Pearson Edexcel
GCSE (9-1)
Design & Technology
Module 4 – Q and A

First teaching in 2017

First assessment 2019

Pearson

Part 1: New exemplar portfolio and commentary

Part 2: Your Questions answered from Module 3

Part 3: Live questions and answers session

Pearson

Please Note:
This training material is designed to cover assessment for 2023 and beyond.

Pearson

Exemplar folder and commentary

Pearson

NEA

ASSISTING PEOPLE WHEN SHOPPING IN TOWN CENTRES

Links to video clips will not work here on the training document.
Reminder a separate file containing MP4 work can be uploaded to the Learner Work Transfer Platform

Any videos within this project will not be accessible through the .pdf document however there are links on the slides that contain videos. These links will allow you to access the video on youtube. These videos have been uploaded in a way that only allows people with the link to access. The links look like the red box to the side of this text.

Link to video

- Investigation
- Specification
- Initial Ideas
- Ideas Review
- Development
- Chosen Design
- Review of Chosen Design
- Materials & properties
- Construction
- Testing & Evaluation

RESEARCH OF A SPECIFIC TOWN CENTRE

Gloucester is a very large city / town in Gloucestershire and this makes it a perfect place to find out about town centres and how people can be assisted whilst shopping. It has many different areas that could be researched specifically, however I have chosen Gloucester Quays due to its different ways that shoppers are assisted as well as its popularity. It is within walking distance of Gloucester's town centre making it a largely important part of the town.

Gloucester Quays has many different ways that it can be accessed such as the adjoining car park and many different entrances for people on foot, most of which have automatic doors. The shopping centre as a whole has a relatively flat floor plan as most of it is only on the ground floor and therefore does not require help up to different levels. Elevators can be found for people that need assistance getting back to their car in the multi-story car park. A customer service help desk is located as you enter the main front entrance, this can make it easter to find instructions and get directions to specific shops as well as any other help a customer might require.

It offers a large variety of shops and restaurants so it caters best for people that want to shop or get something to eat. Many different types of shoppers would like Gloucester Quays due to the wide variety of shops that sell different types of products from clothing to books and stationery.

The shopping centre has both indoor and outdoor areas so it accounts for any weather conditions from a rainy day because people can stay inside to a sunny day where shoppers can use the outdoor area and shops that come with it. The large downside to this is for the business owners as the indoors shops will be more desirable and therefore cost much more.

Page conclusion:

Town centres can assist shopping in a large variety of ways, many of which we will take for granted due to them being so common. Some of these will be more beneficial than others such as a flat floor plan being more important than the implementation of stairs for some people. A large variety of different shops will bring people to the town centre in the first place so this is also very important.

MY CLIENT PROFILE

For my client I have decided to talk to the town centre manager to get ideas about what can be improved in the town centre and suggestions about potential products that might improve people's visits.

Me - What would you suggest are problems that most town centres face when it comes to assisting shoppers?

Manager - I believe that a very common problem many town centres face is finding the balance between aesthetics and not making the town centre too difficult to traverse. It is easy to get ambitious about many different levels and stories of the the town centre itself however these must be easy for everyone to move around even if this means dialing some ideas back.

Me - What products and forms of help do you personally use whilst shopping in town centres?

Manager - I do not require any specific products whilst I am shopping however there are a few things that I do like and find very important when carrying large amounts of bags. I like automatic doors as this stops the struggle of opening and closing a door with no free hands. I also like escalators as they remove the need of stairs though I do understand that they are not helpful for everybody. In this specific case I suggest the use of lifts.

Me - What sort of products would you suggest to be developed to help others whilst shopping in a town centre?

Manager - I would like the implementations of an easier way to carry many different bags at the same time as this can create some difficulty for those who buy lots. As these are the people that use our services the most I believe we should spend more of our time creating something that makes their lives easier. I also believe that there is not enough to help people that require wheelchairs as they might not have the ability to carry lots of shopping bags and there is very little to help them with this problem.

Me - What is you best suggestion for designers of products to assist people shopping in town centres?

Manager - My best suggestion would be to pick a problem that you have identified and try and remove that problem entirely or to the best of your ability with your product. The product that you are designing must be truly helpful for people and not create more of a hassle for them than it removes if you want them to start using it without others suggestion.

Page conclusion:

In this page you will see a conversation between me and a town centre manager where I have asked some questions to find out about what needs to be changed and potential ideas for products that I can develop.

EXISTING PRODUCTS

There are already many different products and ideas that have been implemented into town centres to help and assist the people shopping there. Some of these ideas have been adopted more commonly than others in different shopping centres.

- Trolleys are very common in shopping centres, less common in town centres and allow most people to carry more of their shopping **(Function)** however there are some that can't use them such as people in wheelchairs. Some larger supermarkets will have specific trolleys to attach to the wheelchairs. These seem like a good start towards helping people that require wheelchairs however they are not very common and are not the best solution to the problem as most of the time they are bulky **(Form)** and more difficult to use.
- Wheelchair ramps allow people who cannot use stairs to navigate around the layers and levels of the town centre **(Function)**. However they are more difficult to go up as they can be steep and are less convenient than other alternatives such as lifts and wheelchair friendly escalators. They have many different appearances as they can be made to fit a specific aesthetic **(Form)**.
- Mobile apps are a new way that town centres are making themselves more easily traversable. These apps are able to tell the user where they are and also directions to where they want to go **(Function)**. They are a very simple way to make shopping easier for most. This does rely on other factors such as people owning phones and other mobile devices as well as having means to access the internet however in our society today it is safe to assume that most people will own a mobile phone and have the means to connect to the internet.
- Direction boards are another relatively new idea that are helping people in town centres. They are put up to provide information about where you are and how to get to other places **(Function)**. They have very little downsides as they don't rely on other items that people might or might not own. They are stationary boards **(Form)** so if the town centre does not have enough of them they can be difficult to find.
- Elevators are a very commonly implemented means to bring people to a different level of a building **(Function)** due to the limited floor space needed **(Form)** for them to function and their ease of use.
- Escalators are another idea that has been around for a long time and so people have had a long time to adapt and get used to them. They are very similar to elevators due to them both helping people get to the next level of a building **(Function)** however escalators are less accessible as most do not allow for people in wheelchairs to use them. There are a few exceptions to this as some have been made into moving ramps rather than moving stairs **(Form)** allowing anybody to used them with ease.
- Help desks are something that can be found in many town centres due to their simplicity and easy human interaction **(Function)**. Sometimes people don't want to use technology to find their way around and would rather speak to a real person and this gives them the opportunity to do so. They also allow for other products to be sold or new shops to be advertised.
- Paper folded town maps **(Form)** can be found in limited places nowadays due to the increase of electronic alternatives **(Function)**. A lot of the time these electronic maps are a much better option for the town centre due to the lower cost as printed copies are not required, however there are still some people that would prefer a paper town map as they might see it as more convenient or more trustworthy.
- Automatic doors made of transparent glass, make shopping easier as they remove the need to open doors **(Function)**, this is especially helpful that people are carrying shopping and those with disabilities that limit movement.

Page conclusion:

Products that can assist people whilst shopping are very common in a modern town center as they are necessities for many people. The form and function of each product are both important factors that can determine how well a product works and whether its aesthetic matches the desired look

MARKET RESEARCH

I have sent out a survey to many people to find out information about peoples visits to town centres and what specifically they want and value when they visit. I believe that I have had enough information to give me a good understanding of people's preferences and trends that can be found within them.

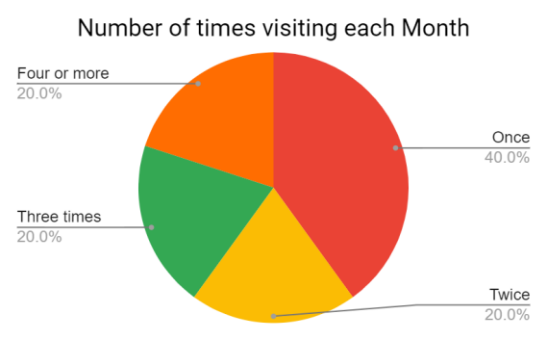
Everybody that was surveyed visits a town centre at least once a month, with most people falling into this section. Some visit more than this and a few visit four or more times a month.

Most people visit their closest town centre however some travel further afield for different reasons such as looking for different types of items that cannot be found at their local town centre.

Most people seem to fall into a few groups when it comes to consistency as they either care very little or care a lot. This means that roughly half of people will be happy to change what they are used to if a better option arises.

The average number of bags that people carry is 2 with some carrying more and others carry less. The group that carries more bags has more of a dislike for them as they are shapes that don't help those carrying more and the people that carry less seem to be neutral about the subject as they are not affected by poorly designed bags as much as others.

The large majority of people visit town centres for shopping or for food so these are the two main categories that I believe should be developed the most.



Page conclusion:

Most people only visit a town centre once a month. Some carry lots of bags and don't like them because or poor design. Roughly half of people don't value consistency very much and would be happy to change their norms.

SPECIFIC PRODUCT ANALYSIS: TROLLEYS

Trolleys are a very widely used product that can be found in many different places from shopping centres to town centres. There are many different reasons for this such as;

- Ease of use. This can be very important because people want to have the easiest option possible.
- Simplicity and cost. This is helpful because the easier their form is to understand the easier they are to manufacture and subsequently cost less making them more widely found and available. This also makes them easier for people to use.
- In almost all cases they are not made of luxury materials and do not require any extremely specialist or expensive equipment to manufacture.
- Many different people are able to use them due to the wide variety of types that can be found, they can also be made to work with specific niches and compatible with people who have disabilities.
- When people are accustomed to something they like consistency.
- The possibility of sustainable materials being used makes them an ideal option for many people.

Outside of the normal trolley that can be found in supermarkets there are other trolleys that can be used for other things and are primarily designed for a specialised purpose.

Trolleys that are designed to carry large pieces of wood or large sheets of material can be found most commonly in places that you would buy these items. They usually consist of large flat sides that the sheets of material can rest against so that they are stable, this makes their form fit their function.

There are also trolleys that people can buy and own themselves and they can be brought to any place that they are needed. They are ideal for people that cannot drive because they can help carry shopping home from a town centre or supermarket. These are usually quite small and relatively light as they are designed to be carried or pulled around easily.

Some trolleys have been designed to climb stairs and this lowers the workload of the person that needs to use them. If the person didn't use one of these specialised trolleys they would have to carry the item up the stairs and this could be difficult if the item was excessively heavy. The other large upside is that employers are suggested to not make workers carry anything in excess of 16kg for women and 25kg for men so this would allow heavier objects to be moved up stairs. The form of this trolley is highly developed to its function.

Page conclusion:

There are many different types of trolleys. The form of a trolley is very well refined in most circumstances as they are built off of very simple design premise. This also allows them to be modified to specific functions that might not otherwise be accounted for.

SPECIFIC PRODUCT ANALYSIS: WHEELCHAIR RAMPS

Wheelchair ramps are a very common way that town centres can help their shoppers, staff and everyone that may need to use them. They are very simple and allow for them to be implemented very easily. People that require wheelchairs can use them to get to levels of the town centre or shopping centre that they otherwise couldn't access. Wheelchair ramps have a suggested incline of 1 cm of height gained for every 12 cm moved forward, this means that even though they are very simple they do have some downsides such as the space required.

Other alternatives such as an elevator may be better however this is completely dependent on the specific situation. Factors like cost, space availability and the desired aesthetic will determine which should be used.

There aren't many disadvantages to wheelchair ramps however the few can make a large impact on the user. If the ramp is too steep there is an increased possibility of the wheelchair tipping backwards and this poses a large amount of unneeded danger for the users. This can also make the use of manual wheelchairs more difficult because it makes it too difficult to push. Ramps without guardrails have an increased chance of people falling off of either side and this has large dangers for any users.

Other things like the materials used can make a difference to wheelchair ramps. There are a number of factors that can affect the material used;

- Overall budget of the project, cheaper materials such as wood will be better in a situation of a smaller budget whereas brick or metals can be better suited to larger budgets.
- Whether the wheelchair ramp will be used inside of outside makes a difference to the materials that can be used as it might need to be suitable for outside use or strong weather conditions.
- If the wheelchair ramp is going to be used by many people can affect the budget and the decisions of its desired longevity.
- The desired aesthetic can have a large impact on the chosen material as some might not fit the surroundings due to their looks.
- If the wheelchair ramp is to be built into the surrounding building or if it is going to be an addition, this can decide the materials needed as they might need to match.
- If it is to be used in an area with lots of rain, the use of grip on the floor may have some benefits as it can stop wheels from slipping and help with the prevention of accidents.

Page conclusion:

The form of a wheelchair ramp is very refined due to their simplicity and extended uses and their function can be unrivaled in specific situations where a large space is available for use. For these reasons they are very common and can be found in lots of town centres. There are also a large variety of materials that can be used, this helps with making them fit in with a desired aesthetic and use case.

MATERIALS RESEARCH

These are some potential materials that could be used to create my final product. I have chosen to research materials that are widely recyclable and can then be reused. The aim of the material being recyclable is to cause the least amount of damage to the environment as possible:

PLA (polylactic acid) is common in 3D printing because it has a relatively low cost whilst having a high tensile strength. It is very easy to manufacture products with because it melts at a low temperature when compared to other options such as ABS so less energy is required for heating. PLA also emits less greenhouse gasses and does not emit toxic gasses. There are many different colours available so the desired aesthetic of a product can be reached fairly easily. PLA is reusable due to its ability to be recycled making it less damaging to the environment. PLA is also able to be made into lots of different and specific shapes due to its use in 3D printing.

Otherwise known as flexible filament, **TPE** (thermoplastic elastomers) can be found commonly used for 3D printing as it can be used for flexible prints that require stretching or movement. It is more difficult to manufacture because it requires more specialized equipment such as a different 3D printer. TPE does have some other useful properties; good resistance to chemicals and weathering, can be coloured differently for desired aesthetics, high impact strength and tear resistance. The recyclability of TPE is very important as it allows it to be used more than once and cause minimal damage to the environment.

Acrylic is commonly used in laser cutting machines as it is very often found in large flat sheets, this makes it ideal for cutting into different shapes. You can find it in a very large variety of different colours so the desired aesthetic can be reached very easily. It is very brittle so it is not ideal for any use where it would be bent or put under lots of pressure and stress. It is a relatively lightweight material making it ideal for use in cases where weight would be a large factor. Acrylic is recyclable however it is not easy.

Aluminium follows many of the same trends as most metals meaning that it conducts electricity and heat very well and has a very high tensile strength allowing it to withstand large amounts of force without being deformed. It can be found in large sheets and less commonly found in profiles allowing it to be used to many different purposes. The large sheets of aluminium can be cut to desired shapes and sizes using CNC machines, these can all have different specifications so they will all be able to cut different thicknesses of material. You are also able to cut aluminium with some hand tools making it very easy to work with. It is not commonly found in different colours like the plastics so the use of paint would most likely be needed to get the desired aesthetic of the product. Aluminium is the most cost effective material to recycle.

Page conclusion:

The material that is chosen to be used in a product heavily depends on the aesthetics that are desired as well as the properties that are needed. It is very important that materials can be recycled so that they do not cause more damage than necessary to the environment.

ERGONOMICS AND ANTHROPOMETRICS

I found a survey originally taken by NASA that shows the average had sizes for men and women, this will allow me to make my final project to dimensions that will fit people correctly.

For a product that would easily fit both men and women the design should find the midpoint between both mens and womens hand sizes.

For a product that is designed to be carried to be comfortable it must follow a few rules:

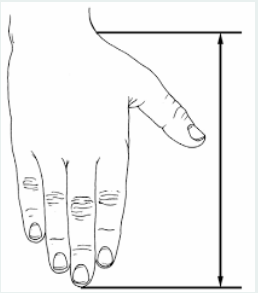
- The weight must be evenly distributed among the product so that it is not difficult to pick up.
- It must be comfortable to hold - the most comfortable handles are 19.7% of the users hand length in diameter.
- It is not too light nor too heavy to pick up easily.

For much heavier items the majority of people can lift between 50 and 75 kg so the weight should stay well under this as to account for people that are under this average because a good product should account for everybody.

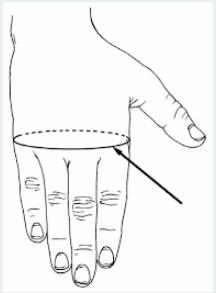
On average people can reach 28% of their height off of the ground. Due to the average height of all people being 162 cm the height of a product off of the ground should be 45 cm or higher to allow everybody to reach it comfortably.

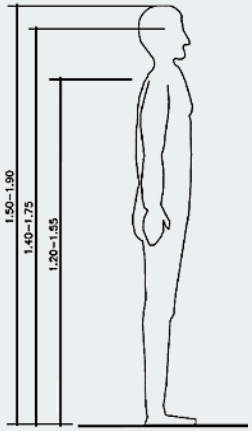
When designing a product you should always use averages of all people because this will allow everybody to use your product. If you use averages of a specific group then you might be stopping your products benign used by everyone else. On the other hand if your product is intended to be used by a specific group of people then using their specific averages might be the right thing to do.

Length



Circumference





	Average hand length	Average hand circumference
Men	19.3 cm	21.8 cm
Women	17.3 cm	17.8 cm

Page conclusion:

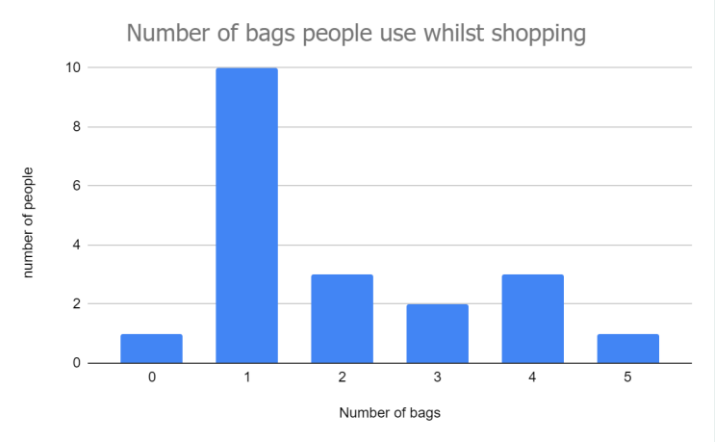
It is very important to research the anthropometrics that are relevant to your product as this allows you to size things so that they are ergonomic and easy for people to hold and use.

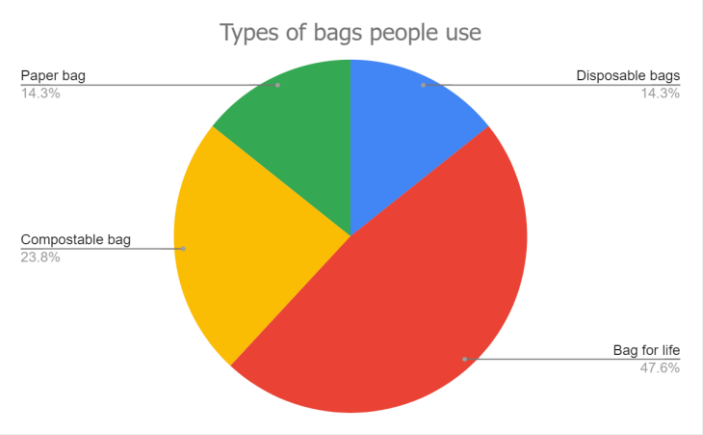
BAG SIZING AND RESEARCH

There are many different types of bag that people choose from while shopping. Each has very different dimensions as they have different intended use cases and life spans. There are also many different materials that are used such as cotton for bags that do not need to withstand much stress and plastics used for bag for life bags.

I asked a group of people what types of bags they use whilst shopping and how many they commonly use. Most people only use 1 bag whilst shopping. The most frequently used bag was a bag for life followed by a compostable bag. When talking to this group about their choices I found out that people either want to use a bag that they can continue using or use a bag that will not damage the environment when it's thrown away. This explains people's choices of a Bag for life and a compostable bag.

There is an industry standard for bags for life that almost all retailers stick to. 450 x 380 x 180 (all measurements in mm) is the most common size of bag.





DESIGN SPECIFICATION

Design brief -
The problem that I would like to solve with relation to assisting shopping in town centres is ensuring that everybody is able to carry as many bags around with them as they need. Some people might not be able to carry as many bags as they want for various different reasons. This can lead to them spending less time in the shopping centre and spending less money.

The product that I decide to create must have the ability to work properly for anybody that is not a young child as this would not be unnecessary for them. Anybody that goes shopping should be able to benefit from my final product for it to have the most positive impact.

	Specification requirement	Justification	Testing for success
Form **(SP 1)**	The product would have to have the ability to carry 3 bags of the bag to life size (from my research).	During my research I found that the average number bags used by a shopper is 1 however, many people also carry 2 or 3 bags.	I would check if the final product is able to carry 3 bags to the correct scale of a bag for life size.
Function **(SP 2)**	The product would have to be able to relieve people of carrying bags around a shopping centre.	This is because carrying bags for a long time can be tiring and the ability to carry more will allow people to shop for longer.	Does the product have the ability to relieve the stress of carrying bags for the user.
User requirements **(SP 3)**	The user would have to be able to reach their bags easily and if the product has handles they would have to be the correct size.	The product should be as ergonomic and easy for the user to use as possible.	Use the ergonomics and anthropometric data to ensure the sizes are correct.
Materials **(SP 4)**	The material chosen for the product would have to be weather resistant.	This would allow the product to be used outside during rain or other weather conditions.	Use the product in the rain and test for any damage caused to it.
Scale of production **(SP 5)**	The product would be made using batch production.	This product would not just be a one off and there would be not need to have a large scale factory set up for a medium number or units.	Check whether the manufacturing methods and process used adequate for batch production.
Sustainability **(SP 6)**	The materials chosen for the production of the product will have to be recyclable.	This is so they cause the least amount of damage to the environment as possible.	Checking that all of the materials used in the final product are fully recyclable and sourced sustainably.
Safety **(SP 7)**	The product has very little to no safety risks.	This would stop people that are using the product from getting hurt from its use.	First check to see if there are any obvious hazards and then using the product and testing if it causes any harm to the user.
Cost **(SP 8)**	The cost of the product would have to be kept as low as possible.	This is to allow the highest number of town centres or users to afford the product.	Use surveys to find out if the final cost of the product is seen as affordable or not.
Dimensions **(SP 9)**	The dimensions would have to be small enough to fit around the town centre without obstructing anybody.	If the product caused an obstruction for the user then realistically it would not be used.	Using the product around a town centre and testing if it fits through small spaces.

Portfolio Mark records

1 Investigate	Page ref	Comments	Level	Mark awarded (please circle)	Pearson use only
1.1 Investigation of needs and research (AO1 8 marks)		They have started by setting the contextual challenge into a context they know well. They have sought to find out what potential users might need help with when shopping including some primary research when interviewing a shopping centre manager. They have looked at a good range of existing products in some depth which is well justified and with good detail they have started to identify aspects of form and function that would help shoppers in a town centre. They identify a problem with the number of shopping bags people can end up carrying during their stay in the town centre. A specific size of bag has been determined and this is then further investigated by looking at some ergonomic and anthropometric specific data detailing the size of hands and the height bags are comfortably carried above the floor to support a potential prototype product. This constitutes a good example of work seen in the highest mark band and is agreed to be representative of the full **8 marks.**	No rewardable material	**0**	
			Level 1	**1** **2** **3**	
			Level 2	**4** **5** **6**	
			Level 3	**7** **8**	
1.2 Specification (AO1 8 marks)		The candidate has produced a design brief that is open has been developed from the investigation when user needs have been explored. It has been written to enable the contextual challenge to be relevantly explored further in the project ahead. The candidate sets out a suitable range of specification titles but unfortunately does not complete the specification points with many really detailed points and justifications that are realistic & measurable in sufficient depth to be assessed in the higher mark band. A mark at the top of the level 2 mark band is appropriate as they have included enough points that are realistic and measurable	No rewardable material	**0**	
			Level 1	**1** **2** **3**	
			Level 2	**4** **5** **6**	
			Level 3	**7** **8**	

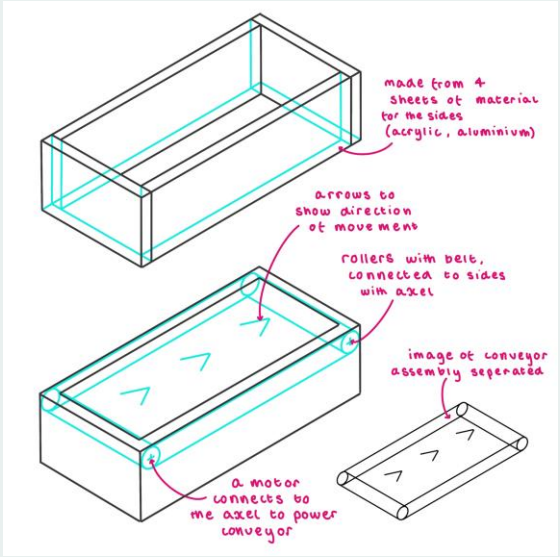
IDEA 1 - BAG CONVEYOR BELT

This conveyor belt would allow people to put their bags on it and walk alongside them **(SP 1)**. Ideally the conveyor belt would run all the way around the town or shopping center so that people could use them at any point they need. They would be ideal for people that just want a rest from carrying bags **(SP 2)** or if there were enough conveyor belts they would help people who struggle to carry many bags at once.

It will be very important to ensure the speed of the conveyor belt is correct. They would have to move at the lower end of the average walking speed so that they are not too slow for most people however they do not move too fast of others. The ideal speed based on the lower end of average would be 0.8 metres per second. The height of the conveyor belt off of the ground would also affect how accessible it would be. It should not make people bend down too far however the higher up it becomes the more materials are required and the more space it takes up. A good balance between these factors can be drawn at 400mm **(SP 3)** off of the ground.

The aesthetics of the conveyor belt could vary largely based on where it is being implemented. You would probably want the aesthetics to blend in with it surrounding town or shopping centre so you would make it match. The materials that are chosen could include aluminium or even acrylic for the sides so that could be painted or just purchased in different colours.

The material that the top of the conveyor belt is made out of will also be important because if the rollers are exposed there could be a safety risk as well as smaller items falling between them. There should be a thin layer of some flexible material over top of the rollers that people can put their shopping on **(SP 4)**. This could be a fabric that has a high durability so that it lasts longer however I believe that the best option would be a rubberized surface because this would allow larger inclines to be achieved without the items slipping back.



There are many different types of conveyor belts as some can go round corners, take inclines or work without power due to gravity. However on the flip side of this most cannot do all of these so it might require different types on conveyor belts depending on the inclines and speed at which they need to function.

To make the rollers inside the conveyor function properly you will need to allow them to spin freely without much resistance. The smaller the resistance the better because less power will be needed to spin the roller. This will cause the price of running the conveyor belt to be less making less of an impact on the shopping / town centre. To lower the resistance to be the least possible you would want to use bearings in either side of the rollers as well as minimising the frixion within them with a lubricant.

Page conclusion:

A bag conveyor belt would allow everybody to either have a rest or buy as much as they want. There could be problems such as people not being able to keep up with bags however this would be combated with testing and finding the ideal speed. The perfect design would be scalable to any length.

IDEA 2 - BAG TROLLEY

The bag trolley would be allow people who cannot carry many bags to carry as much as they want **(SP 1)**. They would put the bags on the flat surface at the top of the trolley and pull it around with the handle that extends at an angle off of the top **(SP 2)**.

The materials chosen for the production of the bag trolley can vary largely based on the clients requirements **(SP 4)**. The client might favor rigidity and for the product to be hard wearing or they might prefer a nicer aesthetic, both would depend on the specific use case. If the client favors aesthetics over strength, a plastic such as acrylic could be used alongside the process of line bending for manufacturing. On the other hand if the strength is more important, then aluminium would be a better fit as it is much less likely to break due to it being less brittle.

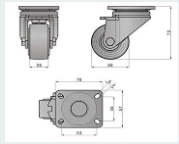
If the bag trolley was implemented into many different town centres then the colours that are used could correspond to the specific town centre. For example in one town centre they could all be blue and another they would all be red.

The bag trolley would have rough dimensions of:

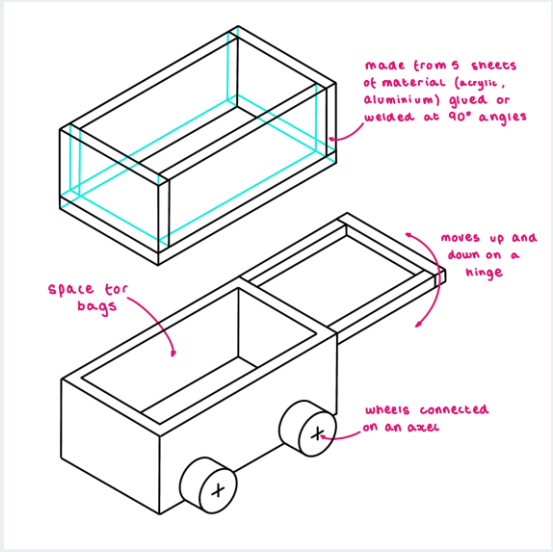
- Height 150mm
- Width 400mm
- Length 600mm

This would allow it to be easy for the user to reach their shopping bags however not too large that it makes it difficult to drag around **(SP 9)**.

The bag trolley would have a similar design to these toys however would be much stronger to hold heavier items, be made out of different materials so it could have a different aesthetic and be more resistant to wear as well as a different target audience of adults insead of children.



The bag trolley would have have the option of wheels if I choose a more conventional route with the design or it could use casters underneath. The casters would allow for the trolly to move in any direction and not be limited to just forwards and backwards. They would also make moving round corners easier.



The size of the handle would have to be ergonomic and comfortable for most people to use easily. As found in the ergonomics and anthropometrics research the ideal handle diameter would be 19.7% of the users hand length. When you add the average hand length of both men and women as 18.3cm you get an ideal handle diameter of 3.6cm **(SP 3)**.

The Handle would be attached to the main body of the trolley with hinges that are free to move. This would allow the handle to move up and down to allow for a larger range of people's heights to be accounted for. It would be more comfortable for the handle to adjust than it would be for taller people to reach down for it.

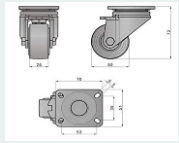
Page conclusion:

The bag trolley as an idea has the ability to fit many different client requirements. The materials can be changed along with the strength and even features. The size could be a problem as if it is too large then it might not fit around the shops easily however this would be tested to ensure it is not a problem.

IDEA 3 - FOLLOWER ROBOT

The main idea of this robot would be to follow you and carry your bags **(SP 1)** at the same time. This would allow people to who cannot carry many bags to still buy as much as they want **(SP 2)** and not be limited by the weight they are able to carry.

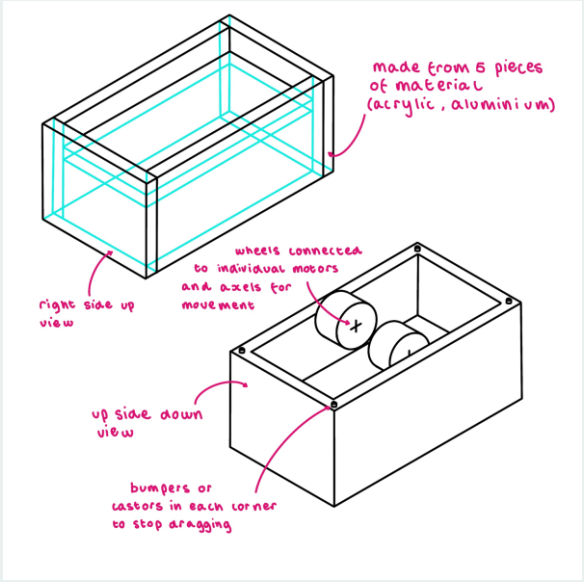
These existing robots have a similar function of carrying items for people however they do not follow the same form as my idea. They are somewhat spherical and will be able to balance and stay upright. My idea will not need to balance due to the use of castor wheels underneath in each corner, this will make it more friendly for commercial use because less can go wrong.



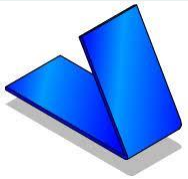
Castors and wheels could be used to allow this robot to move. The castors will be able to freely swivel allowing the robot to move in any direction. The two wheels will be powered via motors giving the robot all of the means to move around by itself.

This idea is extremely flexible when it comes to the choice of material being used. Using aluminium would make it very robust and not get damaged very easily even if a large problem occurs however this could be very expensive and more difficult to manufacture than other materials **(SP 4)**.

On the other hand acrylic could be used as this would allow for the aesthetic needs to be met due to the varying colours that can be chosen. Acrylic would also be less costly **(SP 8)** and easier to manufacture however this would be at the downfall of the robots strength and durability. Acrylic and aluminium are both easily recyclable however aluminum is much easier to recycle when compared to acrylic **(SP 6)**.



The process of line bending would be used with acrylic sheets to achieve the external box shape of the robot. This would allow for the highest possible rigidity within the robot because there will be less joints needed and these are weak points.



This product would take inspiration from roombas as it would like it to be fully autonomous however instead of cleaning the floor it would carry peoples bags for them. This could also cause safety issues that would need to be taken care of **(SP 7)**.

The robot would have rough dimensions of:

- Height 200mm
- Width 400mm
- Length 600mm **(SP 3)**

(SP 9)

Page conclusion:

This robot has the main purpose of carry bags for people around a town centre. For the most part this should be achievable however it is likely that some problems might arise such as the robot not being able to carry enough bags for that person.

IDEAS REVIEW

Evaluation and Third party feedback:

I have spoken to a group of people and showed them this table to get their opinions of which idea would provide the most assistance to people whilst shopping in town centres. Most of the people had a similar opinion that the follower robot is the best idea to develop because it has the least number of red areas. Meaning it fit the specification in almost all aspects. The only area where it didn't comply with the specification is cost. The follower robot idea would be costly due to the electronics required to function. Other than this there are no major downsides to the follower robot as it complies with every other specification point. It assists the largest number of people compared to the other two ideas because it would be fully autonomous meaning anybody could use it regardless of disabilities. **For these reasons I have chosen to develop the follower robot idea.**

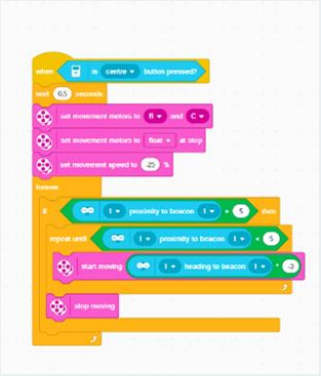
Doesn't comply with spec point Does comply with spec point	Bag conveyor belt	Bag trolley	Follower robot
Form - The product would have to have the ability to carry 3 bags.	The bag conveyor would have the ability to carry many bags (more than 3).	The bag trolley would be able to carry 3 or more bags.	The follow robot would have the ability to carry 3 or more bags of the bag for life size.
Function - The product would have to be able to relieve people of carrying bags around a shopping centre.	Through people putting their shopping on the conveyor they would be relieved from carrying it.	The bag trolley would relieve people of the stress involved with carry bags however they would have to pull the trolley around	The follower robot would stop people from having to carry bags and it would move itself so there is not need for the customer to do anything.
User requirements - The user would have to be able to reach their bags easily and if the product has handles they would have to be the correct size.	The bag conveyor would be made to the correct height so it' easy for people to reach their shopping. No handles are need for this product.	The bag trolley would be made to the correct height and have the correct size handles.	The follower robot would be made to the correct size and if handles are found as necessary they would be made to the correct size.
Materials - The material chosen for the product would have to be weather resistant.	The bag conveyor could be made out of a weather resistant material.	The bag trolley could be made out of a weather resistant material however this could add weight for the user to move around.	The follower robot could be made out of a weather resistant material.
Scale of production - The product would be made using batch production.	The bag conveyor belt would not be easily made with batch production because each would have to be specific sizes.	The bag trolley could be made with batch production due to the same product being produced every time.	The follower robot could be made with batch production due to the same product begin produced every time.
Sustainability - The materials chosen for the production of the product will have to be recyclable.	The materials chosen could be recyclable.	The materials chosen could be recyclable.	The materials chosen could be recyclable.
Safety - The product has very little to no safety risks.	The bag conveyor would be constantly running so it poses the most risk out of the 3 ideas.	The bag trolley is controlled by the user so as long as they are sensible then there should be no risk at all.	The follower robot would have lots of testing to ensure that it didn't hit objects and therefore should pose very little safety risks.
Cost - The cost of the product would have to be kept as low as possible.	The cost of a bag convey would be quite high because it would require the most materials.	The bag trolley would be relatively inexpensive because the materials needed are quite cheap.	The follower robot would also be costly because it would require lots of electronics.
Dimensions - The dimensions would have to be small enough to fit around the town centre without obstructing anybody.	The bag conveyor would be quite large and therefore would cause the most obstruction.	The bag tolley would be quite small and therefore cause very little obstructions to shoppers.	The follower robot would be quite small and therefore cause very little obstructions to shoppers.

2 Design	Page ref	Comments	Level	Mark awarded (please circle)	Pearson use only
2.1 Design ideas (AO2 8 marks)		The candidate has shown three different design ideas that would fulfil the chosen product concept of “carrying bags” for the user. Each idea has some additional research on possible materials, components and fixtures that could be incorporated into the ideas. However, the design sketches themselves are a bit fundamental and do not really contain very much detail into how each idea could be made. They could be seen to be very similar in shape but have each received a different treatment so can be seen as different enough. The ideas do refer back to specification points and user needs are explained in the text well enough to be assessed in the higher mark band.	No rewardable material	**0**	
			Level 1	**1** **2** **3**	
			Level 2	**4** **5** **6**	
			Level 3	**7** **8**	
2.2 Review of initial ideas (AO3 8 marks)		The candidate has completed a single sheet on the review of the design ideas. This comprises of a table of comments relating back to the original specification (which was not completed well). They have made comments to evaluate and analyse by rag rating the criteria to help determine the idea to be taken forward to be developed, the follower robot. Third party feedback has been sought and documented to help lead to a summary as to which idea is to be developed further.	No rewardable material	**0**	
			Level 1	**1** **2** **3**	
			Level 2	**4** **5** **6**	
			Level 3	**7** **8**	

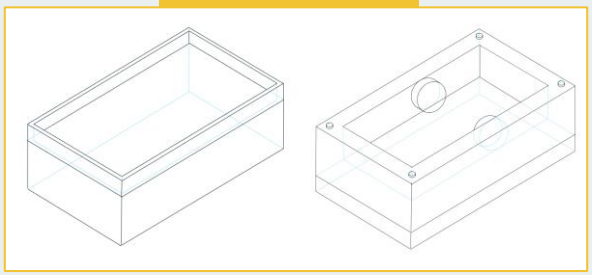
DEVELOPMENT - MODEL OF ORIGINAL IDEA

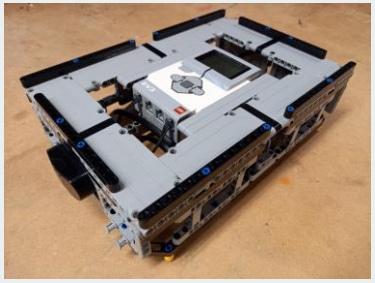
I have made a functioning model of the follower robot, below you can see a video of it working. The robot follows the remote beacon and will always try to orient itself facing towards it. Eventually the beacon would be a sort of wrist band that the shopper could wear. The code that the robot is running can also be seen on this page. The model that I have made is a model of my initial idea of the follower robot, so that any developments that I make can be added to the model and the improvements can be seen more noticeably.

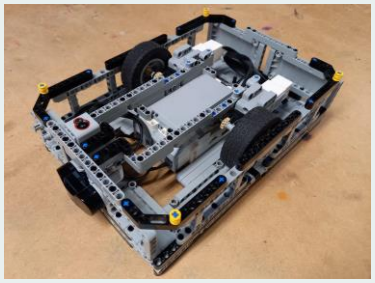
Link to video



Original design idea







Overall the idea of a follower robot allows for many different types of shoppers to benefit, however with these many different types of shoppers, lots of problems can arise. It would be ideal if any foreseen problems are fixed before the robot is made. Problems evolving the functionality of the robot may include:

- Bags falling off of the robot
- Colliding with shoppers

- Navigating small spaces
- Being a trip hazard

- Charging

- Correct sizing for all shoppers
- Holding varying item sizes

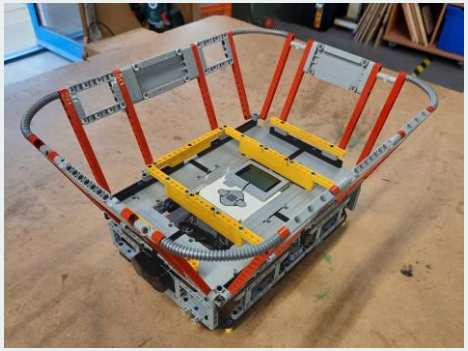
Other things that should be considered are:

- Allowing for different colours
- Making people's lives as easy as possible
- Inputs from the user to tell it what to do
- How it will be controlled
- People returning the robot after use

DEVELOPMENT - FIXING FORESEEN PROBLEMS

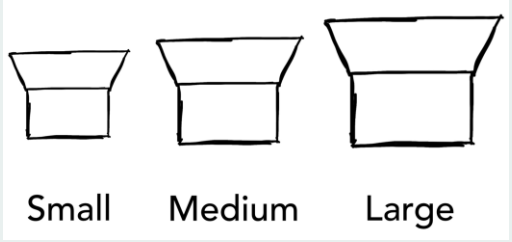
Hopper -

Bags falling off of the robot and accounting for different sized items should be done with one solution. One possible solution is straps that go over the item that you don't want to fall off of the robot. Another solution are tall sides that will function as a hopper, this will give a safe place to put items. The idea of straps will work very well in specific situations such as large boxes because there is only one thing that needs to be held down, however this idea becomes less suitable when lots of smaller items need to be held. The idea of a large hopper is very universal and should work in most cases.



Different sized robots -

Having a few different sizes of robot for shoppers to choose from would allow there to always be a robot that is the correct size. This would also allow different sized items to be held easily. There could be two or three different sizes such as a small medium and large. Having more than that would become unnecessary and make the system more difficult to understand for shoppers. The different size options might also have different maximum weights as the larger robot might be used for larger and heavier items.

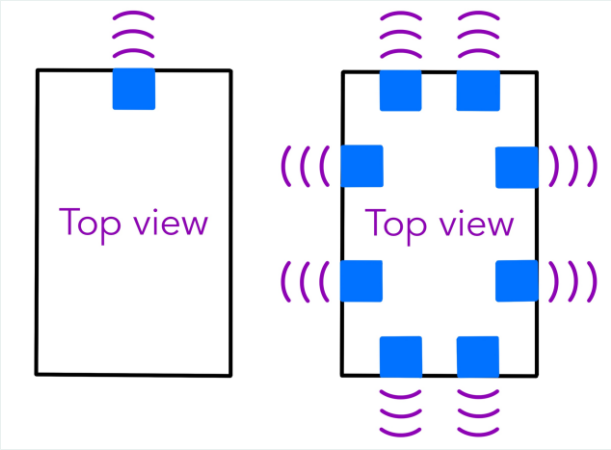


Colours and customisation -

Choosing the correct material that allows for any colour will make a large difference to the aesthetics of the robot. The material should have a wide variety of colours available so that the cost does not increase by much. The town centre might have a distinct colour scheme and in this case the colour of the robot should match this scheme. It would also be nice if the robot could have images and text engraved into its sides. This could be used for advertising or numbering each robot.

Sensors -

Adding a multitude of sensors all around the robot that can find its distance from people and obstacles should be able to fix many problems. It would not collide with shoppers as it would be programmed to stop if it was too close to people. This would also be used to stop it running into other obstacles in small spaces. The sensors would be arranged on the robot in a pattern similar to the image below on the right. I believe that the robot having 8 sensors with 2 on each side will have the biggest impact without having unnecessary equipment on the robot. More sensors will allow the robot to have a better understanding of its surroundings as well as follow the wristband with more accuracy. The original design only had one sensor as shown in the image on the left.



DEVELOPMENT - CONTROL WRISTBAND

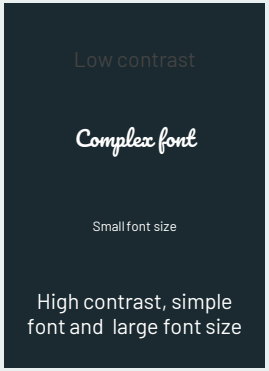
A control wristband will fix many different problems that might arise with the robot. Due to the robot being fully autonomous it will need a beacon to follow in order to function. It will vary the speeds of each of the wheels based on its heading with regards to the band. The robot will also need to inform the user of any problem that it might encounter, this could include:

- Colliding with an object
- Being too far away from the user
- Being too close to its border (area it is allowed to move in)
- Battery levels
- Not being able to navigate crowds due to being larger that the user
- Weight allowances

The final problem that the wristband fixes is allowing the user to input different instructions to the robot such as telling it to stop and start again. This is useful when shopping is being put into the robot as you do not want it to be moving. The shopper might also want to tell the robot to return to its docking station once the shopper has finished with it. All of these instructions should be available through the control wristband.

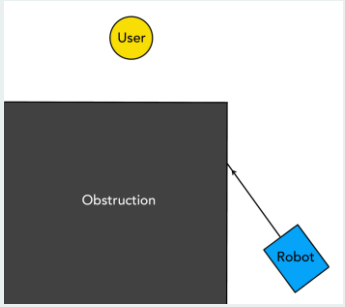
The wristband will take inspiration from smart watches as it will have a small screen that allows the user to navigate through the user interface (UI). This design is very simple because only the information that the user needs to access is in sight. The controls will also be very simple and easy to use as they will either be a touchscreen or have a rotary dial and a button that allow the user to scroll through and select different options. Any notification that the robot needs to tell the user can be displayed automatically and the wristband might need to vibrate to get the shoppers attention. The band would be collected and deposited after use at the same place as the robot. It would also have to have a very long battery life so that it doesn't die whilst it is being used. The most important part with regards to the wristband design is its strength and durability. It will need to withstand being dropped as well as being waterproof so rain doesn't affect it.

The UI of the wristband will need to be very simple so that everybody can understand it. Including easy to read fonts, high contrast colours and large enough font sizes. It will need to function with limited input options. And have the minimum number of options to the user as possible to keep the screen uncluttered. Only necessary options should be available to the user.



The disney magic bands serve a similar purpose and therefore a good place to start for inspiration. The magic bands collect data about the users such as; The rides they have been on, their card details so that payments can be made with them and the users ticket information so that they can use the band to enter a park. These bands have an internal RFID chip and their functionality is based around this. This is the main way that the control wristband will differ from the magic band; The control wristband will be an Infrared beacon (IR) so that the follower robot can find its heading towards it.

The main problem with the controls wristband is that an IR beam needs a line of sight connection to functions so the robot would have to stay very close to the wristband to avoid having walls and other obstacles from getting in the way of the IR beam.



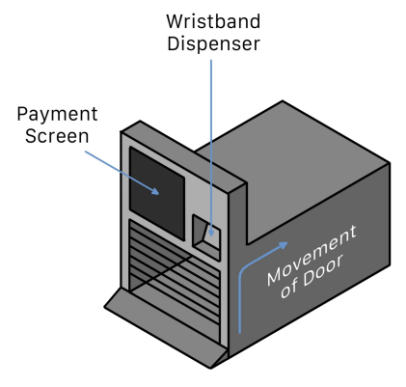
DEVELOPMENT - ANTI THEFT CHARGING STATION

A Charging station will allow the robot to be charged once it has been used by a shopper. The robot would have to have a large battery and would need to charge quickly so that it doesn't run out of charge whilst in use. The robot will need to be returned to the charging station when the shopper has finished with it. To stop people from taking the robot the charging station would be proprietary and imbedded into the shopping centre, possibly by a help desk. This way, even if the robot was stolen it would not be able to be used once the battery had died. Another way to stop people from stealing the robot is by setting a boundary within the town centre to stop it from leaving. People would need to set up an account with the town centre, possibly via an app that will get their bank details. This will allow the town centre to charge the user only if the robot is stolen or damaged after use. This system is a large improvement over paying to use the robot because it would be free to the shoppers and the town centre would have security. It would be very important that the charging station is quite large so that all the different sized robots could fit within it or so it would be more difficult to steal without being noticed by anybody.

The anti theft charging station would look something like the design below. The robot would be stored inside the charging station with charging points on the bottom that would connect with the charging points on the floor of the station. This will allow for the robot to charge without having to plug it in every time a user has finished with it. The user would use the touch screen above to connect their town centre account and choose the size of robot they want. Once all of this is set up the robot will be released for the shopper to use. The wristband will also be dispensed from the same place.

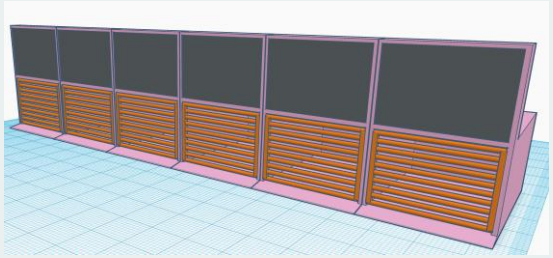
The charging station door is a very important part to get right. I believe that the best option is a rolling shutter for a few reasons:

- This would not take up space when it's either open or closed
- There isn't enough space to put your hand through to access the robot
- It has the option to use a solenoid on each side to ensure it stays closed
- It can be fully automatic



I would take inspiration from this charging station for autonomous robots where they drive themselves back to the station when they are low on power. These robots are modular whereas the follower robots would come in different sizes. This charging station is completely open so it is most likely used in a factory where the chances of the robots being stolen are very low however the charging station that will be used in shopping centres will need to be enclosed to reduce the risk of theft.

When there are many different charging stations next to one another they might look similar to the image below. On the screen above they will show whether the robot that corresponds to that station is available or currently in use.



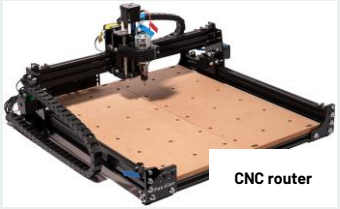
DEVELOPMENT - AESTHETICS

One of the largest benefits to the follower robot idea is the flexibility of the its aesthetics. The materials that I will choose will need to have the ability to be engraved or even printed onto so that the town centre can have whatever they want put onto the side. This could include logos, important phone numbers for the town centre or even advertising. I believe that the best use of the space on the sides of the robot would be advertising to counteract its expensive nature.

There are several different ways that things can be put onto the sides of the robot and the technique chosen will heavily depend on the chosen material. If aluminium is chosen then plasma cutting can be used to cut completely through the material however this cannot engrave it. A CNC router would need to be used to engrave the material. If the chosen material is a plastic such as acrylic then a laser cutter could be used as an alternative to both machines because it can cut and engrave the material. However if any of these machines are used then permanent marks would be left on the material and they do not put different colours on the robot. Either of these could be a problem for the town centre because they might want to change the advertisements or have them in colour.

For the town center to have the advertisements in colour then printing would have to be used. It is possible to print onto both acrylic and aluminium with specialist techniques however this would also be hard to remove. The better option would be to have a sheet of board stuck to the side of the robot that has already had the advertisement printed onto it. This way would be easy to remove if the advertisement needs to be changed. To hold the board to the side of the robot the town centre would have a choice between having it come off easily so replacing them takes less time or having it less likely to come off. If they wanted it to be removed easily then high strength velcro could be used or if strength is more important, then a strong glue could be used.

Laser cutter

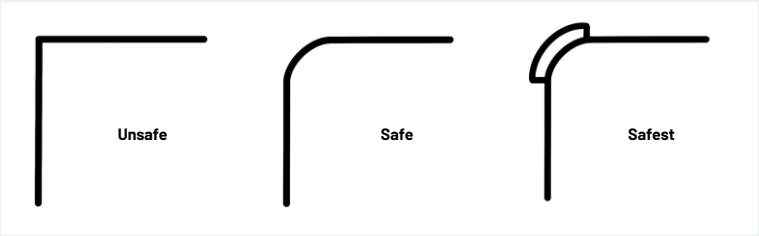


CNC router

Plasma cutter

Keeping the robot safe and nice to look at are very important and can both be achieved with one solution. If the corners of the robot are rounded then even if it bumps into a person it will not be painful and it will also improve upon the aesthetics of the design. Any place where the robot initially had a sharp 90 degree angle should be rounded off so that anybody near it is safe.

Another way to make the robot safer and possibly improve aesthetics is putting a softer material on the corners of the robot. This could be as simple as gluing a small sheet of foam to the already rounded corners. This could minimize that damage to anything It could collide with. Foam can also come in many different colours so the town centres colour scheme can still be matched.

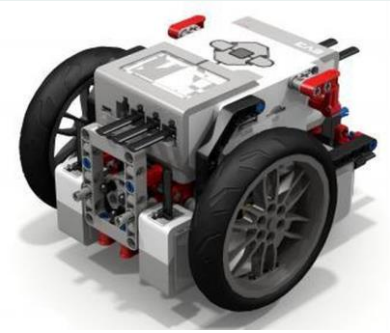


Ensuring that any engraved text put into the robot is readable is very important because this will allow anybody to understand what is being said. It would defeat the point in having it there in the first place if nobody could read what it was saying.

I believe that the best way to use these techniques is to have the number or name of the robot permanently engraved into the robot as well as the name of the town centre it is going to be used in. Then advertisements can be put onto the sides of the robot via printing on board. This way uses the advantages of both permanent and temporary techniques without having to deal with the disadvantage of either.

DEVELOPMENT - MOVEMENT METHOD

The current way that the robot moves is through the use of two motors each connected to a wheel. This allows the robot to turn when you vary the speed of each of the motors. To stop the front and back of the robot from scraping the ground, four castor wheels would be used. These will be placed in each corner and can pivot to move in any direction so that the movement of the robot is not hindered. This movement method is very reliable and works very well if the surface it is driving on is flat however if there are bumps then it will not work as intended and could have problems traversing the area.



Wheels on either side of the robot

The next option would be using tracks to move, each would be powered by a single motor. This would mitigate the problem of rough terrain and bumps. The tracks would also remove the need for the four castor wheels because they would not allow the robot to tip forwards or backwards to hit itself on the ground. Another problem that still aren't fixed by the use of normal tracks is moving up stairs.

Tracks on either side of the robot

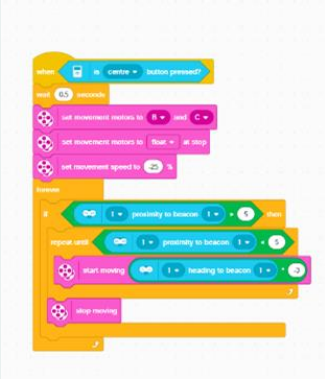
There are many different ways to give the robot the ability to move upstairs however all pose a large problem. Giving the follower robot longer tracks could allow it to move upstairs however these tracks would have to have lots of grip and the robot would be tipped back at the same angle of the stairs meaning fragile items will be moved around in the basket. Another option would be to have the robot step up each step similar to how a human would however this would require much more complex internal components and therefore make an already expensive problem even more so. This would also take a long time for the robot to move up the steps so would not work properly in a real setting.

For these reasons I have decided to use normal tracks as the follower robots movement method. This method has the most upsides with the least overall downsides.

DEVELOPMENT - PROGRAM

To the left you can see the code that the original model of the follower robot is using. This needs to be adapted for the use of more sensors and needs to have some features added to it.

Rather than re-coding the robot I have decided to write out the original code in words and then write out the developed code in words. This is due to the limitations that the original model has (it can't have multiple sensors) so I wouldn't be able to test the code.



Original

When a button on the robot is pressed the robot will start

A loop starts

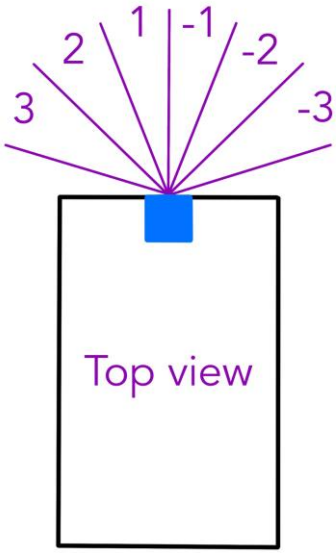
A variable is set with the heading of the first sensor to the beacon

The robot is set to turn in the direction of this heading

If the front motor is too close to an object the motors stop to avoid collisions

The loop repeats

The sensor will give it's heading towards the beacon wristband. These numbers indicate the output of the sensor based on the direction of the wristband.



Developed

When a button on the wrist band is pressed the robot will start

A loop starts

A variable is set with the heading of the first sensor to the beacon

A second variables is set with the heading for the second sensor to the beacon

These variables are added together and then divided by two (finds the midpoint)

The robot is set to turn in the direction of the midpoint of the headings

The distance from an object is found for each sensor around the robot

If this is too small the motors are stopped to avoid collisions

If the button on the wrist band is pressed telling the robot to stop then the motors are stopped

The robot then waits for the button to be pressed again to start moving

The speed of the motors are increased if the robot is too far away from the wristband

The loop repeats

The benefits of the developed code include:

- Facing towards the beacon is more accurate because multiple sensors are used and the average is found
- The robot takes inputs from the wristband that were not taken before
- It is able to detect if things are close to it in all directions and not just forwards, this mitigates the risk of collisions by a large amount
- It will speed up if it is too far away from the wristband so that the IR beam doesn't get interrupted by an obstruction

DEVELOPMENT - MANUFACTURING THOUGHTS

A range of joints could be used to manufacture the follower robot. To the right you can see some drawings of the different joint types.

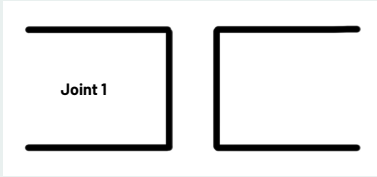
Joint 1 could be used with either acrylic or aluminium and it is the weakest yet simplest joint. If it was used with acrylic then the pieces would be glued together with acrylic cement and held with clamps while it dried. However if aluminium is used it could be welded together.

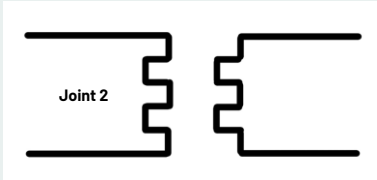
Joint 2 would only be used with acrylic because aluminium would not benefit from this type of joint. This would increase the structural integrity of the robot however would require very precise cuts and would most likely be unnecessary.

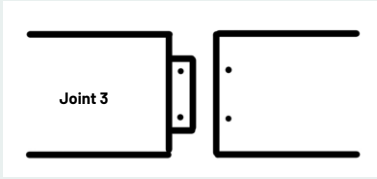
Joint 3 would only be used with aluminium because it would require riveting and welding. Riveting acrylic can be done however due to acrylic being very brittle It could shatter. You cannot weld acrylic in the same way as aluminium therefore welding cannot be used either. This joint would also require the flap to be bent around to the correct angle so therefore require much more time to manufacture.

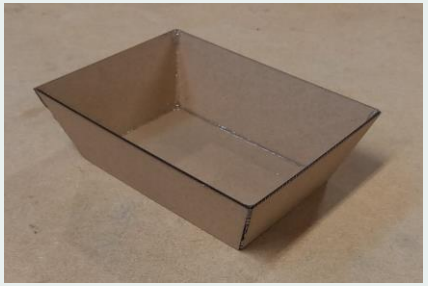
Joint three would be the best joint for structural integrity however It would be much more expensive because of the processes and materials involved. Joint 2 would be second for structural integrity however the extra time taken to manufacture is unjustifiable for a very little increase in durability. For these reasons I have chosen to use joint 1 for the manufacturing of the follower robot.

Another technique that could be used for manufacturing parts of the robot such as the hopper is vacuum forming however this would require a very large vacuum former and this increases the cost of the project by a very large amount. Therefore this is an infeasible manufacturing method.









This is a quarter scale model of the follower robot hopper to test the manufacturing method and ensure everything works as intended when manufacturing the final product.

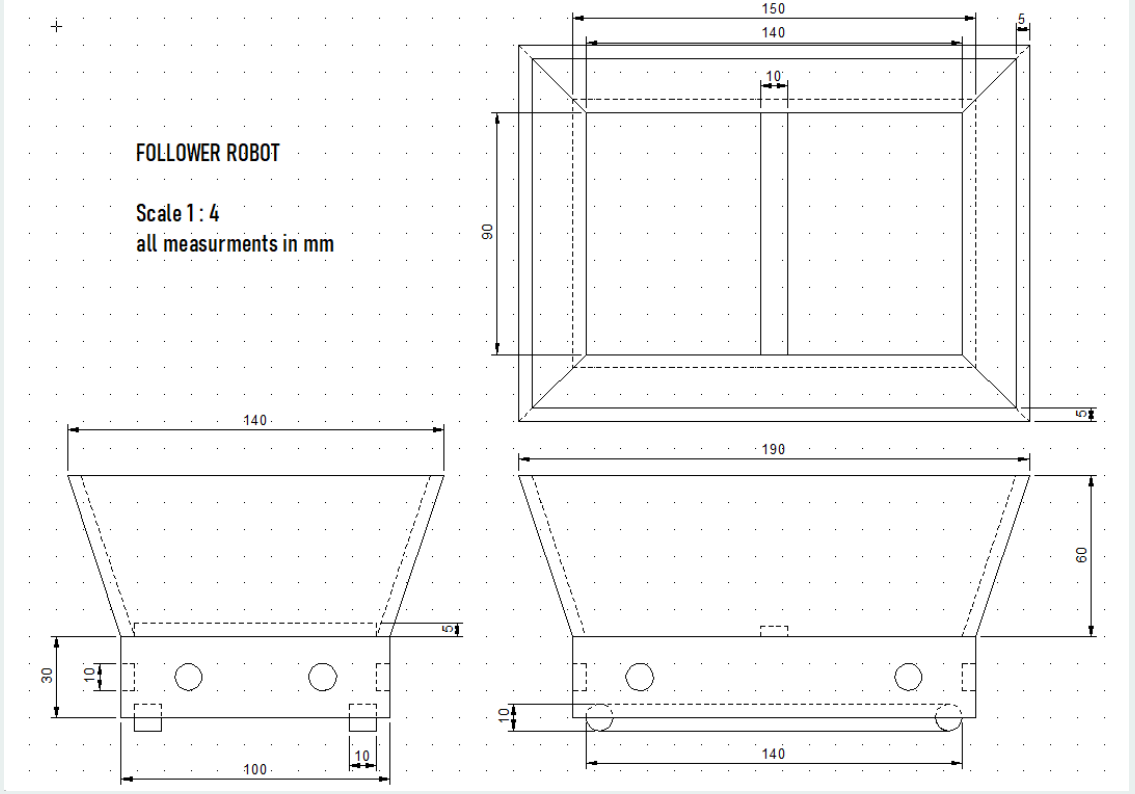
The cardboard was laser cut so that the cuts are precise and then it was glued together using a glue gun. This model used joint 1 and is very strong therefore nothing more than this joining method is necessary.

This is the method that I intend to use for manufacturing the final scale model of the follower robot. This manufacturing method is very precise due to the laser cut pieces and is very strong

CHOSEN DESIGN

Follower robot cutting list for **Real Size** (small) follower robot

Piece	Number of	Material / component	Width (mm)	Length (mm)	Thickness (mm)
Base front / back	2	Acrylic	400	120	20
Base side	2	Acrylic	560	120	20
Hopper front / back	2	Acrylic	560	240	20
Hopper side	2	Acrylic	760	240	20
Hopper floor	1	Acrylic	540	360	20
Hopper divider	1	Acrylic	40	360	20
Sensor	8	IR sensor	N / A		
Motor	2	Motor			
Robotics kit	1	LEGO mindstorms robotics kit			

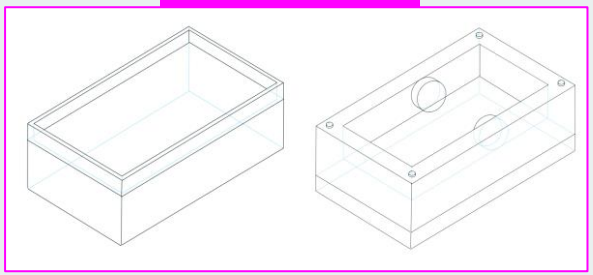


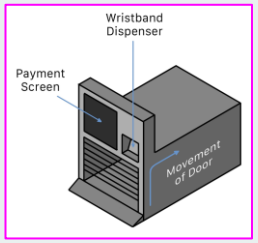
REVIEW OF CHOSEN DESIGN

All of the development that have been made in the development section improve my project for different reasons or fix foreseen problems:

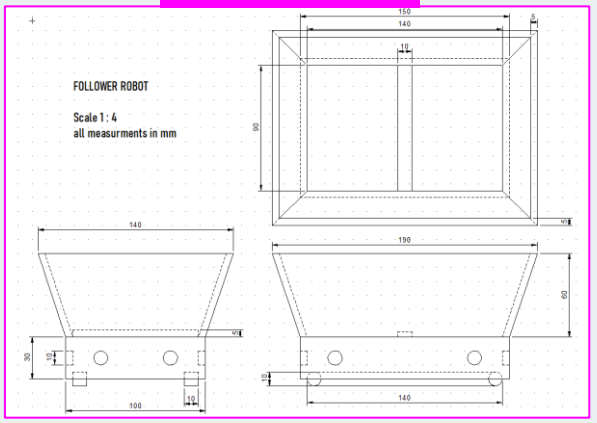
- Large hopper - this stops shopping bags from falling out of the follower robot and allows for a larger range of items to be held easily.
- Extra sensors - this gives the robot additional information of its surroundings and therefore can avoid obstacles or follower the control wristband with more accuracy.
- Different options for sizes - allows for all shoppers to have an option of the robot size that they need as everybody will have different requirements.
- Aesthetic options - these allow the town centre that owns the robots to have advertisements on the side so that the expensive nature of the follower robot can be counteracted. This can also give the town centre the options to number or name each robot.
- Wristband design - this gives a more refined idea of the wristband such as the UI and the buttons that will need to be on the wristband in order for it to function properly.
- Anti-theft charging station design - this shows the design for the charging station and how it would work with the robot. As well as the in general proportions and idea drawings
- Movement method - the improvement of the movement method allows the robot to move over more types of terrain and will not just stop on anything that isn't perfectly flat.
- Code improvement - this allows the robot to take advantage of the extra sensors so that it has a full understanding of its surroundings and not just the things directly in front of it.
- Manufacturing thoughts - this section discusses the different joints that could be used to connect parts of the robot together and then tests the chosen joint with a quarter scale model of the hopper.

Original design idea





Final developed design



Third party feedback

I have spoken to a group of people about the developments that have been made to the follower robot and whether there are any further improvements that could be made. The overall decision is that there is not any large improvements that could be made however some small improvements can be added such as small baskets that can attach to the inside of the hopper to hold the shoppers important or much smaller items whilst shopping.

These are Disney Magic Bands and not the final design of my control wristband however they give a similar idea to what the design would look like aside from the screen on the top.

Design (continued)	Page ref	Comments	Level	Mark awarded (please circle)			Pearson use only
2.3 Development of design ideas into a chosen design (AO1 4 marks, AO2 8 marks)		There are many aspects used throughout to refine developmental changes and decision making. Modelling is excellent in this section. The candidate has used hand drawn sketches, CAD with Lego used to support changes to steering, movements and the shape of the hopper. Laser cut cardboard modelling is seen to refine their design idea for the prototype. They have also included excellent detail on how the product could be used in the town centre to include aspects such as hiring the follower from a secure station in the town centre. Calculations can be found on the formal drawing of the chosen design idea page, identifying material sizes and quantities. The candidate has shown fully sound knowledge of materials and processes, this is seen in their detailed annotation throughout this section.	No rewardable material	**0**			
			Level 1	**1**	**2**	**3**	
			Level 2	**4**	**5**	**6**	
			Level 3	**7**	**8**	**9**	
			Level 4	**10**	**11**	**12**	
2.4 Communication of design ideas (AO2 8 marks)		The candidate has communicated all ideas in a very clear, coherent manner, using quite basic sketches at the start. Later developing the ideas using CAD to their advantage. This candidate has explained a lot of information in a written format that is neat and details all the decisions about the ideas.CAD has been used to develop the shape of the design, along with being used for the chosen final design. CAD seen in portfolios should not solely relate to the manufacture of the prototype, CAD must be seen to explore the design ideas.	No rewardable material	**0**			
			Level 1	**1**	**2**	**3**	
			Level 2	**4**	**5**	**6**	
			Level 3	**7**		**8**	
2.5 Review of chosen design (AO3 6 marks)		There is a summary of all the aspects that have been changed or refined during the development section with a look back at the original design idea and a reminder of the chosen design seen on the page. The candidate has referred back to the contextual challenge in many comments and they have identified some further development to the style of the sensor which could be worn.	No rewardable material	**0**			
			Level 1	**1**		**2**	
			Level 2	**3**		**4**	
			Level 3	**5**		**6**	

MATERIALS AND PROPERTIES

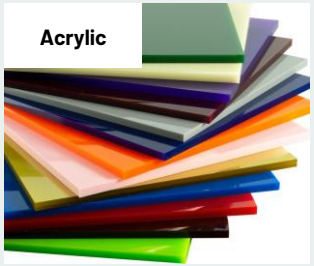
For my final project I have decided to use acrylic sheets as the main material. There are many reasons to choose acrylic and I have explained most of the properties and reasons that apply to the follower robot in the table to the right.

For the test model I have chosen to use cardboard as it is very easy to work with and relatively cheap. It does not have the correct colours however the cardboard models main use is to ensure that I know how to use the manufacturing techniques and that my chosen sizes are correct.

Acrylic and cardboard can use very similar manufacturing techniques therefore they are ideal to use together, with cardboard being the test. The main method being used will be laser cutting the larger pieces to the correct smaller sizes.

Acrylic can be recycled however not biodegradable. This means when this product comes to the end of its lifecycle it cannot just be thrown away because it would not decompose naturally. Recycling acrylic is done by remelting the large pieces and forming new ones. This is not a simple process however can be done. For this reason I believe that acrylic is a good material for use in the follower robot.

To make the chassis of the robot I have chosen to use the LEGO mindstorms EV3 kit because it allows me to get sizes correct and make a fully functioning robot rather than just a model that looks like one. I have access to this kit and as much LEGO technic as I might need to create the chassis so availability is not a problem. This is much more user friendly to code and make small changes to when compared to a circuit board and electronic components.



I have chosen to manufacture the majority of the follower robot project out of sheets of Acrylic

Property	How this applies to my project
Water Proof	This allows my project to be used outside without being stopped by rain water. Using a material that would absorb water of deform when in its presence would restrict the follower robot project to indoor use only. It is best that it can be used in all situations.
SImple to manufacture	There are many different processes that can be used when manufacturing acrylic. The choice of processes is very important because I can chose which is most suitable for the follower robot. I have chosen laser cutting which requires very little cleaning afterward and allows for very precise and reliable cuts.
Lightweight	When compared to other materials that could have been chosen acrylic is lighter and therefore requires motors with less torque to allow the robot to function. This saves money for the project. Acrylic is also very durable when compared to its weight. .
Durability	Acrylic is very durable and therefore the robot should be able to function for years before it needs to fixed or replaced. It would be difficult for a person to damage unintentionally and should not obtain visible scratches on its surface if the follower robot collides with an object. However Acrylic is not as strong as other alternatives such as Aluminium.
High melting point	Acrylic unlike some other plastics requires very high temperatures to deform. The temperate would have to exceed 100 degrees celsius in order for the acrylic sides to bend out of shape. Therefore if it was a hot day the acrylic should not be deformed.
Colour choice	There is a large colour choice when working with acrylic so any specific colour requests of a town centre can be easily met. This allows for the follower robots to match the town centres distinct colours. Acrylic can also be found in transparent variants so this can be used for easy sight for shopping within the hopper.
Cost	The cost of the follower robot is already a large problem as it is the single largest downside to the idea and project. Acrylic is a fairly expensive material however not as costly as some other alternatives (1000mm x 1000mm x 3mm ≈ £50).
Availability	Acrylic has no problems with demand as there is not a current shortage or problems with ordering. At this time it is readily available for purchase and therefore can be ordered in the quantities necessary.

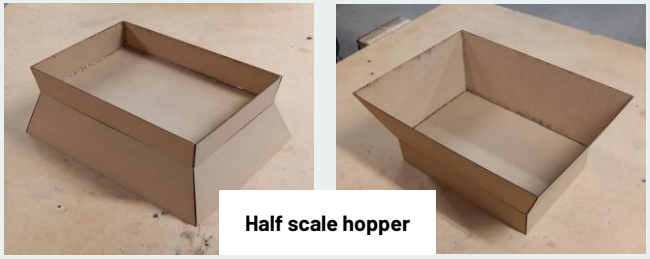
CONSTRUCTION - CARDBOARD MODEL

There is a large emphasis on safety of myself and others whilst constructing any parts of the follower robot. Many different precautions were taken. This included the laser cutter requiring the lid to be down properly before starting and automatically stopping its cut if the lid is opened.

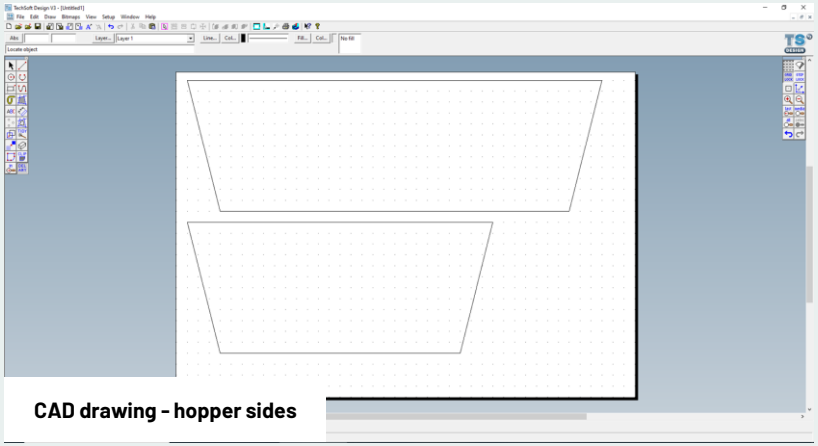
Before creating the final half scale model out of acrylic I decided to make a half scale model out of cardboard as a proof of concept. This would ensure the size I had picked was sensible as this is much simpler to gage when it is in front of you and that the manufacturing processes I had chosen were functional and worked as intended. To construct the cardboard scale model I followed the steps below;

- I used the technical drawing to find the sizes of material that needed to be cut.
- I sent these to the laser cutter and got precise cuts. These cuts did not need to take the thickness of materials into account because the cardboard model is a test and this level of detail is unnecessary.
- I used a glue gun to connect all of the pieces together using joint 1 as talked about in the development section of the project.
- The result was the cardboard model that was the correct size and shape of the half scale follower robot.

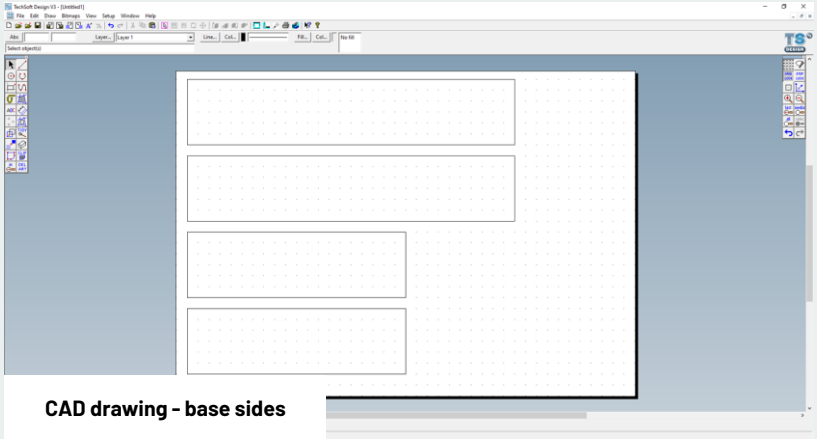
I decided that this size was appropriate for the follower robot considering that it is half scale. From making this model I also knew how the processes would work for the acrylic half scale model and had the understanding I would need to carry them out without errors.



Half scale hopper



CAD drawing - hopper sides



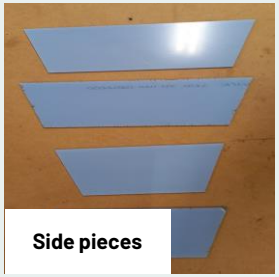
CAD drawing - base sides

CONSTRUCTION - ACRYLIC MODEL

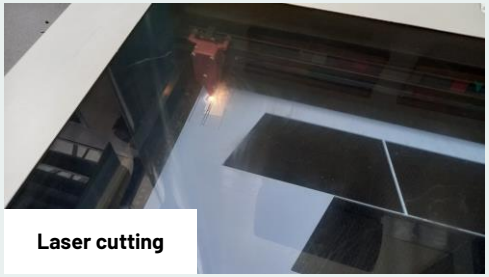
I also needed to ensure a safe environment whilst using the acrylic cement. For this I stayed in a well ventilated area whilst gluing and kept the hopper in this area whilst the acrylic cement was drying.

From here I started working on the final project model using similar techniques to the cardboard model as I now had proof that these worked as intended. I had the dimensions of the pieces I needed to cut from the cardboard model however this time I needed to take the thickness of the material into account when cutting pieces out with the laser. This final scale model should be much more accurate than the cardboard model and taking thicknesses into account will allow for this.

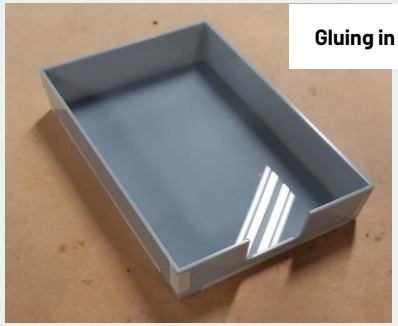
- My first step when constructing the final acrylic scale model is cut these pieces with the laser cutter.
- I then had to use a planer to get the top and bottom of the hopper sides to the correct angle before being glued.
- I assembled these pieces by holding them together with masking tape. This would leave minimal residue on the material however is strong enough to hold it together whilst any glue is drying.
- To hold the pieces together permanently I used acrylic cement. This is very strong as it doesn't just hold pieces together but instead fuses the two pieces into one.
- From here I decide to add an extra small basked within the hopper from the shoppers very small items to be placed into so that they would not get lost. This was a 3rd party suggestion during the review of the developed design.
- This was made using the same steps as the rest of the final half scale model.
- First I found the sizes and shapes of the pieces I need to cut.
- I cut these pieces taking into account the thickness of the material.
- I held them in the correct place in the model with masking tape.
- Then used acrylic cement to hold them there permanently.



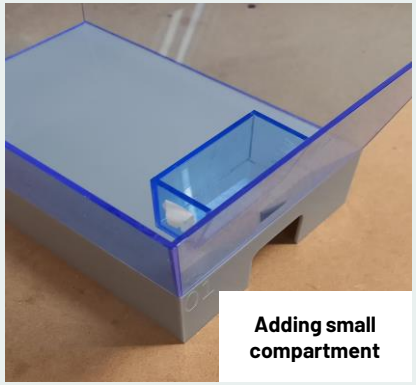
Side pieces



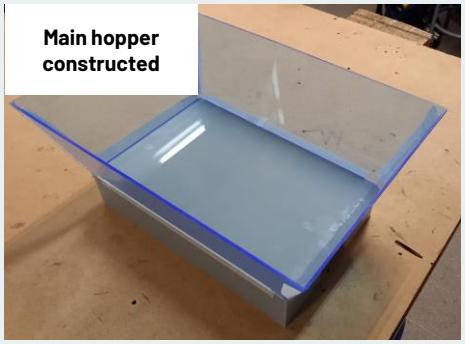
Laser cutting



Gluing in progress



Adding small compartment



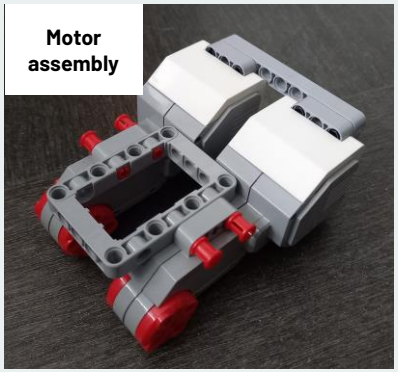
Main hopper constructed

CONSTRUCTION - INTERNAL ROBOT

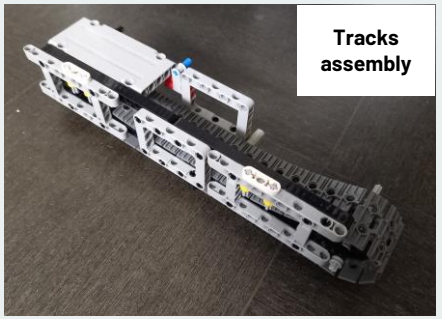
Another way I ensured a safe working environment was making sure the follower robot was not a trip hazard whilst being tested. For this I never left it unattended on the floor and made people aware of it if they had to walk past.

The final part of follower robot model was the robotic insides that would allow the model to function. For this I used pieces from the LEGO EV3 robotics kit however the design of the robot was entirely my own. I knew that the chassis I made would have to be to the correct scale, use tracks as its movement method and have an infrared (IR) sensor to detect the IR beacon.

- I stated with finding the correct length of tracks by laying them out alongside a ruler.
- From here I added more structural support so the tracks would be connected in a way that would not fall apart.
- I added one motor to each track (two motors total) so the robot could move.
- I connected the two sides of the robot together with the main controlling EV3 brick in the centre.
- I added more structural support to not only make sure that robot wouldn't fall apart but also make sure it would not break if it collides with an object.
- The final step was adding the IR sensor to the front and connecting the motors and IR sensor to the main brick with connecting cables.
- I ensured that the robot was then to the correct measurements.

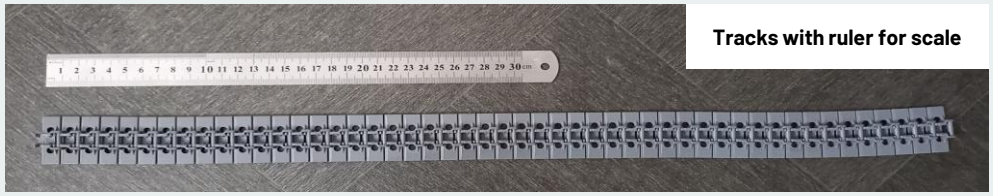


Motor assembly

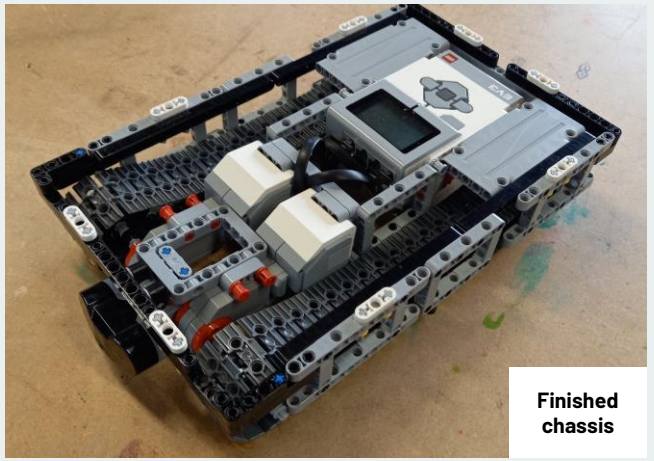


Tracks assembly

IR beacon



Tracks with ruler for scale



Finished chassis

CONSTRUCTION - PUTTING COMPONENTS TOGETHER & CODING

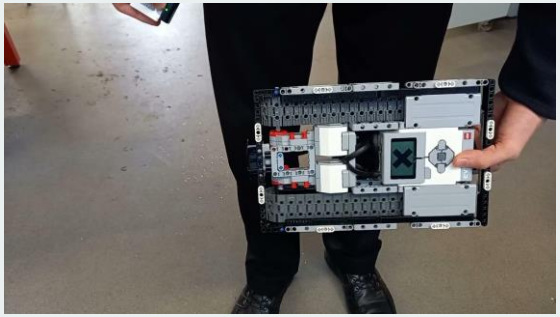
When the follower robot is in use the hopper assembly will be placed on top of the LEGO robot chassis. The robot chassis will power the robot allowing it to move and the acrylic hopper is where bags and items will be placed.

The final step in constructing the follower robot is the code, this will enable the robot to function properly. The final code is shown below.

This was made with many different steps including;

- Ensuring the motors worked correctly
- Ensuring that the code is doing what I think it should be
- Adding simple improvements that make it simpler for the user such as the colour of light shown on the robot or what is being displayed on the screen

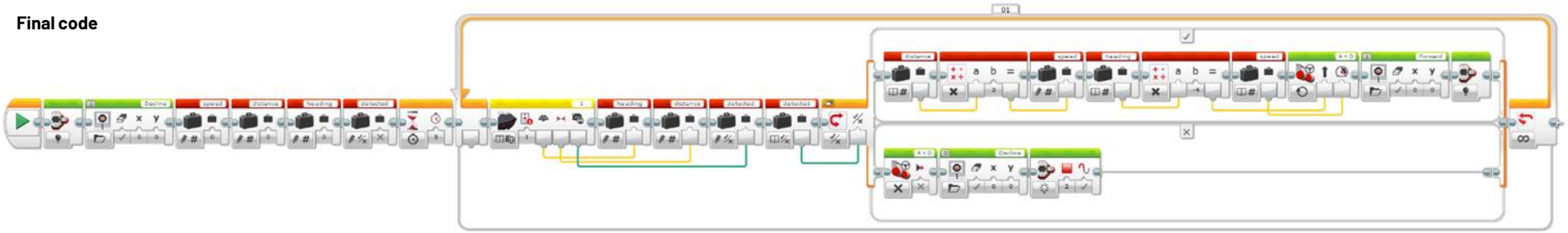
The robot starts off by setting the screen to the cross to indicate that it isn't moving and the colour of the lights to red. Then the variables that are going to be used are defined. A pause is implemented so you have time to put the hopper onto the robot once you have initiated the code.



Link to video

After this pause, a loop is started. Once per loop the distance from the beacon, the direction of the beacon and whether it is detected are stored in variables so they can be used later in the code. An if statement is used so if the beacon is detected the robot uses the direction to calculate how much to turn and uses the distance to calculate the speed it should move. These answers are then put into moving the robot. The screen is set to a forwards arrow and the light is turned off. For the other side of the if statement (if the beacon is not detected) the motors are stopped, the screen is set back to the cross and the light is set to red to indicate an error. This loop repeats indefinitely until the user stops the code running on the robot.

Final code

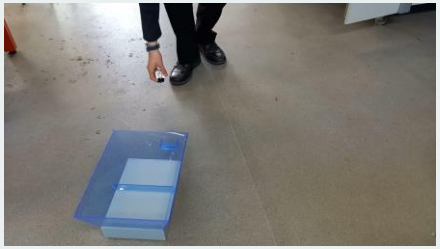


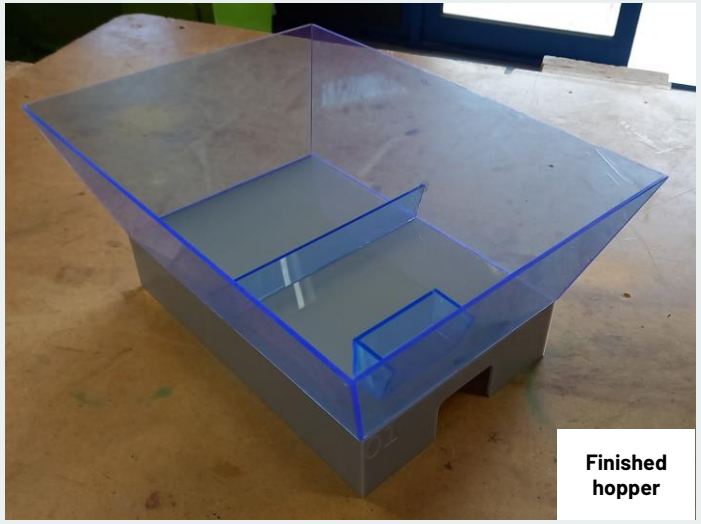
3 Make	Page ref	Comments	Level	Mark awarded (please circle)				Pearson use only
3.1a Manufacture – selection of materials (AO2 8 marks)		Here the candidate has shown work that best indicates work suitable for the middle mark band due mainly to the nature of the prototype being largely comprising of the Lego chassis with a fairly minimal use of "materials" used for the hopper. However, the level of detail shown that is specifically relating to the prototype and the references back to the contextual challenge allow additional credit to be awarded for the understanding of the material properties which have been very well documented and explained	No rewardable material	**0**				
			Level 1	**1**	**2**	**3**		
			Level 2	**4**	**5**	**6**		
			Level 3	**7**		**8**		
3.1b Manufacture – skills and processes (AO2 16 marks)		The scaled prototype produced demonstrates fully competent making skills, these include the use of the CAD files and the laser cutter to produce the small pouch, chassis cover and the hopper. This has been again modelled in card then workshop time allowed for full production. The product includes a fully functional working system that follows the sensor, can carry scaled quantities of bags and reacts well to the conditions it would be expected to work in.All fixtures, components and fittings chosen are fully appropriate for the chosen prototype. The candidate has used all tools and equipment competently during the manufacture of the prototype. A sustained high degree of safe working practice for self and others has been observed throughout.	No rewardable material	**0**				
			Level 1	**1**	**2**	**3**	**4**	
			Level 2	**5**	**6**	**7**	**8**	
			Level 3	**9**	**10**	**11**	**12**	
			Level 4	**13**	**14**	**15**	**16**	
3.2 Quality and Accuracy (AO2 12 marks)		The final prototype is fully functioning and meets the user's needs to carry shopping bags around the shopping centre. Many specification points have been achieved and the quality and accuracy of the product are good but there is some room for improvement especially with the controller part of the product	No rewardable material	**0**				
			Level 1	**1**	**2**	**3**		
			Level 2	**4**	**5**	**6**		
			Level 3	**7**	**8**	**9**		
			Level 4	**10**	**11**	**12**		

TESTING - FINAL FUNCTIONING ROBOT

Link to video

Link to video



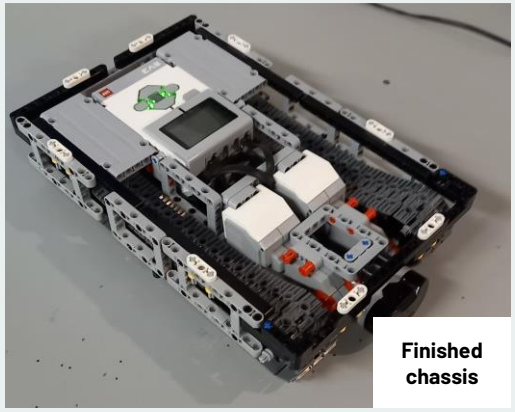


Finished hopper

Link to video

Link to video

Link to video



Finished chassis

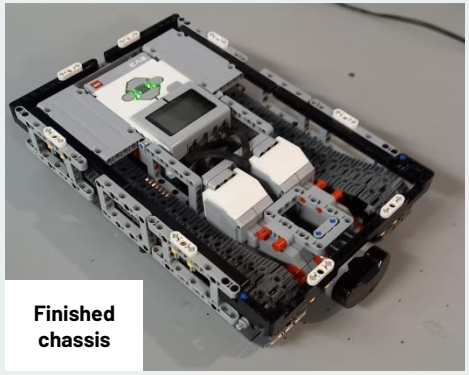
EVALUATION - THIRD PARTY FEEDBACK

I achieved a fully functional follower robot that can assist people while shopping in town centres. It does this by carrying their bags for them and following them with the use of a remote beacon (In the real produce this would be the control wristband). The model splits into two parts - the chassis that houses the electronics and controls the robot and the hopper that the bags can be put into (this also makes the robot look more professional and user friendly). These two easily separable parts makes it much easier for maintenance and making adjustments during the construction stage however in the real product these would not be separable.

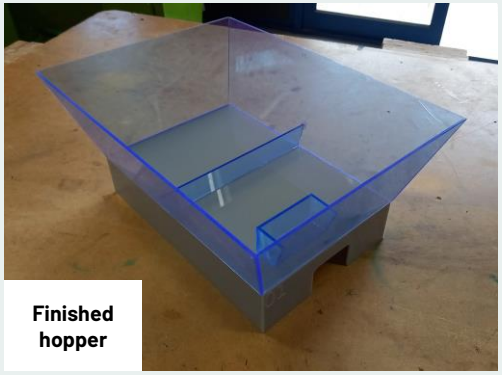
I have spoken to the same group of people that reviewed my development and the unanimous decision is that the follower robot has achieved its purpose. This product meets the client requirements of assisting people whilst shopping. It has the ability to assist anybody who chooses to use it. These group of people were especially happy that I had implemented their idea of the small section for carrying easily lost smaller items.

I have also surveyed a group of 20 people and asked them whether they believe the follower robot could be improved and whether they would use one if it were a real product. 13 out of the 20 said that they would use the follower robot with the other 7 saying they would not use the robot because they would not need it to start off with and would not benefit by much. 17 out of the 20 believe that it had achieved its purpose and didn't need to be improved before it could be used.

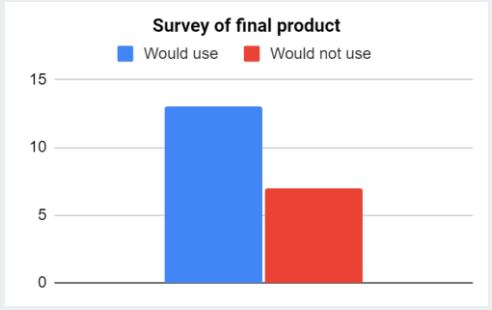
The 3 that believed that it could be improved gave very good ideas as to why and how this could be done. They come up with ideas such as a suspension system to stop fragile items being broken on rougher surfaces. A security system or some form of this that would reduce the risk of items being stolen. Finally the follower robot would need to have a much tighter turning radius and higher turning speed. These ideas could all be implemented into the real product.

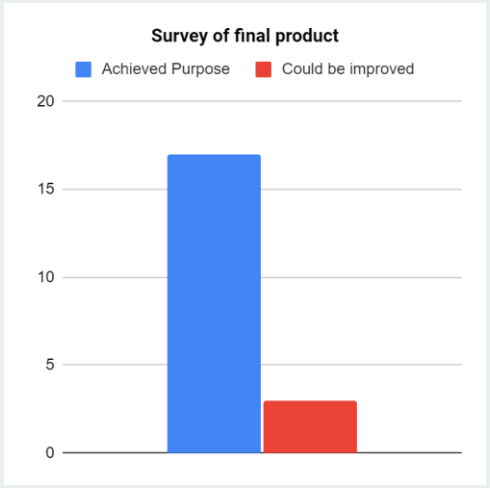


Finished chassis



Finished hopper





EVALUATION - COMPARED TO SPECIFICATION

Specification point	Testing for success	Was this point met?	Could this be improved?
Form - The product would have to have the ability to carry 3 bags.	I would check if the final product is able to carry 3 bags to the correct scale of a bag for life size.	The follower robot has the ability to carry 3 half scale bag for life bags within its hopper.	Due to the extra sizes that would be available there is not much to improve because if somebody required more space they would be able to use a large follower robot.
Function - The product would have to be able to relieve people of carrying bags around a shopping centre.	Does the product have the ability to relieve the stress of carrying bags for the user.	The follower robot can carry any bags for any person in turn completely relieving them from carrying anything.	The weight of the wristband could be reduced as this is the only thing they would have to carry, however this would not be a heavy item to start off with.
User requirements - The user would have to be able to reach their bags easily and if the product has handles they would have to be the correct size.	Use the ergonomics and anthropometric data to ensure the sizes are correct.	A full scale follower robot would not not be too low down for most people to reach the bags. The sizes of handles does not apply to the follower robot because it does not require any.	This could be improved by having a mechanism that lifted bags to an easier to reach height however this would be and expensive mechanism and not be feasible for use due to the extra cost.
Materials - The material chosen for the product would have to be weather resistant.	Use the product in the rain and test for any damage caused to it.	The acrylic is water resistant and would not be damaged by the rain however I cannot use the LEGO chassis in the rain as this would be damaged if I did.	The internal parts of a real and usable follower robot would be water resistant and not be damaged by it.
Scale of production - The product would be made using batch production.	Check whether the manufacturing methods and process used adequate for batch production.	I have only made one follower robot however I believe that the manufacturing methods that I have chosen to use would be viable for batch production as they are fast and accurate.	If I were to batch produce the follower robot then i would make templates that would fit as many of the pieces onto a single piece of acrylic as possible so there is minimal waste.
Sustainability - The materials chosen for the production of the product will have to be recyclable.	Checking that all of the materials used in the final product are fully recyclable and sourced sustainably.	The acrylic that is used in the hopper of the follower robot is recyclable. The LEGO chassis would not be used in the real product so the sustainability of this does not apply.	I could use different materials however it would be difficult to find a replacement material that shares all of the properties of acrylic without paying more money for it.
Safety - The product has very little to no safety risks.	First check to see if there are any obvious hazards and then using the product and testing if it causes any harm to the user.	There are no obvious ways that follower robot could harm a person due to not having enough power to do so. Harm to people is also reduced because it slows down as it gets closer.	Having sensors surrounding the robot as talked about in development would allow it to have a view all around the robot.
Cost - The cost of the product would have to be kept as low as possible.	Use surveys to find out if the final cost of the product is seen as affordable or not.	I cannot ask if the price is reasonable because I do not have a final price of the follower robot.	The price would be reduced if the chassis was made out of motors circuits rather than LEGO
Dimensions - The dimensions would have to be small enough to fit around the town centre without obstructing anybody.	Using the product around a town centre and testing if it fits through small spaces.	The half scale robot is small enough to fit through small spaces however I cannot tell if the full scale robot would be because I have not made a full scale model.	If the extra sensors were on the robot then it would be more aware of its surrounding so would be able to fit through small spaces with ease.

EVALUATION - LIFE CYCLE ANALYSIS

The manufacturing should not have much impact on the environment as it will only have the impact of the electricity that is used by the laser cutter. If this electricity is produced from sustainable sources then there would be no impact at all.

The life of the follower robot should not harm the environment as long as the electricity being used is generated from sustainable sources. The robots will require lots of electricity to run and therefore lots of sustainable electricity will need to be generated by the town centre.

The repair and upkeep of the follower should not cause any damage to the environment as the extent of upkeep will be updates to the software that it runs and replacing broken parts. Due to these parts being picked initially to not cause damage to the environment this should have a negligible effect.

The life of the follower robot should be very long - many years as a minimum. This is because the materials were chosen to last and therefore not be damaged easily. It will reach the end of its life when it meets one of these criteria:

- It is not used enough to warrant the space it takes up
- It is damaged beyond simple repairs
- A newer version / model becomes available for use (it's replaced)

After any of these have happened the follower robot will need to be disposed of. Each of the parts can be disposed of in different ways.

The Acrylic has a few options, some of which being more expensive and others being worse for the environment:

- One option is to bury the acrylic and send it to landfill. This is by far the cheapest option however the worst for the environment because acrylic is not biodegradable. When a biodegradable alternative to acrylic is made widely available this would be chosen instead of it. Therefore the acrylic would stay in landfill until it was dug back up again.
- Another alternative is to melt it down and reform it into something that can be used again - recycling. This is quite expensive however can be done with acrylic and would be the move environmentally safe method of disposal.
- The last option would be to burn the acrylic. This would give off lots of heat so can be used for running power stations. Due to the electricity generated this is not a very expensive option however is very bad for the environment because this would give off toxic gasses. These gasses can be made safe through the use of a scrubber.

The electronics inside the model are created out of LEGO so can be dismantled and used again - they would not need to be disposed of at all.

In a real follower robot the electronics could all either be recycled by melting it down and forming new electronic components (copper wires) or removing them from the circuits and using them again (motors). The circuit board could be melted down to take the metal off of it to use again.

Almost all of the follower robot can either be reused or recycled and used again in a different way. I believe that the best way to dispose of the acrylic is melting it down and forming it into another usable item. This does not harm the environment and there is no chance of harmful and toxic gasses escaping.

4 Evaluate	Page ref	Comments	Level	Mark awarded (please circle)		Pearson use only
4.1 Testing and Evaluation (AO3 6 marks)		The final prototype is fully functioning and meets the needs of the end user in relation to a demanding design problem that is appropriate for the chosen contextual challenge The prototype meets many of the specification points, which unfortunately did not suggest many points that were measurable and could have been tested here. They have however, been evaluated in some good detail. Third party feedback has been well used to evaluate the product and is related back to the contextual challenge again. A Life Cycle Analysis has been included with references to the product's materials, durability and the suggested recycling of its various parts should repair not be possible.	No rewardable material	**0**		
			Level 1	**1**	**2**	
			Level 2	**3**	**4**	
			Level 3	**5**	**6**	
General comments…						

A very detailed prototype that has been very well made has enabled this candidate to be consistently scoring well in the assessment of the project. It is a suitable example of a very good GCSE product that has matched the Contextual challenge.

Summary for Exemplar folder

Assessment Grid	Mark Range	Exemplar Marks
1.1. Investigation of needs and research	0-8 marks	8 marks (level 3)
1.2 Specification	0-8 marks	6 marks (level 2)
2.1 Design ideas	0-8 marks	7 marks (level 3)
2.2 Review of initial ideas	0-8 marks	6 marks (level 2)
2.3 Development of design ideas into a chosen design	0-12 marks	12 marks (level 4)
2.4 Communication of design ideas	0-8 marks	8 marks (level 3)
2.5 Review of chosen design	0-6 marks	6 marks (level 3)
3.1a Manufacture – selection of materials	0-8 marks	7 marks (level 3)
3.1b Manufacture – skills and processes	0-16 marks	16 marks (level 4)
3.2 Quality and accuracy	0-12 marks	10 marks (level 4)
4.1 Testing and evaluation	0-6 marks	6 marks (level 3)
	Total	92 / 100

Your pre submitted questions from module 3.

Answers to your pre submitted questions from module 3……

Pearson

Questions you wish to raise now concerning Assessment of NEA…….

Pearson

Support Available:

For further support, contact your Subject Advisor or the Design & Technology team:

Subject Advisor: Evren Alibaba

email:
teachingdesignandtechnology@pearson.com

telephone: 0344 4632819

Twitter: @PearsonTeachDT

Pearson