ergonomic handles



My client thought it would improve the ergonomics of the toy if I made more elements of it curved / rounded. I thought that one obvious way to do this would be to add curved handles. This would make the toy more comfortable to handle and also improve the way the toy looks – it would appear less angular.

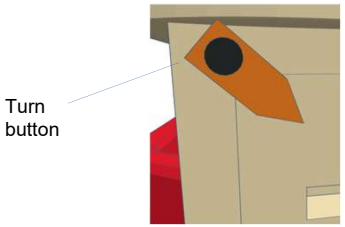
4. Adjustable Phone Stand

One important modification is to make the phone stand adjustable. This is important so people of different sizes and people sitting at different heights can see the phone comfortably. One modification therefore would be to make a phone stand with a hinge so the phone can be tilted backwards and forwards to suit the user.

5. Instruction Manual

When my client was testing the toy there were a number of things I had to explain to her – we both agreed that creating some instructions would be a good idea. The instructions would tell you how to a) set-up the toy (placement of phone stand, buckets, category cards, matching cards), b) how to use the toy by tapping on the right part of the phone and then placing a card in the drawer, c) how to reset the game so you ready to use it again. It would also contain instructions for making new sets of cards and downloading the videos.

6. Drawer locks



When I was testing the toy with my client we agreed that there should be a mechanism for stopping the drawer sliding out. This is particularly important for when the toy is being carried. Two simple locks, each side of the drawer would stop this from happening. I did some research into what these types of locks are called (“turn buttons”) and the different styles that are available.