little linac

Education through play to make even the hardest of times a little easier

10 Page Summary

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MENG Product Design Engineering

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THE GLASGOW SCHOOL OF ART

pde

The Problem

Radiotherapy for childhood cancer treatment

Every year in the UK over 1,600 young people, aged between 0 to 15 are diagnosed with cancer. One of the most common treatment programmes is radiotherapy, the use of x-rays to kill cancerous cells, however their is very limited child friendly information surrounding the treatment process and patient can often be overwhelmed by the experience, leading to the need to be sedated during treatment.

“The use general anaesthetic during treatment adds further risk to the patient, increased costs and limits patient intake”

“Lack of child and family friendly information about the radiotherapy process”

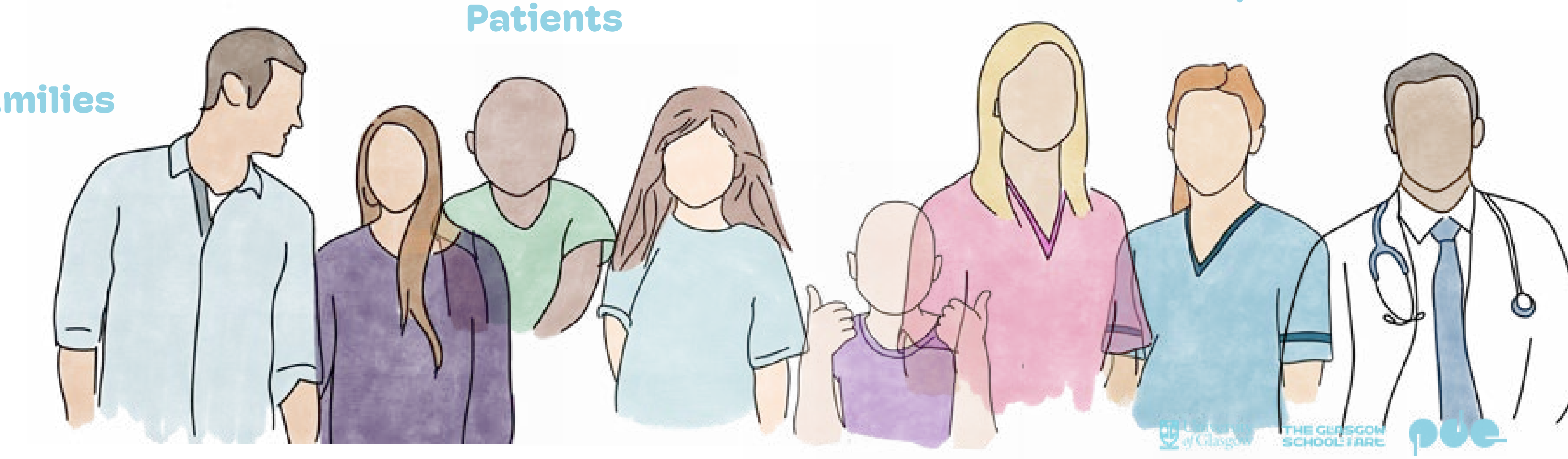
“Increased stress in young patients can lead to longer treatment times and inefficient imaging”

Stakeholders

Healthcare professional

Patients

Families



Research

Site visits

I was able to spent a lot of the research process focused on the two main treatment centres in Glasgow. 75% of all patients treated at the Beatson will be admitted patients at the children's hospital. I observed current systems in place to reduce stress, exploded the impacts of play therapy and spoke with patients and their families.

The Beatson Centre is the largest specialized cancer treatment centre in Scotland, treating up to 3 children a day. I was able to observer the typical user journey before and after treatment, visit the LINAC machine myself and identify the demand of more patient experience orientated products within the health care industry.

Existing solutions

Existing products on the market are largely focused towards the MRI experience, which is a very different machine and treatment process to the radiotherapy. While all the products were focused on reducing stress in the hospital environment, non where directly applicable to a patient undergoing radiotherapy and wanted to

User Group / Interviews

A wide range of interviews were conducted throughout the project with Radiotherapy staff, families, doctors and play specialists.

This highlighted that the product would be beneficial to a much wider group that initially suspected. The main focus would be on young patients aged 5 to 15 undergoing treatment

Environment of Use

The product was designed for use in hospital playrooms, such as the teddy hospital at Glasgow Children's hospital in order to fit in with existing play therapy routines. This would allow multiple children to benefit for the product each day.

The design brief

To design and implement a product or system, within the healthcare environment, to reduce stress and anxiety in paediatric patients undergoing radiotherapy for the treatment of cancerous tumours

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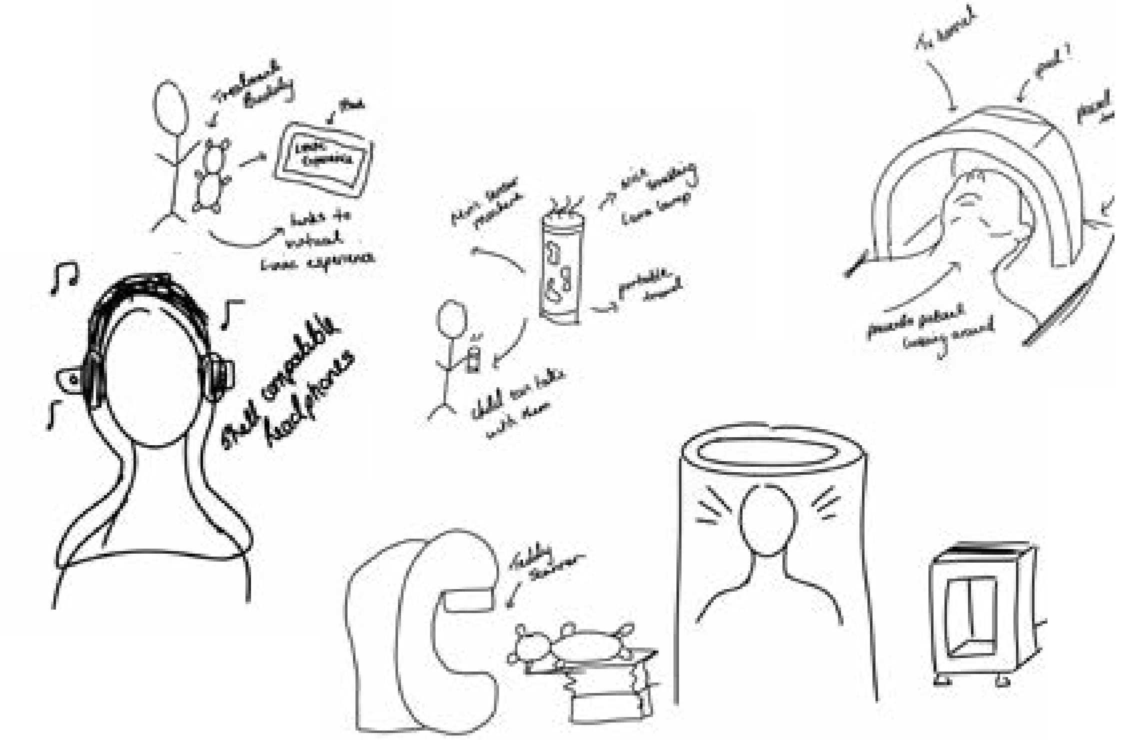
Concept development

2D Exploration



Real Scale

A huge range of initial concepts were generated based on researched distraction and play therapy techniques. These included VR googles to were whilst in the treatment machine, portable calming lights and . interactive pretreatment experiences. The selected concept was an educational toy model that children could use to treat a soft toy.

User Interaction

To establish the desired scale, features and motions the toy would need i used rapid prototyping to explore user interactions. Asking friends to act out different scenarios using the toy highlight which concepts worked and which didn't. The design underwent multiple iterations, with constant feedback from hospital staff.

3D Exploration

The aesthetic of the design was important as it had to accurately reflect the Radiotherapy machine, whilst remaining child friendly and fun to engage with. Using cardboard models and 3D printing varies design iterations could be produced.

The final design reflected a minimalist interpretation of the Linac machine in order attire to the design requirements so soft curves. A realistic colour scheme was stuck to after advice from hospital staff.

Product overview

Who

Children up to the age of 15 undergoing radiotherapy treatment

What

Teddy sized educational toy model of a radiotherapy LINAC machine.

When

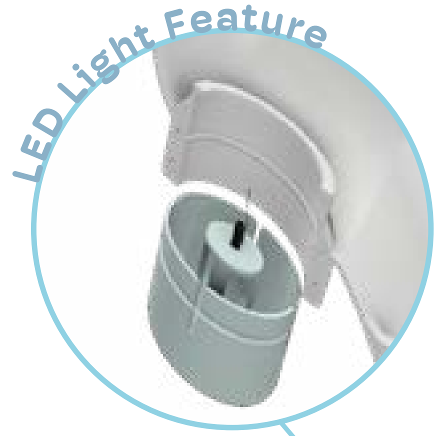
Before or during the treatment process to help aid in understanding and communication

Why

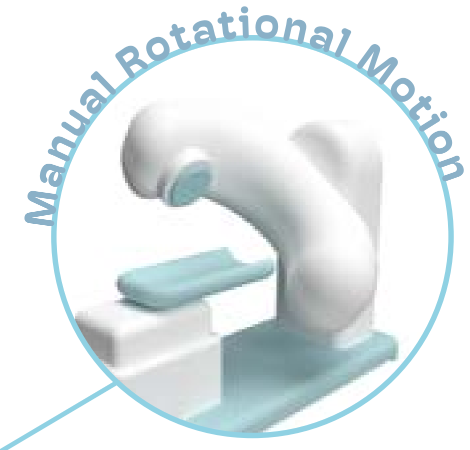
Help reduce pretreatment stress and anxiety by allowing children to explore the machine of their own scale

Where

The product will be used in the healthcare environment, such as a children's hospital or cancer treatment centre

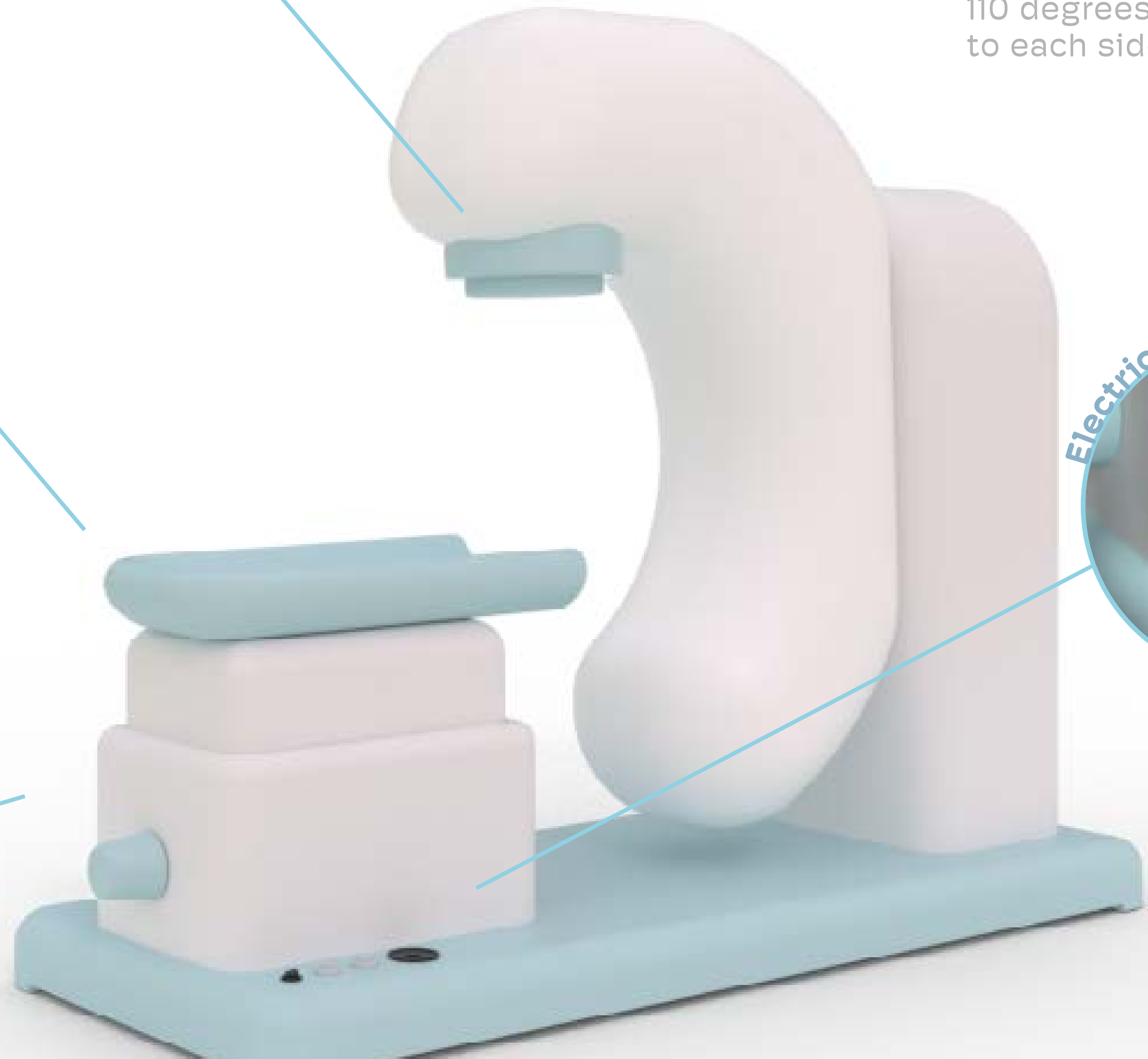


LED with cross section aperture to recreate proton beam aliment



Mimics movement of the real machine with 110 degrees of rotation to each side

Bed can be moved up to 100mm closer to Linac machine



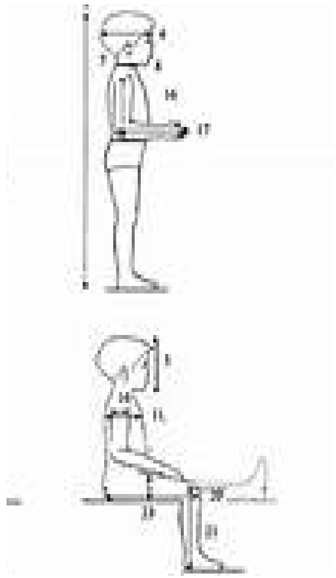
Simple control panel, no external remote required

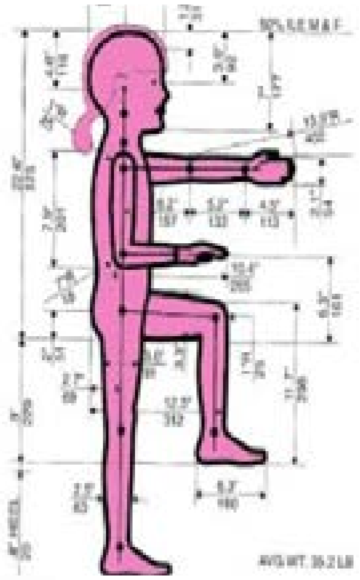
Self locking system design to allow for bed height adjusted up to 50mm

Development

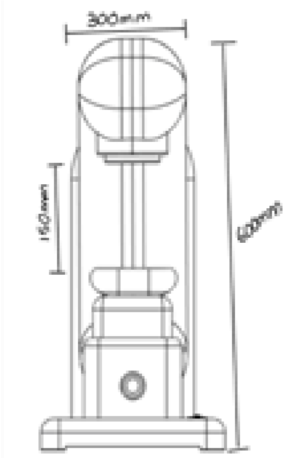
Anthropometrics and scale

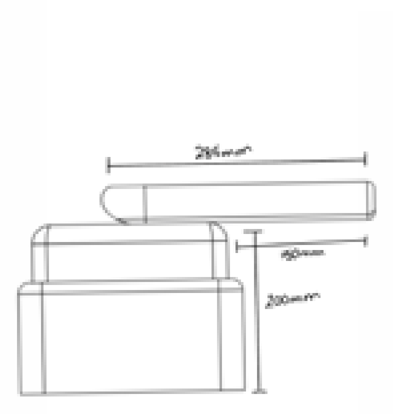
The finalised height of the design was defined using anthropometric data for children aged 5 to 15, looking at both the 5th and 90th percentile. With the 5th percentile height of 5 year old being 101.9cm, it was decided that the design should not exceed this or it would become to cumbersome for staff. The final height of the design was set at 600mm tall and 750mm wide.

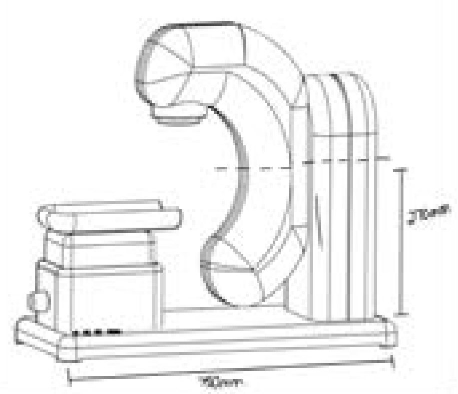




Children's upper arm length data for the same aged group was also considered, with the 10th percentile for a 5 and 15 year old 199 and 354 mm respectively. Due to the toll radiotherapy takes on patients health and energy level I wanted the majority of features to be easily controlled from a seated position. The max bed travel was decided 100mm, allowing for an appropriate amount of extension.







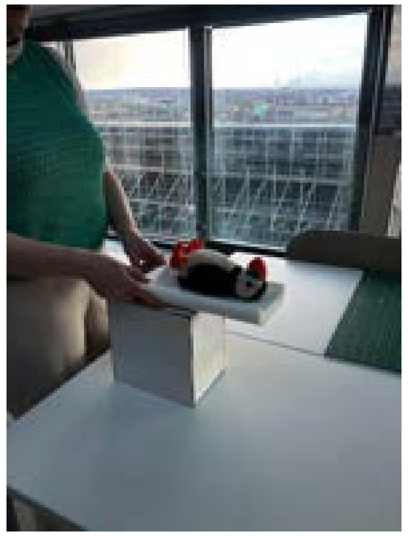
The handle for operating the vertical bed movement was set at 50mm, therefore with a base height 50mm a total of height of 100mm was suitable.

Linac machine features

It was decided early on that not all of the Linac features would be feasible to incorporate into the design. The side arms were neglected due to the possibility that they would add unnecessary width to the design and could be easily broken off by young children if made of plastic.

To demonstrate that the Linac machine comes very close but doesn't touch the patient, the distance from the bed to the Linac led section when fully extended is 150mm. This leave enough room for a suitable sized soft toy to fit onto the bed without the Linac touching it.

Defined interaction



Electrically controlled motion as considered however to increase user interaction and help patients to feel empowered, a manually operated design was chosen.

Technical content

Standards

As the toy is classed as an educational model it falls out with the Safety of Toys Directive outlined by the EU. However, the British standard BS EN 71: 2014+A1:2017 outlining toy safety was still considered during the process.

NHS safety and hygiene standards were also used to guide the development of the product, with no sharp corners or protruding elements allowed.

Mechanical movement

Mechanical function was of critical concern throughout the project. A huge range of different solutions were explored to provide the 3 main movements required.

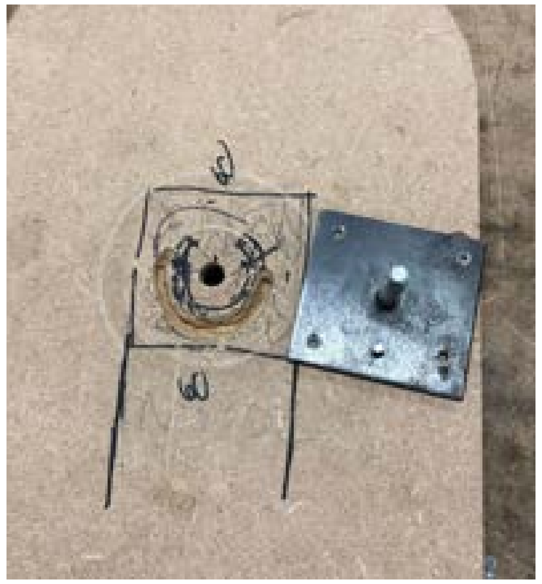
Bed sliding motion – Linear guided rail bearing for controlled and stable movement of 100mm.

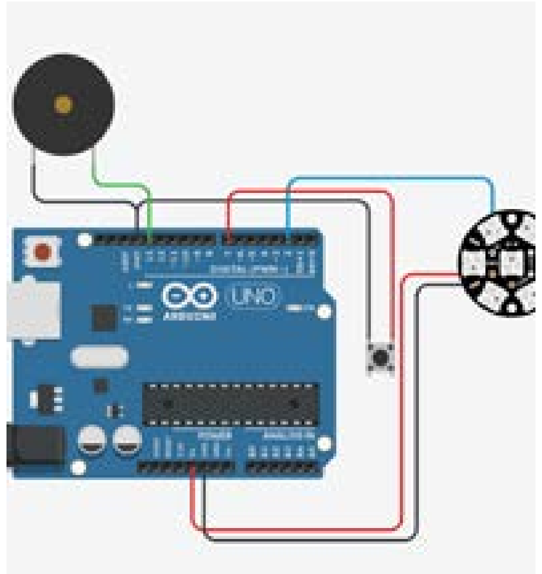
Rotational motion – a friction clutch was implemented to dampen the rotational motion and steel rod fixed at both ends of the backboard to prevent unwanted moment.

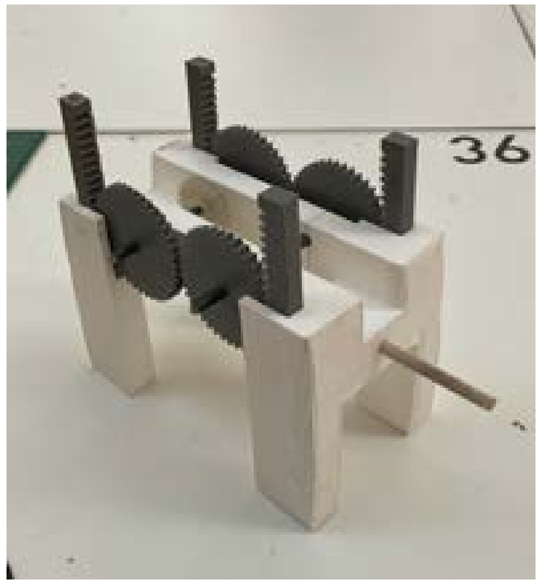
Vertical movement – Miniature screw jack system to

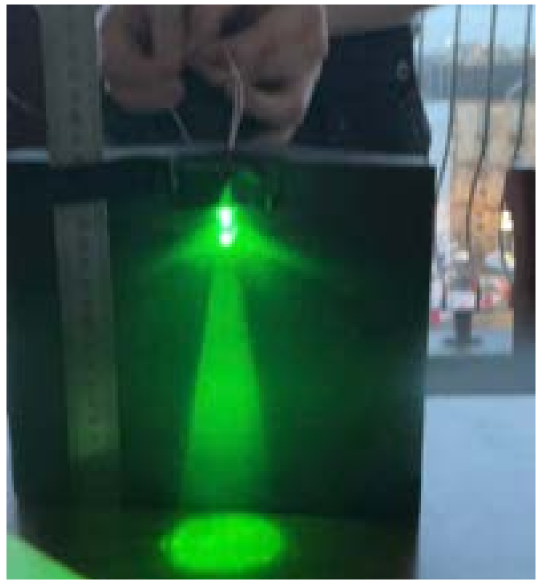
Electronics

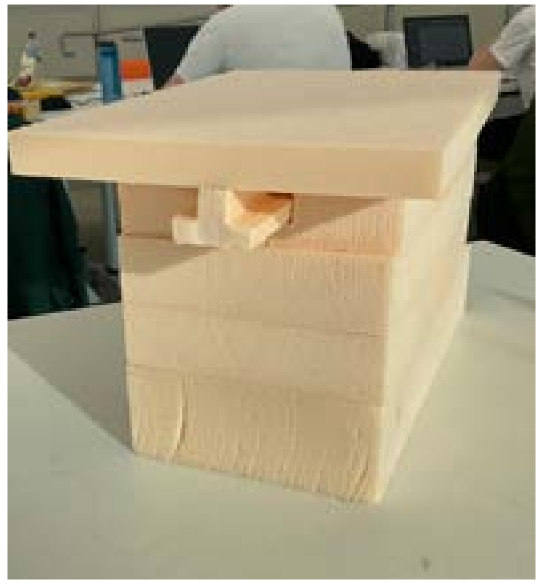
Arduino testing and circuit design where prototypes to establish the required electrical components for the design. The design had to be battery controlled to avoid extra NHS testing standards.

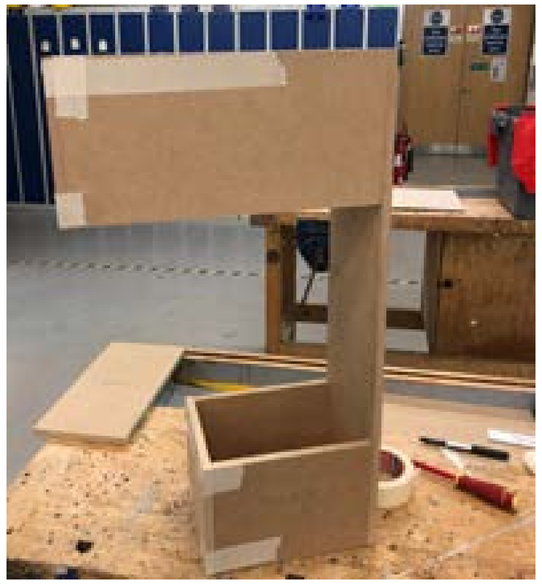








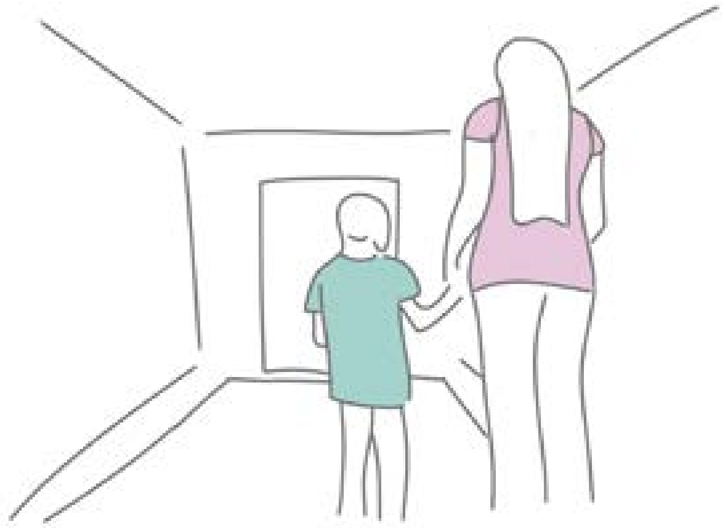




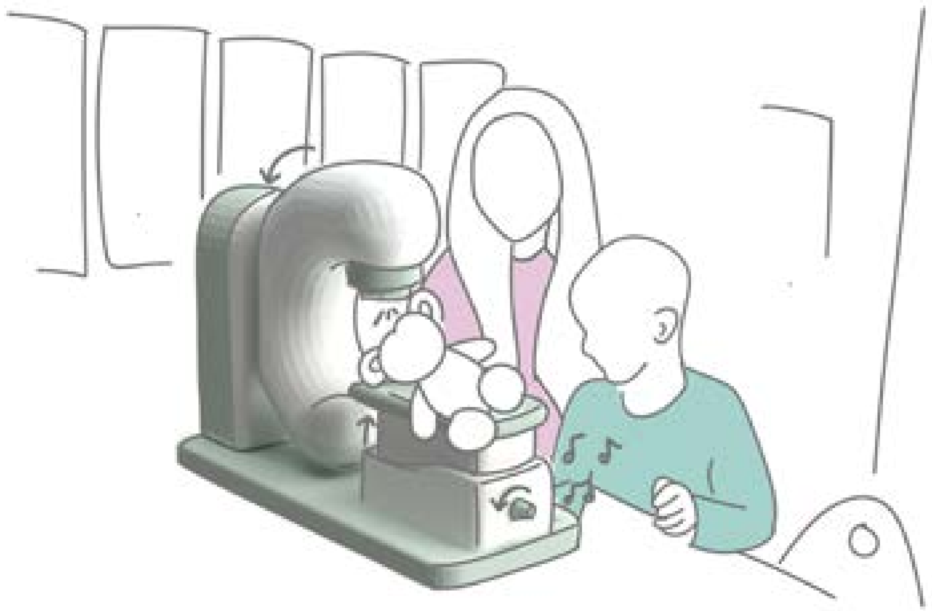
User journey

Patient expresses anxiety and before or during treatment process.

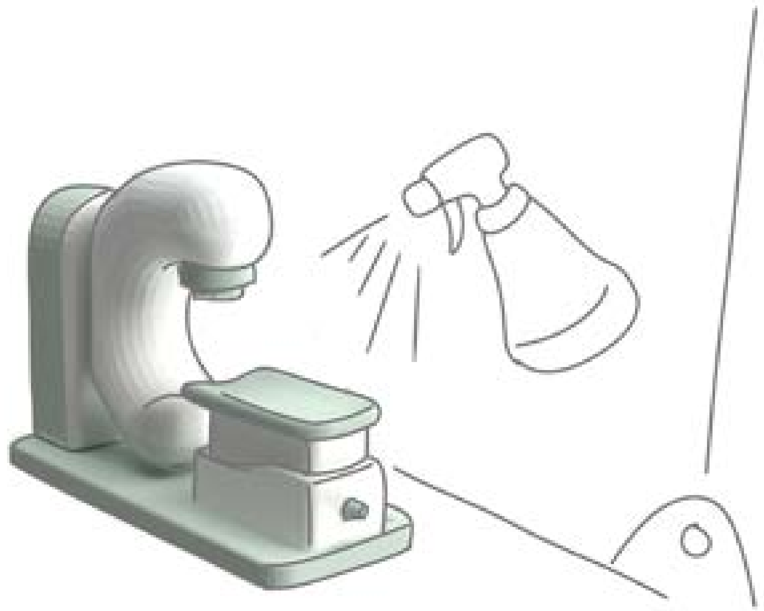
If able the play therapist will take the patient away from the ward.



The product will be used in a play room environment such as the teddy hospital. This is a familiar and relaxing space for the patient, adding to the experience



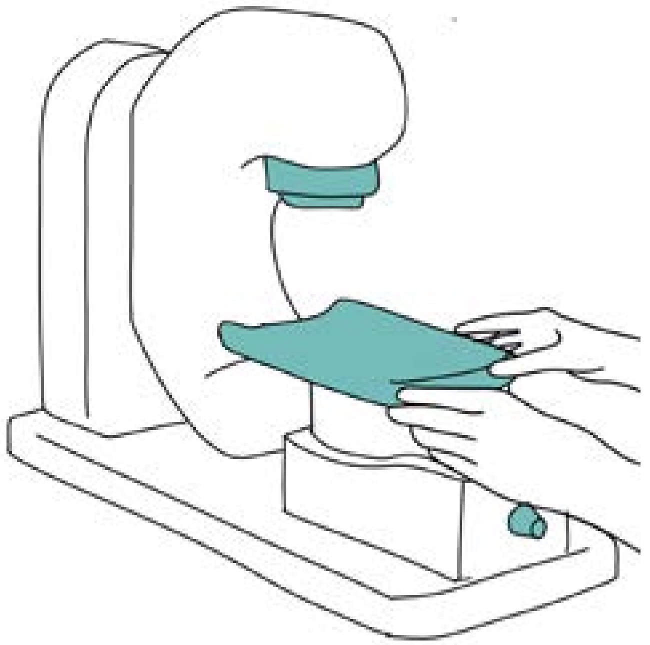
The child will be able to place a soft toy on the model and explore through play the different functions of the Linac machine. Movement, sound and light are all incorporated into the model. This is carried out under the supervision of staff.



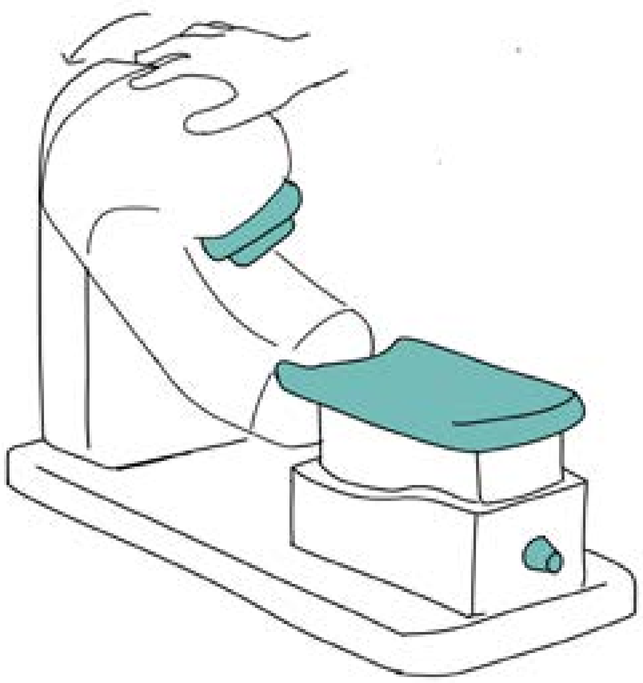
The curved design and plastic finish of the shape mean that it is easy to wipe down after play.

The flat base and back of the product allow it to be easily stored up against the wall, on top of tables or in a cupboard.

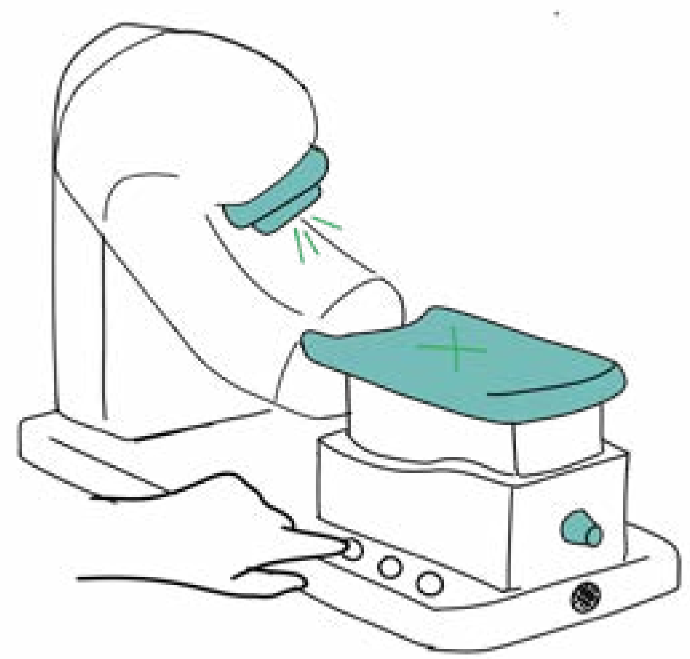
User interaction



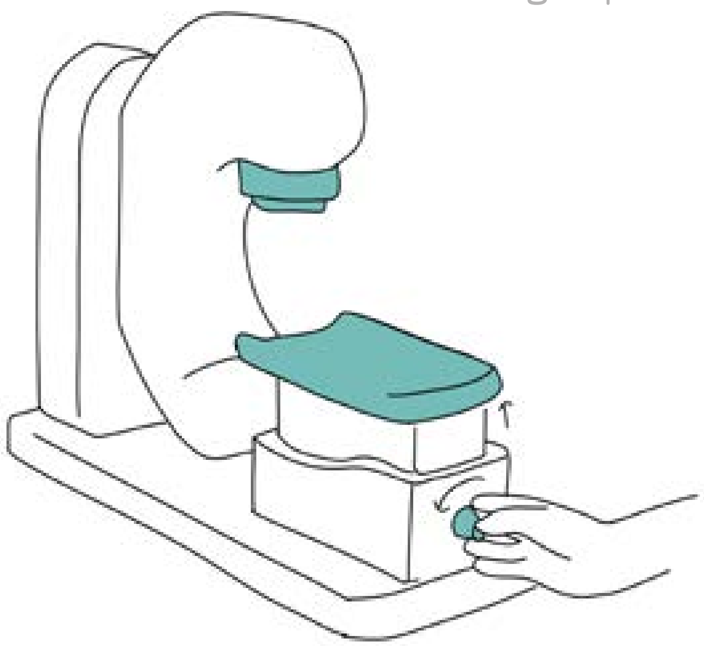
By pushing the bed, the patient can adjust the distance away the bed will be from the main body of the toy.



The rotational motion of the Linac is operated by hand, therefore the patient or play specialist has control of the rotation at all times to enchant the learning experience



To turn on the LED "proton beam" the patient simply pushes one of the buttons on the base. This will active the light for 30s.



The vertical position of the bed is controlled by the handle at the front of the bed. Patient can adjust the height within a 50mm range.

To replicate the sound of the machine, a small speaker is position on the Linac base. The patient simply pushes the button for 10s of sound play.

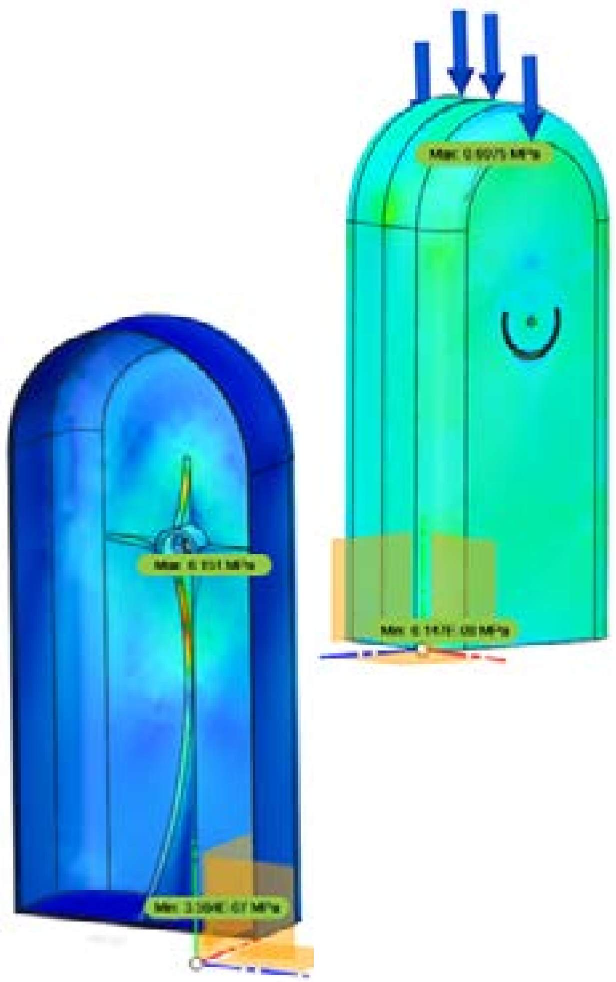
Design Details

Materials and Manufacturing

As the product is indented for a small batch production of fewer then 5 units, FDM 3D printing was selected at the primary manufacturing method. Typically associated as a prototyping tool only, 3D printing allows for a cheaper alternative to achieve injection mould like parts.

The final material for the overall product is polylactic acid (PLA) as it has low thermal expansion coefficient making it ideal for the printing of large scale parts. Available in a range of colours and already medically approved PLA was also the more environmental conscious section compared to ABS or Nylon.

Structural Integrity and wall thickness

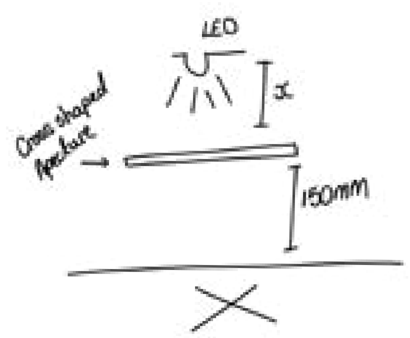


Fusion based FEA was used to determine the required wall thickness and ribbing in order for the toy to withstand the impact of play.

Unlike injection moulding 3D parts are not constricted to tooling limitations therefore a universal thickness of 2.5mm was decided for both walls and ribbing.

Double walled parts would have a reduced wall thickness of 1mm with 20% infill to provided the required structural integrity but reduce overall component weight.

LED light projection



When pressed the LED projects a green cross onto the treatment bed, to represent the proton alignment beam. Experimental testing was carried out do establish a suitable size and intensity of light, with the cross, at the maximum distance from bed being 100mm in length.

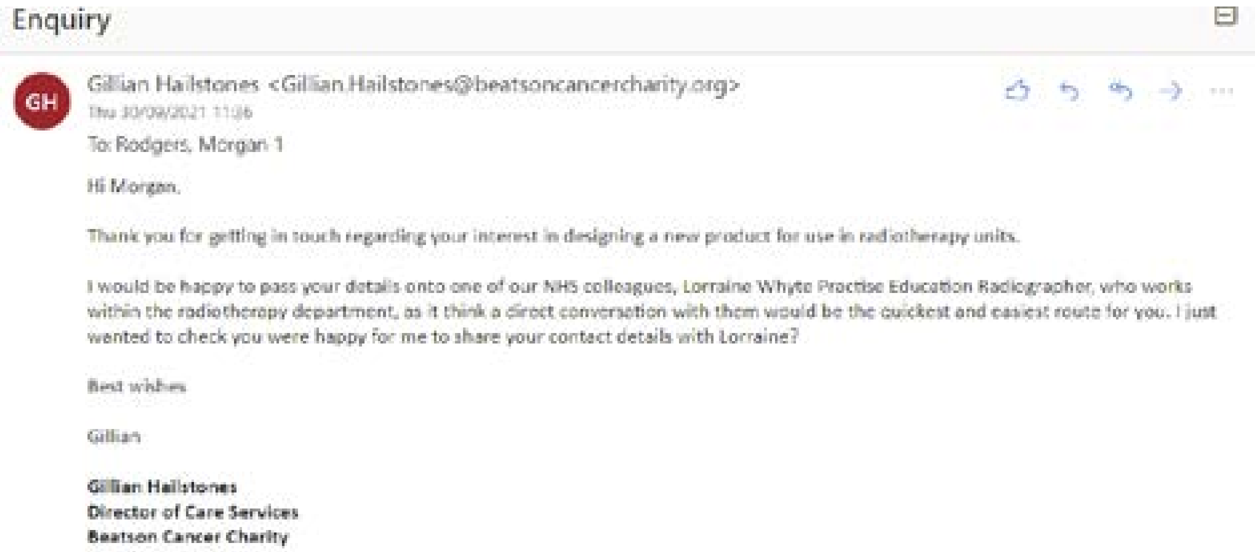
Rotation

A friction clutch mechanism allows for controlled, damped rotation of the Linac bed in a 220 degree arc.

Communication with Beatson

Discover

Communication with staff has been ongoing throughout the design process with support from the Beastson Charity early in the project.


Enquiry

Gillian Hailstones <Gillian.Hailstones@beatsoncancercharity.org>
Thu 30/09/2021 11:36
To: Rodgers, Morgan 1

Hi Morgan,

Thank you for getting in touch regarding your interest in designing a new product for use in radiotherapy units.

I would be happy to pass your details onto one of our NHS colleagues, Lorraine Whyte Practise Education Radiographer, who works within the radiotherapy department, as it think a direct conversation with them would be the quickest and easiest route for you. I just wanted to check you were happy for me to share your contact details with Lorraine?

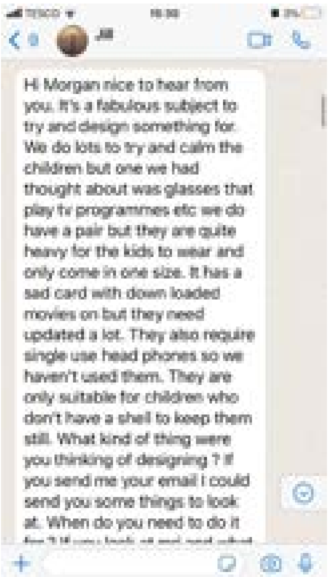
Best wishes

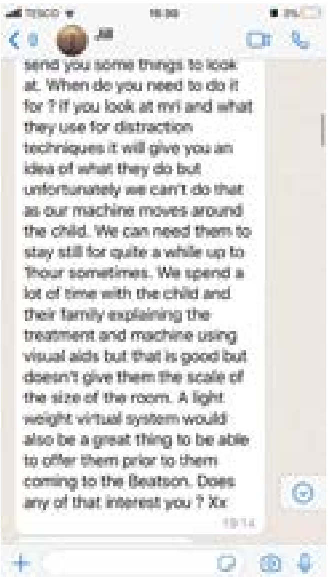
Gillian

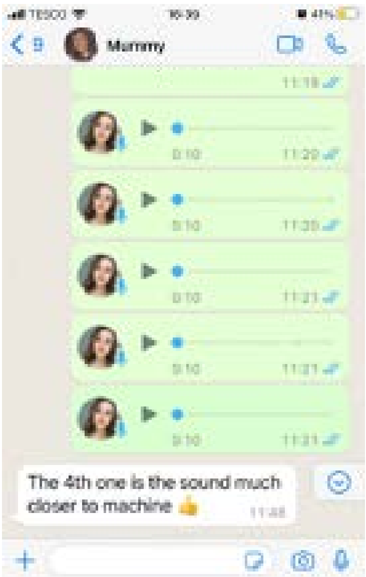
Gillian Hailstones
Director of Care Services
Beatson Cancer Charity

Develop

During the development stages staff were consulted, aiding in the concept selection by advising on what designs were actually suitable and could be realistic implemented into the current treatment journey. Staff also offered support such as advising on the lighting and sound aspects.







Define and testing

Final scale prototypes were sent to the Beatson so that further feedback could be gathered from the whole department. It was also important to see the product in its environment of use and despite only being a small model, I was still able to access the impact the project was having.

Quotes from staff

"Its amazing to see a design focused around the radiotherapy treatment process for once"
- Lorraine Whyte

"A product like this will have such a lasting impact on patients undergoing radiotherapy " - Alice Paterson

"Making the treatment process as fun as possible is the most important part of our job - a toy like this helps us do just that" - Jill Scott

"We want a design that allows children to feel comfortable around the machine - this idea achieves that perfectly" - Maureen Smith

Assembly and parts list

Bill of Materials

Part Name	Quantity	Material	Manufacture method	Finishing (if required)
Linac body 1	1	PLA	FDM Printing	Sanding
Linac body 2	1	PLA	FDM Printing	Sanding
Backboard 1	1	PLA	FDM Printing	Sanding
Backboard 2	1	PLA	FDM Printing	Sanding
LED casing	1	PLA	FDM Printing	Sanding
Bed	1	PLA	FDM Printing	Sanding
Bed lid	1	PLA	FDM Printing	Sanding
Bed base	1	PLA	FDM Printing	Sanding
Screwjack holder	1	PLA	FDM Printing	N/A
Base 1	1	PLA	FDM Printing	Sanding
Base 2	1	PLA	Laser Cut	Sanding
Handle	1	PLA	FDM Printing	Sanding
Led	1	N/A	Bought	N/A
Led holder	1	Nylon	Bought	N/A
speaker	1	N/A	Bought	N/A
push button	2		Bought	N/A
switch	1		Bought	N/A
battery holder	1	ABS	Bought	N/A
ATtiny	1	N/A	Bought	N/A
Clutch	1	Aluminium	Bought	N/A
Bearing	1	Aluminium	Bought	N/A
Steel plate	1	Stainless Steel	Punching	Polishing
Steel rod	1	Stainless Steel	Bought / cut	Polishing
stopper	1	Stainless Steel	punching / welding	Polishing
gear box	1	ABS/Aluminium	Bought	N/A
trapezional lead screw	1	(1015) carbon steel	Bought	N/A
nut	1	Brass	Bought	N/A
Linear rail	1	Stainless Steel	Bought	N/A
Linear guide	1	Stainless Steel	Bought	N/A
screws (Tamper proof)	30	Aluminium	Bought	N/A
Metal pins	10	Aluminium	Bought	N/A