How can we enhance connected services through the Internet of Things (IoT) in museum and gallery spaces?

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1 Introduction

In this design project, the team worked towards creating a solution for enhancing museum services via the Internet of Things technologies. We chose the Tate Modern as our museum space and worked with the challenge statement of 'How can we make navigation at the Tate Modern easier?'. During the process, we established a design framework, researched Internet of Things technologies and ideated through utilising a wide range of creativity techniques. As a result of this process, we created a personal guide device (ALFREDD) for supporting navigation at the Tate Modern.

2 The Creative Process

Considering that this was the first time the team had ever worked together, we began by learning about each other's backgrounds, strengths, weaknesses as well as preferred ways of working. Design frameworks were discussed and it was clear that we wanted to create a collaborative, flexible and supportive environment. This is why we chose to follow the Service Design Thinking framework developed by Stickdorn & Schneider (2010) and Shneiderman's Situationalist Creative Process.

We followed the five principles highlighted in the Service Design Thinking methodology:

- User centered - we researched the users' pain points and current experience to inform our design.
- Co-creative - we spoke to volunteers who were working at the gallery to gather ideas.
- Sequencing - we developed user journeys and storyboards that showed the order tasks took place and the touchpoints encountered.
- Evidencing - we gave visitors access to their visit, providing evidence of their tour and increasing their customer loyalty.
- Holistic - to cover as many approaches as possible the team produced alternative customer journeys whilst considering how the design would benefit the Tate Modern.

The techniques adopted for the Situationalist method (Shneiderman 2007, p25) suited the team's preferred social working style. Our collaborative approach meant that all team members contributed equally to the design process. The trusting and open work environment we built allowed a steady flow of ideas.

The team bonded well, worked with humour and were relaxed around each other. The project was well planned and kept to time using Slack, Asana, Google Drive and WhatsApp. We found some meeting places were better than others but with a whiteboard and sticky notes we created our own comfortable environment.

2.1 Creativity Techniques

We used a range of divergent and convergent techniques throughout the conceptual design process to generate and refine ideas. This method follows the double diamond design process identified by the Design Council (2011) which consists of four phases Discovering insights, Defining the problem area, Developing solutions and Delivering finalised execution. Many of the ideas were produced during divergent exercises, such as brainstorming and analogical problem-solving. Convergent techniques, such as voting and design scenarios were used to refine the design.

Each activity in our search for novel ideas produced design artefacts in the form of sketches, 3D models and documented concepts. There is a clear path through the design process as each of our exercises informed one or more of the next stages in the development. We used our time in tutorials to try out creativity techniques, then built on successful ones, and added new ones when working outside of the contact hours. Some techniques like Imagery Trek, and Creativity Triggers didn't produce novel ideas for us and were abandoned.

2.1.1 Museum Research, Observations and Interviews

We started by researching a few museums suggested by each member of the team. We then listed pros and cons for each space and voted, choosing the Tate Modern. This was followed by individual and group field visits which according to Sharp, Rogers and Preece (2015, pp. 252-269) are helpful in discovering user needs, requirements and opportunities for design.

Observations and interviews revealed that the majority of opportunities for improvement linked to four areas:

1. Difficulty navigating around the museum
2. Visitors not understanding the artworks and feeling intimidated by them
3. Families having different needs which are not currently being catered for

4. People were enjoying interactive spaces, but there were too few of them

After weighing up the pros and cons of all opportunities, we decided to focus on the first problem area as it had most issues and was seen as the main barrier between the visitors and the museum.

2.1.2 Internet of Things Research

In tandem with researching the museum, the team explored a wide range of Internet of Things technologies, highlighting ones we wanted to use. The Internet of Things defined as 'the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity' (International Institute for Analytics, 2015). In our research about the IoT we came up with several ideas but settled on iBeacons as the best solution for our challenge statement. The iBeacons can communicate with the device to provide information about the artworks and also monitor the crowd movements. (Apple Inc., 2013)

One other device that the team thought could be useful was the smart pen. This device has been successfully implemented at the Cooper museum in New York, but it didn't fully address the issues that were raised by our research. Other devices included the eye-tribe eye tracking device, various smart watches, wristbands and flip-flops as well as Amazon's key and dash products.

2.1.3 Personas

After debriefing on museum research findings, the team came up with two personas - characters rooted in research, which are used to help the design team build empathy towards users and gain perspective on their point of view (Stickdorn & Schneider, 2010, pp. 178-179). The primary persona, Diana, is a first-time visitor who came to London for the weekend. The secondary persona, Benji, is an art student that avoids crowded spaces and wants to find the easiest way to see specific artworks. The personas we created were helpful when making design decisions through team's empathetic thinking in the style of 'What would Diana do?', 'What would Benji want?'. Personas were relatable and effective and one of the 'tools' the team used throughout the process.

2.1.4 Empathy Maps

The empathy map fits neatly into the design process after the personas have been generated (Knox 2014). The idea is to put yourself in your user's shoes and imagine what they are experiencing. We chose to put Benji and Diana in the Turbine Hall at the Tate Modern and then asked questions about what they were seeing, hearing, feeling, thinking, saying and doing. Once the lists had been made it was easier to establish what 'pain' and what 'gain' they experienced.

In our example, Benji loves the environment but is frustrated that he can't find his way to a particular artwork very easily and Diana, aside from getting lost, has trouble understanding the art. This helped us with the conception of a navigation device that also provided information about the artworks.

2.1.5 Current User Journeys

After Benji and Diana's profiles were completed and the team felt like they knew them well, current user journeys were created. The Design Council (2011) describes a User Journey Map as a journey through a service, showing the different interactions. A current user journey identifies pain points, where the system may need improvement and areas where things are working well.

The team drew current user journeys for both, Diana and Benji. Benji has been to the Tate Modern before and he uses the mobile app to find his way around. However, it is confusing and he ends up in the wrong building and there are too many people around. This user journey identified Benji's pain points of navigation and overcrowding. The user journey for Diana highlighted her difficulty reading the map and her lack of understanding of modern art.

2.1.6 Brainstorming

The team then moved to the ideation phase, a significant part of which was brainstorming. Brainstorming is an idea generation technique which relies on producing large quantities of solutions that address a design challenge (Gasca and Zaragoza, 2017, pp. 132-133). This was one of the techniques that we used throughout the project. We came up with ideas as a group, as well as individually, converging and diverging as needed.

At the start of brainstorming sessions, we used warm-up exercises, which we found to be very successful. In the 'Randomisation' ice-breaking technique, each participant writes down an object and an activity on two separate pieces of paper and passes them around to create new scenarios (Crinid, 2009). We found that this activity made us feel comfortable with each other and it set an open-minded tone for the brainstorm.
For our first brainstorm three sub-challenges related to the navigation problem were highlighted:

- 'I can't find the artworks I'm interested in'
- 'I can't find my way around easily'
- 'I can't move around easily, there are too many people'

The sub-challenges were transformed into HMW questions - concise questions beginning with 'How might we' which help to frame problems as opportunities for a brainstorm (Gasca and Zaragoza, 2017, pp. 116-117). Ideas for all three sub-challenges were brainstormed, and based on the results the team decided that the challenge statement should be: 'How can we make navigation at the Tate Modern easier?'. This incorporated all three aspects of the problem.
Brainstorming individually worked especially well as it gave each person an opportunity to think and contribute equally. Generated ideas overlapped in some areas, but there were many different perspectives which complemented each other making the solution ideas richer. A large number of ideas produced from brainstorming were carried through to the final design e.g. the personalised guided tour idea, live crowd heat map, AR navigation and swiping interface for artwork browsing. Some more fantastical like guiding hoverboards, Hogwarts-like moving staircases and sophisticated robots were left behind.

2.1.7 BrightSparks

Another technique which the team tried during ideation was BrightSparks - a tool which supports problem-solving through generating a random profile of a famous character. The generated profile is accompanied by a list of questions which helps to solve the problem from the character's perspective.
The first randomly generated character was Pac-Man which seemed to be the ideal character, as our solution is for a navigation system. We discussed ways that Pac-Man would cope in Tate modern space and he reminded us of Benji - goal-driven, efficient and likes to avoid obstacles. Although this role-play injected a fun element to the problem-solving process, the ideas generated weren't particularly novel, possibly because Pac-Man was too close to the problem we were examining.
The second character was Hermione Granger. Hermione's rational and assertive attitude lends itself well to problem-solving, she is someone who'd likely plan their visit carefully in advance. Ideas generated through this role play were more novel, and better suited for solving our problem. We talked about how perfectionist Hermione, would prefer a solution that was straight-forward and well executed. She's also loyal and enjoys completing tasks, which we interpreted as a treasure-hunt like experience for the museum.
Although none of the ideas we discussed during the BrightSparks stage made it to the core of our solution, the characteristics of these two characters set a certain standard for the execution of the project which we tried to maintain. As a team, we enjoyed this technique and would use it again in the future.

2.1.8 Constraint Removal

To produce more ideas the team tried the constraint removal technique. Constraints are factors that put boundaries on a system or service. Removing, reducing the impact of or reinterpreting constraints allows designers to come up with new ideas without being restricted by the rules.
The team brainstormed constraints that affect the 'personal guide solution' and came up with ten different ones. We chose overcrowding and visitor embarrassment as the two constraints that we would experiment with. For overcrowding, the constraint removal allowed us to imagine that each visitor would have their own personal guide, therefore doubling the number of visitors in an already crowded space. For visitor embarrassment, we envisioned no awkwardness from having a personal guide or being escorted by a robot.
After brainstorming at the three levels of constraint removal, an idea emerged that the personal guide could be a handheld device rather than a human or robot escort. To reduce any potential embarrassment, we decided it should also be discreet. These qualities were carried through to the final design of ALFREDD.
The team felt that complete removal of the constraint was too extreme as the solutions were not acceptable.

2.1.9 Analogical Problem Solving

The final ideation technique we used was Analogical Problem Solving. This method explores relationship similarities in two domains - a target domain with a problem to solve and a source domain for inspiration (Gasca and Zaragoza, 2017, pp. 120-121). The source and target domains can be similar, or different.

For the purpose of the design problem, we were trying to solve we used two analogies. In the first one, the team took inspiration from going to a fancy restaurant. There was a shared feeling of intimidation which can be felt at an expensive restaurant as well as a modern art museum, especially for a first-time visitor. The team explored the idea of a waiter, thought to be equivalent of a personal guide. We liked the idea of visitors having a dedicated personal guide whom they could summon if they needed help.

The second analogy compared navigating around the Tate to navigating around a large shopping centre. The ideas of an interactive map, shopping basket as well as a personal shopper were explored. In both analogies, the idea of personal assistance was most prominent and was further built upon. With the latter analogy, the level of personalisation was more advanced, which was something that appealed to us. This idea carried through to the prototype in a form of filters for selecting a guided tour, as well as an option for browsing art works to create a unique tour. The shopping basket idea was executed in a form of a 'heart' button that saved the artwork to the equivalent of a shopping cart. The user could then refer to their favourite artworks later. The team enjoyed these exercises as they triggered our imagination and allowed for a thorough analysis of proposed solutions and finding inspiration in unexpected places.

2.1.10 Future User Journeys

Having established our challenge statement, identified the pain points and produced solutions to the navigation problem, it was time for some convergent thinking. A future user journey shows the ways that users could interact with the service and product that has been designed (Mears 2013).

We used future user journeys to explore our design ideas and establish which solutions would work. The design artefacts produced at this stage were fed into the final full Storyboard.

2.1.11 Sketches

Sketching is a significant part of the design process and we have used it to accompany many of the techniques outlined above. The generation of ideas through sketching is a long established part of the design process. We used sketching throughout the design process to explore ideas both as a team and individually. At each stage sketching was used to stimulate the designers to think about the subject, either by visualising the situation or imagining a solution. Another useful application of sketching was for developing the device. The process of sketching led to some surprising results as it provides the freedom for expression and a flow of ideas from the imagination to a concrete form. Aside from producing interesting results, we appreciated the flexibility and low cost of this technique.

2.2 Design Artefacts

2.2.1 Storyboard

A storyboard, as described by Babich (2017), is "a linear sequence of illustrations, arrayed together to visualize a story". Storyboards are useful as they are essentially the visual representation of the prior research done and the conclusions made during the creative process.

We used a storyboard to depict how ALFREDD would be collected and used as well as the user's experience with it. The device itself includes many features all of which cannot be represented in a single storyboard without suffering from a lack of clarity and effectiveness. These limitations helped us to focus and hone in on a particular use case that is in direct correlation with Diana's needs and frustrations. Therefore, within the context of the story being depicted, only three of the devices features ended up being represented. It helped to visually provide a solution to specific problems that users may encounter which is why it was so effective. During the final stages of the design process, we created two versions of the storyboard. Initially, our storyboard was much more objective-based and didn't focus on Diana's thoughts and feelings. This was pointed out to us during the design critique, a conclusion of which was to transform the storyboard into more of a hero's journey. Therefore, for the second version of the storyboard, we made Diana the central focus, highlighting her thoughts and experience which are the priority of the design.

2.2.2 3D Service Environment for Desktop Walkthrough

Stickdorn (2011) explains that 'desktop walkthroughs' are a small 3D representation of a service environment, which can be used to re-enact an interaction, bringing it to life in a highly engaging manner. Throughout the design process we relied on two different versions of a 3D service environment. The first version (V1) was created with Lego bricks and plasticine to validate and reflect upon an initial concept design of a large robot-escort supporting the users in the navigation of the Tate Modern. The second version of the walkthrough (V2) represented the space and the touchpoints involved in the prospective journeys available to the users of ALFREDD.

The two prototypes had very different purposes, which influenced their level of detail. V1 was created roughly and not to scale, it was used to mimic the collection of the robot at the reception. V2 was created to scale for accurate representation of how users might navigate more easily around the museum. In this version, we included examples of multiple touchpoints: two different types of collection/drop off points and how the iBeacons are distributed around the artworks to locate the in-use ALFREDD devices. The collection point was placed in the centre of the entrance for easier discoverability.

2.2.3 Touchpoint Prototype

As part of our design we also produced a touch-point prototype. According to Ahram and Falcão (2017) the main objective of the touchpoint prototype is to understand the user's experience of the main functions of a design as well as evaluate whether the design helps them achieve their goal.

The physical prototype of ALFREDD was constructed out of cardboard covered with black tape to give it a finished, matte look and it featured a metallic on/off button. The purpose of the prototype was to have a hands-on product to evaluate. To accompany ALFREDD we also designed wireframes of the on-screen interactions which we used during the user journey run-through. Our first iterations of the wireframe designs were low-fidelity prototypes sketched on paper. Each team member picked a user journey to design individually and then presented them to the rest of the team. This was very useful as it allowed us to collaborate and gave us a wide range of possibilities to select from. We then picked our favourite elements and used them to build digital hi-fidelity wireframes. We opted for a dedicated device but in the future we could give an option of using an app on a visitor's own device.

We used the hi-fidelity prototype to act out Diana's user journey of planning a tour by sliding the printed out wireframes through the side of the physical prototype. Our prototype was then evaluated during a peer review with another team, who provided valuable feedback on what to improve, including suggestions for unifying the navigation breadcrumbs for clarity. The wireframes went through several revisions until we settled on part of the journey we thought Diana would find most important.

3 Conclusion

The team was very successful at problem-solving, generating ideas and producing solutions. The design artefacts produced were of a high standard and effective. The design process enabled the group to develop new ideas and solutions to the navigation problems at the Tate Modern.

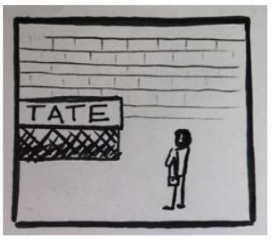
The double diamond design process worked well for us. The first divergent quarter involved discovery of the domain, the second quarter was convergent, where we came up with our challenge statement. The brainstorming and other creativity techniques provided the divergent third quarter where ideas were explored and the final quarter we converged to produce ALFREDD. We found ourselves adapting the process in a less symmetrical way, by diverging and converging more than two times, due to the large scope of the challenge statement.

During the process, we were often torn between novel and exciting designs and practicality. The team was most excited when discussing imaginative and fantastical designs, implementation of which would not be within the scope of the challenge statement and the museum space selected. Although in retrospect, we could have picked a smaller space and a problem statement that would allow for more flexibility, we are glad that with our solution we managed to solve the biggest problem at the Tate Modern whilst introducing more sophisticated use of the IoT technologies. We also stayed true to Tate's minimal aesthetic whilst focussing on the users' needs which was very important to us.

4 Storyboard

End-to-end Diana's journey at the Tate Modern

1



I've read so much about the Tate. I'm really excited to finally be here!

Diana arrives at the Tate Modern. It's her first time in London and she's feeling excited.

2

Ok, where should I go now?

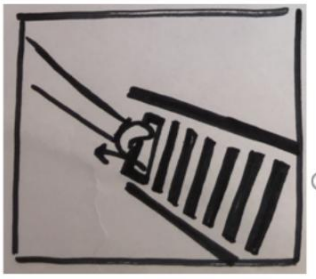
She's unsure about where she should go first and needs some assistance.

3

Ok, I definitely need one of these!

She sees the ALFREDD distribution point and watches a quick intro video on the screen on the wall. She feels intrigued.

4



This is pretty cool!

She picks ALFREDD up and the device starts up and welcome screen loads

5

Wow, I love how convenient this is!

She follows the instructions on the screen and decides to use the plan a tour feature. She's impressed by the level of personalisation and is excited about starting.

6

This beats carrying around a map by a long shot!

AR map gets activated, and ALFREDD guides Diana to the first stop of her tour.

4 Storyboard (cont)

End-to-end Diana's journey at the Tate Modern

7

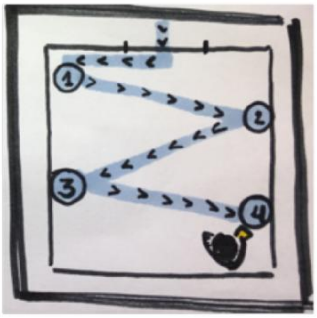
Diana follows ALFREDD and arrives at the first stop

8

Oh, I really like this piece of artwork

ALFREDD displays information about the artworrk Diana has the option on the device to "like" the art and saves it to her favourites list

9



Diana carries on collecting information about the artworks she sees

10

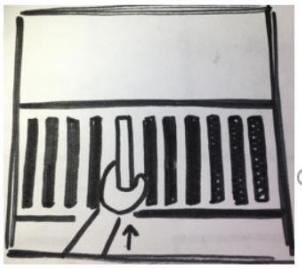
I wish I could stay for a little longer. Using ALFREDD has been so helpful.

Once she reaches the end of her tour, she has an option to either end her experience or take another tour.

ALFREDD displays the artwork she has favourited during the tour. She has an option to buy related gifts or to end the tour. She choses to end the tour.

She is then presented with a prompt to enter her email address. ALFREDD will then e-mail the summary of her visit, which she can then access later.

11



I'll definitely be coming here again!

She deposits ALFREDD at one of the drop-off points

12

Memories…

Back in the comfort of her own home, Diana accesses the information sent by ALFREDD.

5 Touchpoint Prototype

ALFREDD - Augmented Location Finder Recommender Educator Digital Device

Handheld device intended to act as the users' personal guide around the Tate. Users can plan tours, view crowd levels around museums and browse through all the artwork.

Fig 1.1

Fig 1.1 is an image of the ALFREDD prototype device that visitors will pick up at the Tate.
Figs 2.1-2.10 are the wireframes in sequence for the user journey using the 'Help me plan a tour' feature
- Fig 2.2 and 2.3 displays how the visitors view and choose their tour options.
- Fig 2.4 and 2.5 are the detailed maps of the Tate with the artwork on the tour highlighted.
- Fig 2.6 to 2.8 are the guided route screens using the AR technology. At this point the camera on ALFREDD is activated and the surroundings are greyed out, with a blue line shown to guide the user around. The iBeacons placed around the Tate sense when ALFREDD is near and activate pop-ups with artwork information where users can also 'like' the art they come across on the tour.
- Fig 2.9 is the list of 'liked' artworks and fig 2.10 is the last screen seen before depositing ALFREDD with the e-mail option to send their Tate visit.

Additional ALFREDD features. Fig 3.1 is an image carousel users scroll to discover art and can 'like' or 'dislike' them, with the icons underneath, with liked pieces added to favourites list. 3.2 is a dynamic list that updates the crowd levels, so users can view the least crowded galleries, cafes, and other museum spaces. When a gallery is pressed, a drop down dynamic image showing a heat map of the room can be seen.

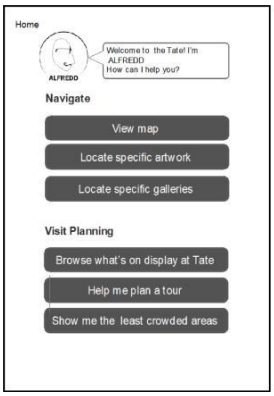


Fig 2.1

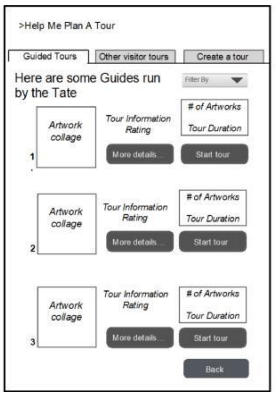


Fig 2.2

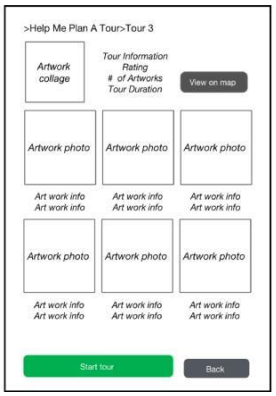


Fig 2.3

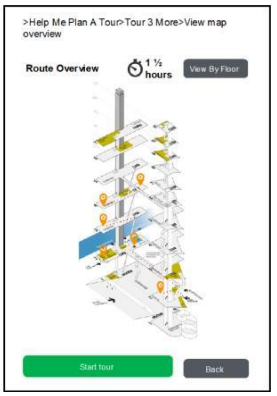


Fig 2.4

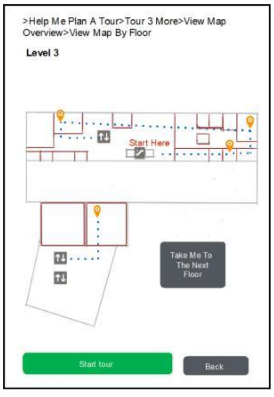


Fig 2.5

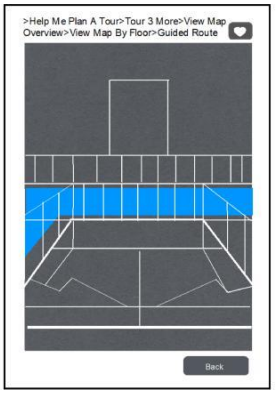


Fig 2.6

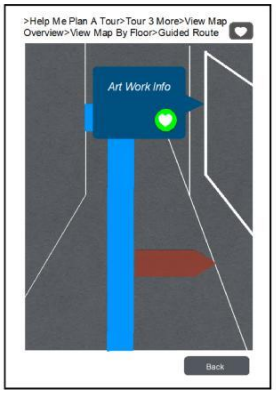


Fig 2.7

Fig 2.8

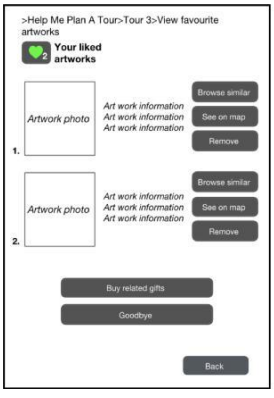


Fig 2.9

Fig 2.10

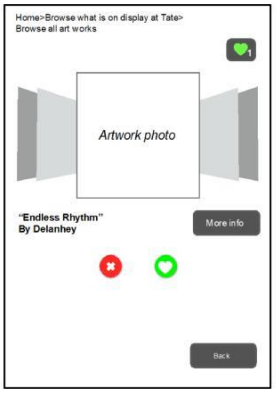


Fig 3.1

Fig 3.2

6 3D Service Environment

A physical model made to scale, used for design walkthroughs and for demonstrating touchpoints

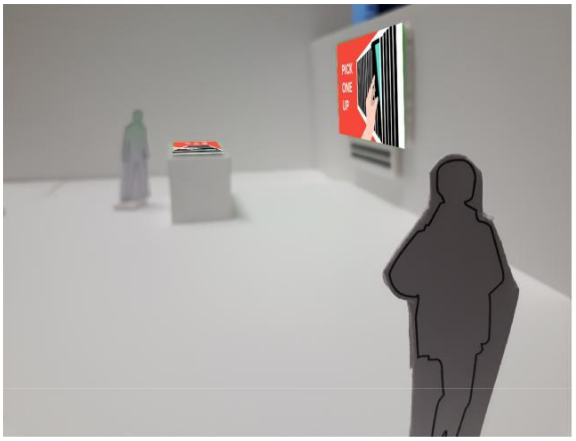


Fig 1.1

Fig 1.2

Fig 1.3

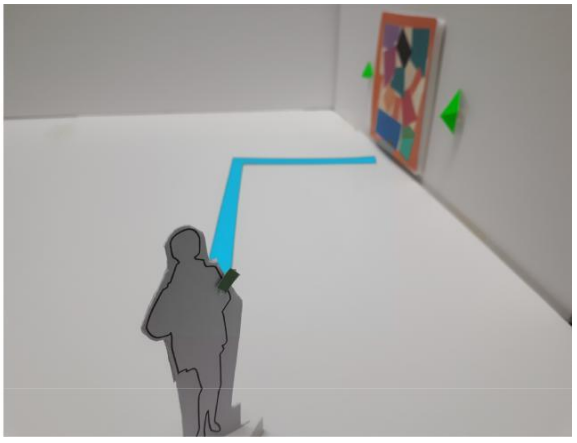


Fig 1.4

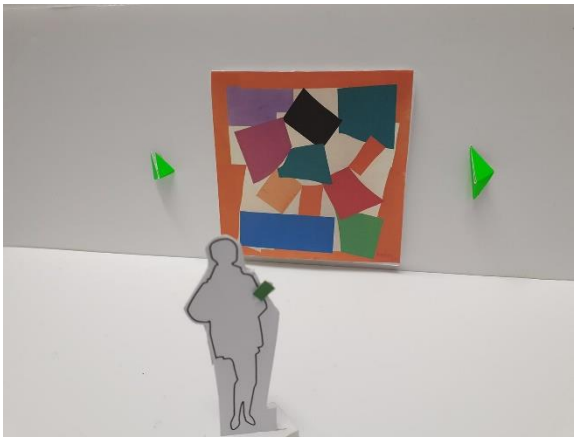


Fig 1.5

Fig 1.1 Pick-up point clearly visible at arrival.
Fig 1.2 Short video plays in a loop, invites to pick ALFREDD up and shows its functionality.
Fig 1.3 User is ready to experiment with the device right after watching the video. Chooses “Help me plan a tour”.
Fig 1.4 ALFREDD takes the user on an art tour through Tate showing paths in augmented reality.
Fig 1.5 Devices get detected by sensors which calculate the position of the users.

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