How can augmented reality be used for independent shopping experiences by individuals with health conditions?

Introduction

There are more than 13 million disabled people in the United Kingdom, which accounts for a fifth of the population. More than half of those find it difficult to buy retail goods because of their disability (Worthington, 2019). Taking this into account, this research paper will identify the theoretical and practical challenges involved in the creation of the augmented reality (AR) application Shopica, designed to enhance the in-store experience for disabled customers.

Even though shopping has existed for hundreds, if not thousands, of years, we have not witnessed the core process evolve much to cater to people with disabilities. Products are still retrieved from shelves and brought to a counter to be paid for; this fundamental part of shopping has not changed. This is a problem for many disabled people around the world, as not all products are in easily accessible locations. Their efforts to meet their daily needs are frequently thwarted by the obstacles they encounter in their living environment (Rostron, 1995; Kaufman-Scarborough, 1999). A consumer in a wheelchair, for instance, will be unable to reach things on the highest or even lowest shelves. This is only one example of the many hurdles disabled customers' experience.

Personal assistants offered by the marketplace and online shopping websites are just some of the existing solutions that could be considered to help the situation. While shopping, many people could feel very uncomfortable asking a person to do

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everything they need, and in some cases, this may lead to awkwardness and unease. The typical shopping experience that individuals might seek is not offered by online purchasing. It would be challenging to make purchases and deal with restoring purchases for products that are not physically present. Online shopping is not instant, and it takes time to physically obtain purchased items. Shopica aims to provide a new means of shopping through which disabled people can have a comfortable and easy shopping experience.

The challenges associated with disability in the retail industry

Accessibility at retail establishments is necessary to ensure that disabled customers have the same shopping experience as everyone else. According to Purple's 2019 survey of people who consider themselves disabled; they spend an average of £163 per month on retail goods. Nearly one-third (29%) of disabled individuals spend money weekly in retail places (Skeldon, 2019). A 2016 Nielsen study found that households with people with disabilities made more shopping trips and spent more money per trip on average than households without a person with disabilities. According to the same study, those with disabilities seem to be more brand conscious.

Historically, people with disabilities have not been widely embraced as a target market by the private sector (Hastings, 2009). Four out of five disabled consumers believe businesses should do more to be accessible, and more than half (56%) think that improving staff knowledge of various disabilities would encourage them to spend their estimated £249 billion in disposable money annually (Purple, 2019). According to Ormesher (2022), 65% of people with disabilities have left a store or website before they could finish their transaction because of their disability. More than three-quarters of the disabled young adults (16-24 years old) have had difficulties purchasing things online or in person on many occasions owing to their disability.

After reviewing this data, it is evident that there is a significant gap in the availability and promotion of shopping experiences that are accessible to individuals with disabilities.

Augmented reality as Assistive Technology

Nowadays, technological progress is taking place at an exponential rate, allowing technologies to move more rapidly from research laboratories to the marketplace. Innovative ideas and products are being embraced by new customers more easily than ever before. Modern technologies, such as computers, smartphones, social media, and the Internet, are used with rapidly increasing adoption rates. The exponential growth of enabling technologies in terms of processing power, big data, device connection, and internet performance has enabled the creation of consumer- and community-valued solutions based on new technologies. Technology has become a necessity for humanity to control the essential aspects required for development and evolution. As people have grown fond of technology and integrated it into every activity of their daily routine, increasing their comfort and confidence in its results, it would be prudent to use technology to build and simulate the required features and characteristics of an environment for the elderly and disabled people to fulfil their basic desires and enhance their productivity and creativity within society.

To develop a mainstream solution that fulfils its role, a user-centred approach needs to be followed; otherwise, there is a risk of having to re-engineer a solution because it does not reflect the specific needs of a certain group of people, e.g., people with different disabilities (Nierling *et al.,* 2018). When talking about the integration of mainstream and assistive technologies, it is worth mentioning that the implementation of accessibility features in everyday applications has proven to be beneficial for people without disabilities as well. For example, subtitles in a video are useful not only for people with hearing impairments but also for people experiencing an ear infection (temporary disability) or people in a noisy place (situational disability) (Gjøsaeter *et al.,* 2019). Accessibility, in general, can be achieved if the principles of universal design are followed, which are defined as the “design of products,

environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design" (United Nations, 2006). When developing a product with the varying needs and abilities of individuals in mind, equitable chances for its usage may be accomplished, as can the integration of people into many different aspects of life.

Augmented reality (AR) produces a heightened and augmented reality enhanced by merging the virtual and real worlds (Bronack, 2011; Klopfer & Squire, 2008). The coexistence of virtual objects and physical environments enables users to visualise intricate spatial relationships and abstract ideas (Arvanitis *et al.,* 2007), have a non-real-world experience (Klopfer & Squire, 2008), engage with synthetic two-dimensional and three-dimensional objects in mixed reality (Kerawalla *et al.,* 2006), and foster crucial skills and literacies that cannot be developed and implemented in other technologically enhanced situations (Squire & Klopfer, 2007). These advantages have made AR one of the most important developing technologies in the coming years (Martin *et al.,* 2011).

Thanks to all this flexibility that this technology provides, it is deemed most optimal to incorporate as part of this project.

Development

The motivation behind this project began gradually from the moment I noticed an article about the challenges associated with disabilities in the retail industry. For instance, disabled young adults (16–24 years old) suffer the worst; more than three-quarters of them have had difficulties purchasing goods online or in person on many occasions owing to their disability (Worthington, 2019). This is a startling figure and needs to be addressed, but there is a lack of innovation regarding this problem.

Therefore, I was already aware of my intended audience and goal for this project, and this stands out as one of its distinguishing characteristics: to design a mobile application that can become a tool for shopping in the day-to-day lives of individuals

with health conditions. This was the fundamental question that kept me going back to the drawing board during the development process.

For the creation and development of this project, the Rapid Application Development (RAD) method is applied. RAD is a form of agile software development (Singh 2019). This method is particularly suitable in the development process, as it parallels the cooperation of the user and the developer. It emphasises rapid prototyping and iterative delivery and focuses on gathering customer requirements through focus groups and early testing of the prototypes with an iterative concept. There are several advantages that this methodology offers, such as the possibility to make quick adjustments during the development phase (Singh 2019). Some of the key benefits it provided me with were the quick iterations and code reusability. This allowed me to reduce the development time and speed up delivery. Code reusability ensured fewer errors, shorter testing times, and less manual coding. However, there are several risks to applying the RAD method. According to Cristina Venera *et al.* (2011), the methodology ignores aspects related to system management. However, that is not a problem within the scope of this project.

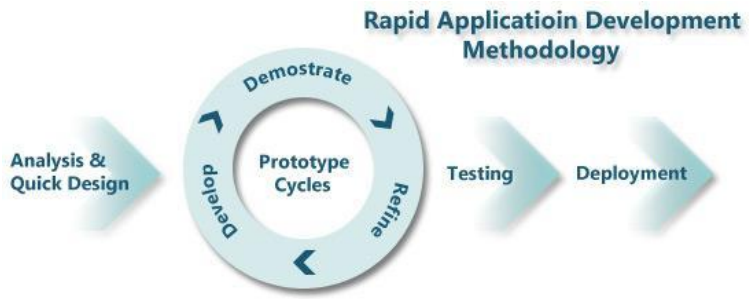


Figure 1: Rapid Application Development Method

Identifying the target audience

To gain an understanding of what the target audience of the developed AR application will be, it was important to produce user personas. User personas are a fictional representation of the ideal customer for the respective product (Veal, 2022).

Developing these user personas helped me to understand what the real user problem was and how to solve it.

Figure 2: Ben's User Persona

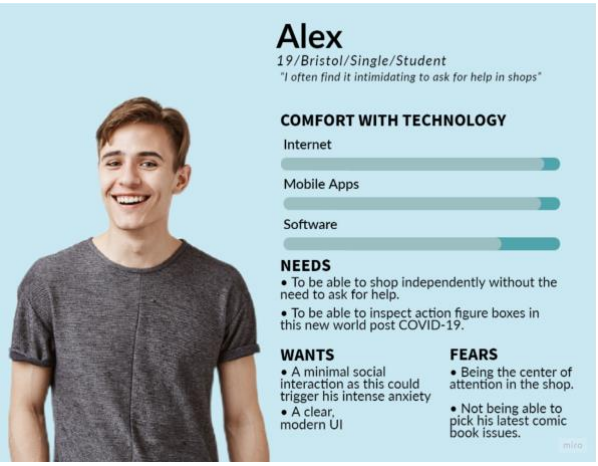


Figure 3: Alex's User Persona

Ben represents one of the user personas emerging from this process. Ben utilises a wheelchair to navigate large stores once every week. He wants to be able to accomplish his weekly shopping quickly and independently so he can pick up his children from school. He wants a user-friendly user interface and is proficient at utilising mobile apps.

Considering this user persona, it is clear how the application may be adapted to meet this individual's requirements. Ben will prefer a straightforward and intuitive user experience that prioritises speed over complication. This implies that Shopica's primary functions should ideally be accessible with a few touches. This aspect of my development and prototype appears to be on track since a product may be ordered with a single click from the camera view. The application aims to improve the user's shopping experience and, for some, make it less stressful and anxiety-inducing. As a result, the onboarding messages inside the app experience should be written in a friendly tone, which will allow more users to feel comfortable using the app.

Alex was another user profile I created. Alex is defined as a media student proficient with mobile applications. He wants to be able to pick up his weekly comics from his local comic bookstore, but he has autism and significant social anxiety, preventing him from doing so. This indicates that Alex desires minimal social interaction while shopping.

When catering to Alex, it is essential to utilise clear and explicit terminology. This is significant owing to his autism diagnosis, as a prominent characteristic of autism is the literal interpretation of language. This suggests that I should avoid terms with many meanings when building the app. I will also strive to make onboarding messaging and instructions clear, concise, and inviting to individuals with less technical expertise.

Design for everyone

When considering the application's colour design, it was essential to consider accessibility. Because the application is intended for people with disabilities, it is crucial that it be accessible. This requires designing for a range of disabilities and making it accessible to everyone, including those with a visual impairment. This can affect people in numerous ways, such as being partially sighted or colour-blind.

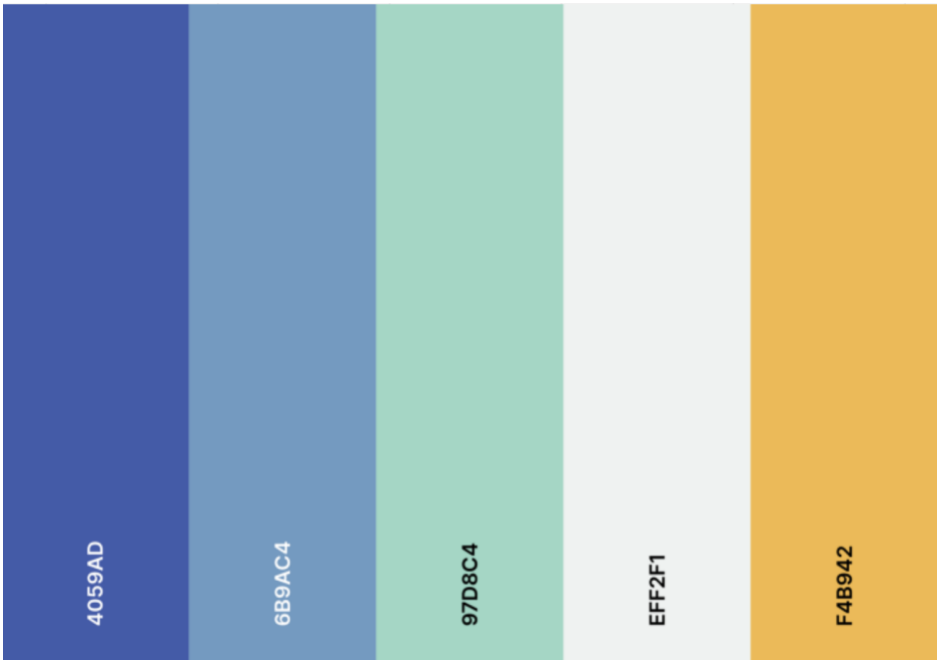


Figure 4: The colourblind-friendly palette used in Shopica

Screenshots of the chosen scheme were run through a colour-blind simulator so that readability and usefulness were not compromised for the sake of design. Text was

also aligned to the left to improve readability for people who may have reading difficulties. The findings of the colour-blind test were encouraging, as the application remained functional and readable when seen via all forms of colour-blindness. This is vital to the app, as its major purpose is accessibility and assisting the disabled community. Below are the findings of a few of the colour-blind simulator tests.

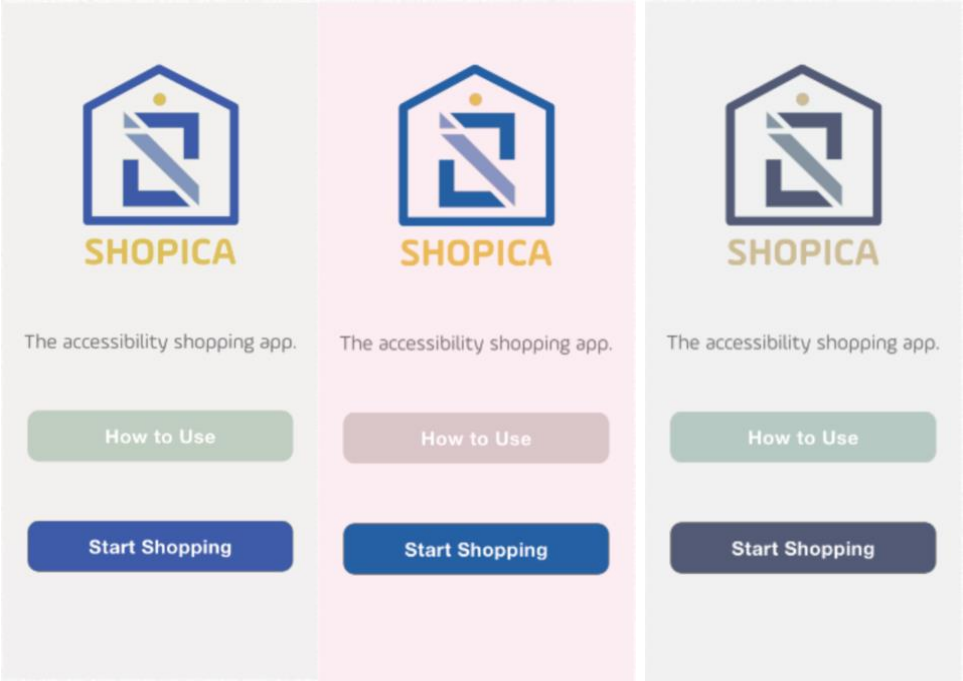


Figure 5: The results from the colour-blind simulator tests

From left to right, the forms of colour blindness seen above are Protanomaly, Deuteranopia, and Monochromacy. As shown in the graphics above, the application is accessible and readable for all types of colour-blindness. This is of vital importance to my application, and I am really satisfied with the outcomes. Based on these results, I have also decided to adopt this colour scheme and layout for the image targets in my application. In addition, I designed a new, separate location-based tracker and included a brief explanation to the image, making it more comprehensible and aesthetically pleasing. This will increase accessibility by clarifying the purpose of the image target. This is seen in the graphic below.

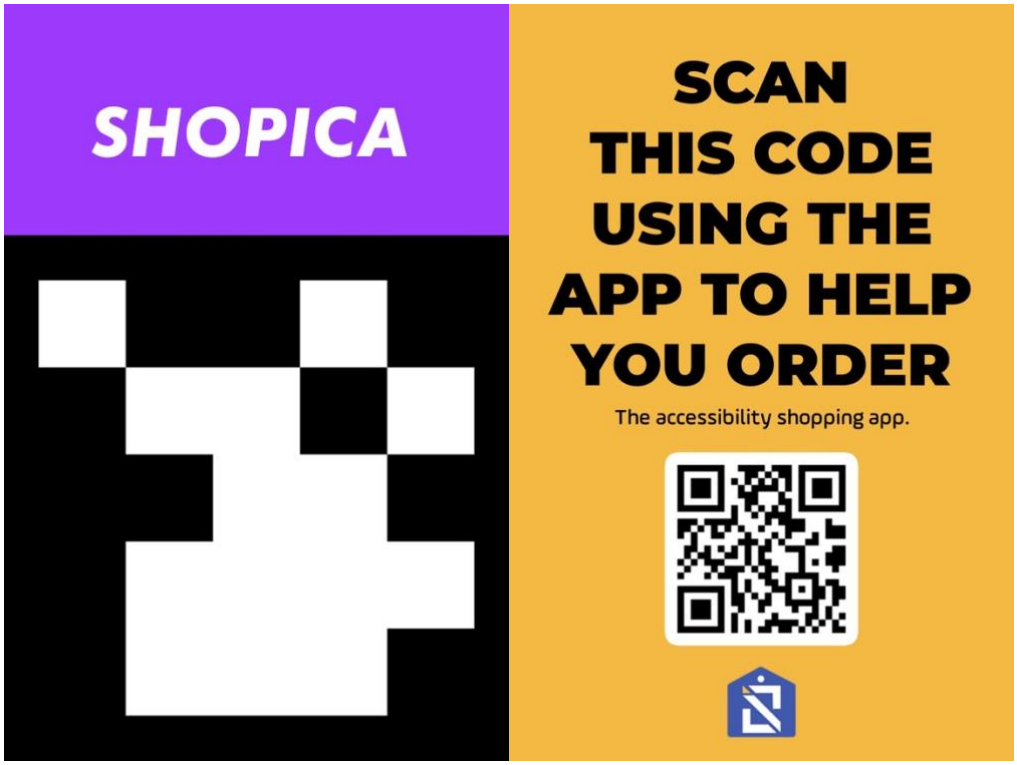


Figure 6: From left to right, the different location-based trackers, from the initial design to the final version

Building the prototype

Figure 7: The User Journey designed in Miro

I began mapping the user journey after developing the user personas. A location-based tracker will be installed at the entrance of every store to detect the user's location. This will ensure the application is modified accordingly, based on the

products in the store. Within the store, unique trackers with information about the products will be set on each shelf. When an order is completed, the products will be delivered by a staff member in the designated accessible area at the check-out counter. The subsequent stage requires user input; it needs them to select one of two options: "I'll take my time" and "I'm in a hurry." Both options indicate distinct approaches to the application's usefulness. On one hand, the first option is intended to be utilised when the user plans to shop alone and utilises the application to scan the targets located at the hard-to-reach shelves. The second one, on the other hand, allows customers to order products without entering the store. Regardless of the option the user selects, the outcome is always the same. The products from the basket are requested for purchase and brought to the appropriate location by a staff member.

To gain an understanding of the application's general structure, the development process began with a hand-drawn wireframe. Having a visual picture of how the application will look, helped the development of the prototype. During the process of defining the application, the functionality was prioritised over the design, saving time, and allowing for a clear image of how the application will perform. The objective of the Adobe XD prototype creation process was to generate a simple and aesthetically pleasing design.

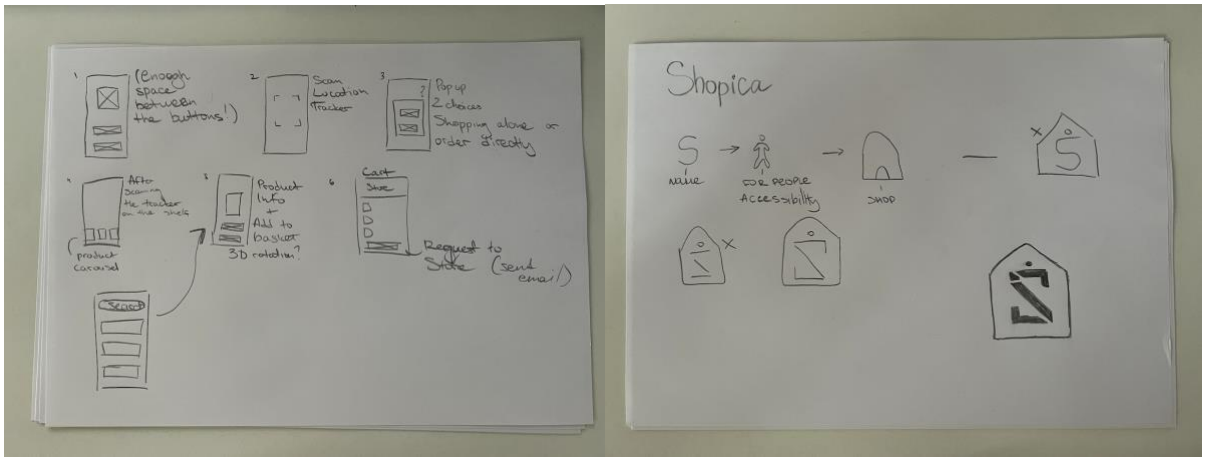


Figure 8: Hand-drawn prototype and logo design

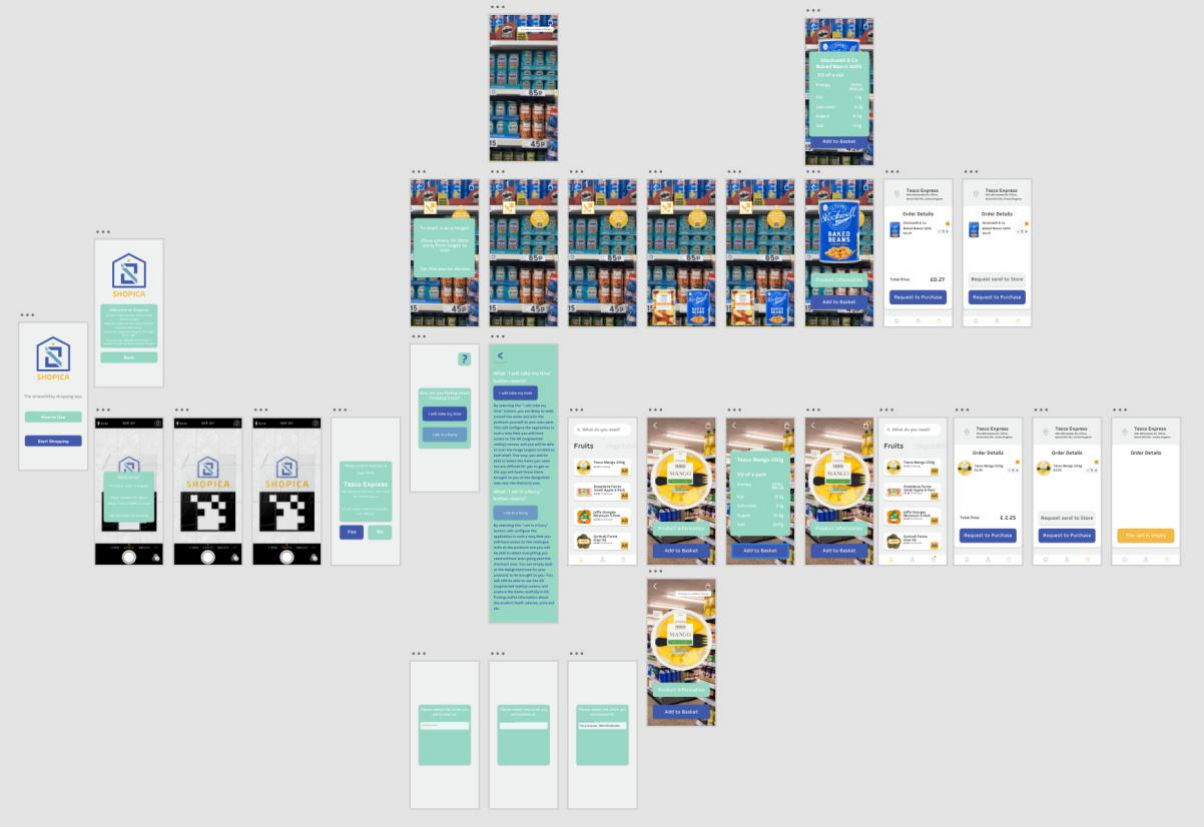


Figure 9: Hi-Fi Prototype in Adobe XD https://xd.adobe.com/view/943cb545-73c3-47bd-9983-c74cb106dbe7-c16f/

Bringing the idea to life

Having created the user personas, user journey, low and high-fidelity prototypes out of the to-do list, it was time for me to integrate the Vuforia augmented reality function. After successfully importing the database from Vuforia I had a very basic scene with one tracker and a button in no time. The process of creating the UI of the application went smoothly and did not require much expertise as for the most part the only function used was the ‘OnClick’ event. This allowed me to quickly develop something to work with and to proceed developing the application.

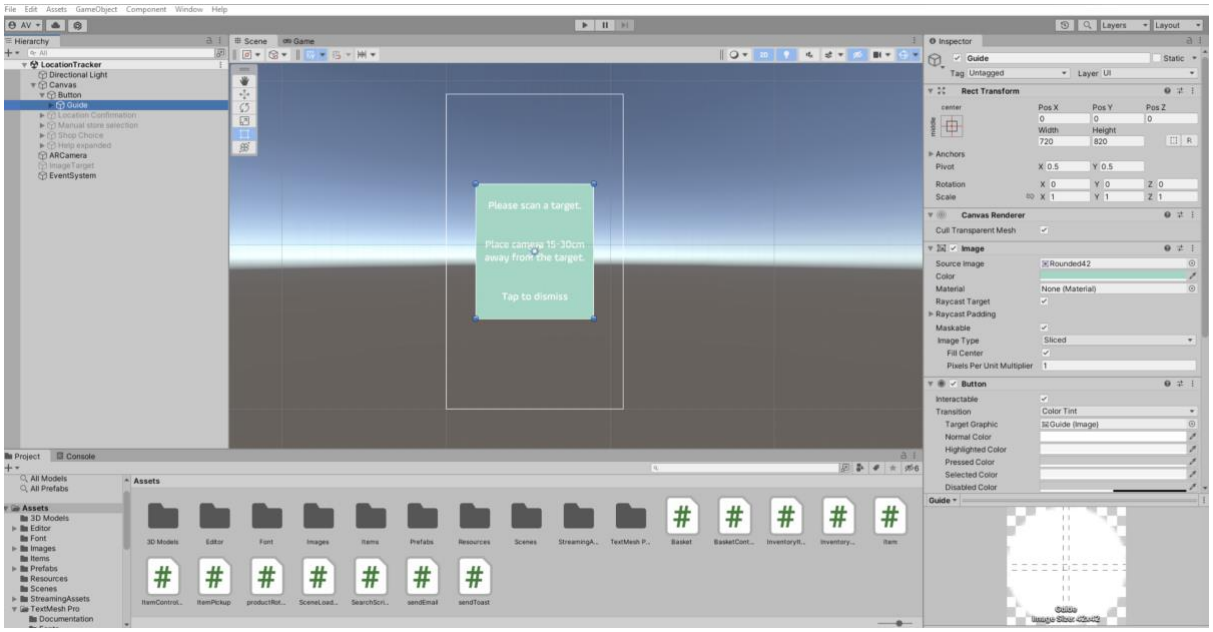


Figure 10: The development of the application within Unity

Assets creation

Because this mobile application has such a wide range of potential applications, I thought it would be helpful to illustrate how the app will work by using an HMV shop. My selections for the items to be displayed are a variety of DVD box sets. I made these by employing a simple array within Blender and then applying the textures that I found on a website called DVDcover.

Figure 11: The texture used to create the Game of Thrones DVD 3D model

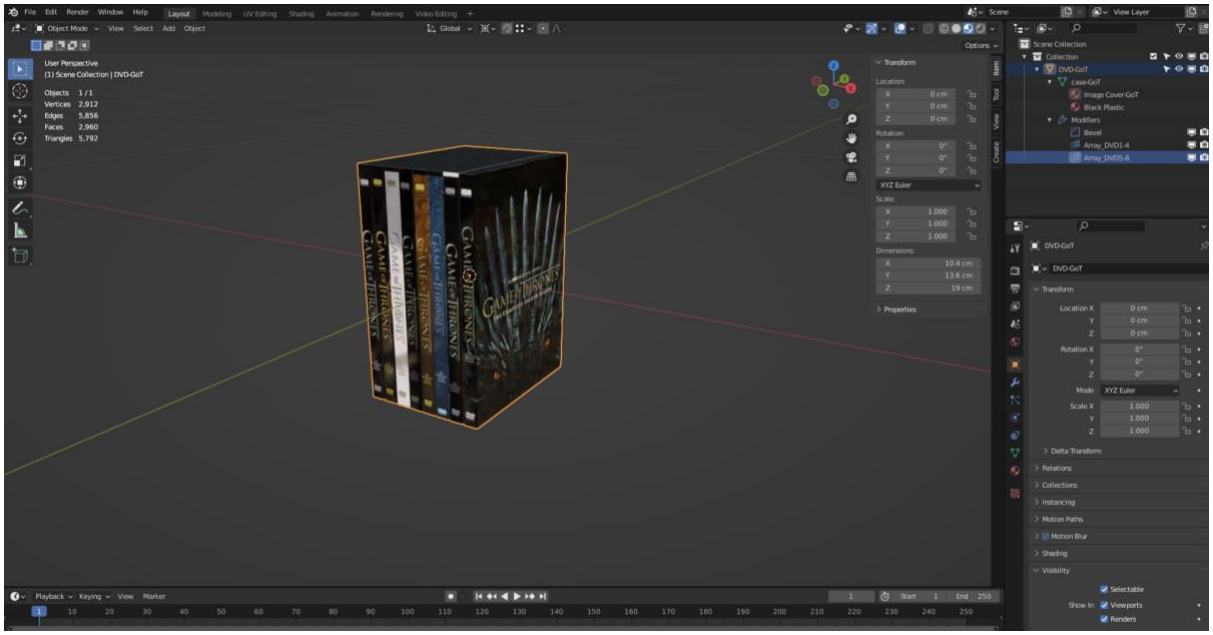
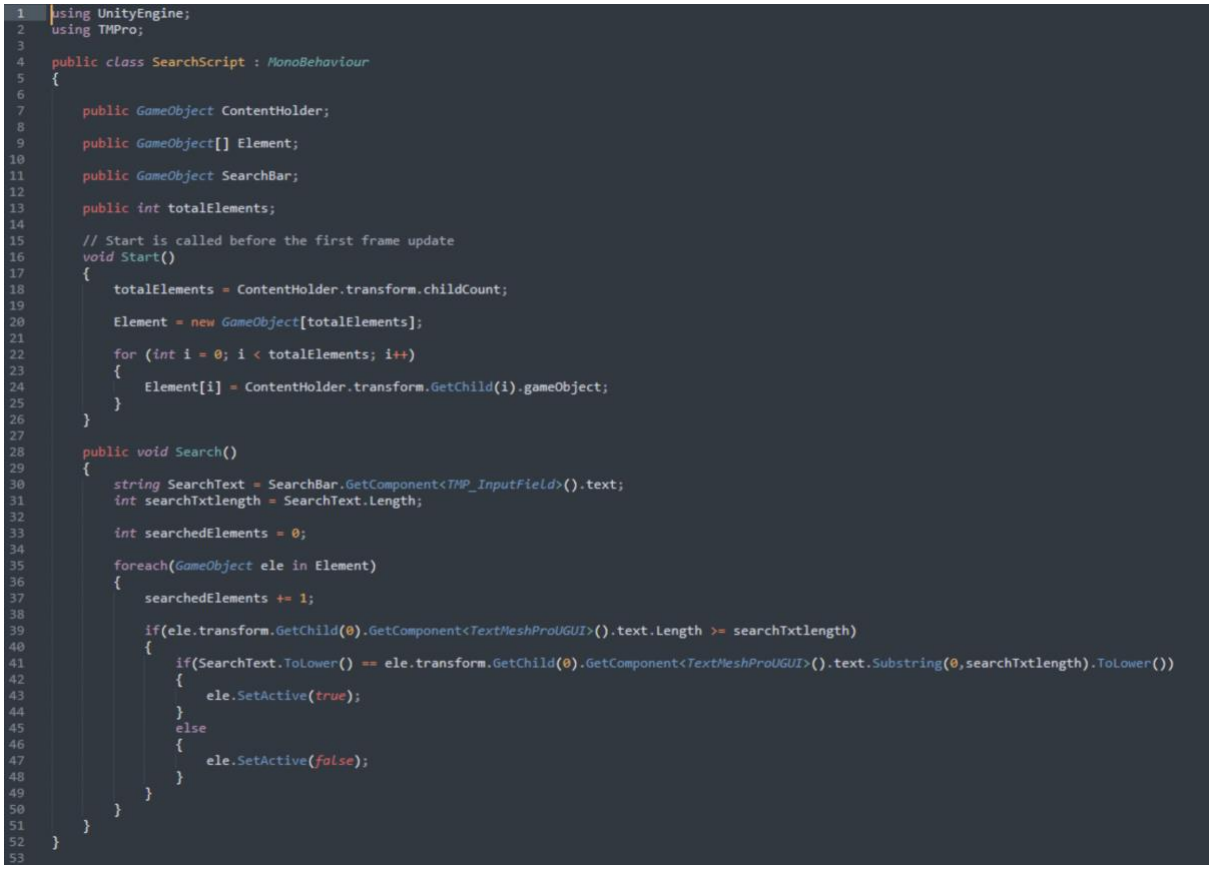


Figure 12: Screenshot of the development of the 3D model in Blender

Finishing touches

To make the application more accessible and user-friendly, I chose to develop a search mechanism that filters the products based on the user's search. This was the first challenge I encountered throughout the application's development, as it needed considerable understanding of the C# programming language. Prior to developing the script, my C# knowledge was very limited. However, after raising some questions in Unity's forum and watching a few tutorials, I was able to reproduce a wording search filter.



```
using UnityEngine;
using TMPro;

public class SearchScript : MonoBehaviour
{

    public GameObject ContentHolder;

    public GameObject[] Element;

    public GameObject SearchBar;

    public int totalElements;

    // Start is called before the first frame update
    void Start()
    {
        totalElements = ContentHolder.transform.childCount;

        Element = new GameObject[totalElements];

        for (int i = 0; i < totalElements; i++)
        {
            Element[i] = ContentHolder.transform.GetChild(i).gameObject;
        }
    }

    public void Search()
    {
        string SearchText = SearchBar.GetComponent<TMP_InputField>().text;
        int searchTxtlength = SearchText.Length;

        int searchedElements = 0;

        foreach(GameObject ele in Element)
        {
            searchedElements += 1;

            if(ele.transform.GetChild(0).GetComponent<TextMeshProUGUI>().text.Length >= searchTxtlength)
            {
                if(SearchText.ToLower() == ele.transform.GetChild(0).GetComponent<TextMeshProUGUI>().text.Substring(0,searchTxtlength).ToLower())
                {
                    ele.SetActive(true);
                }
                else
                {
                    ele.SetActive(false);
                }
            }
        }
    }
}

```

Figure 13: The search script developed for Shopica

Next, I decided to implement some onboarding and quality of life functions. During the creation and self-testing of the app, it became evident to me that there was a need for order-specific feedback. The app user will be unaware that the brief pause signifies that a request has been submitted and may mistakenly believe that the app is not functioning. Consequently, I was required to add a function to the button that shows a confirmation message to the user. I discovered that an Android "toast" was the most effective way to accomplish this. Typically, they are used for crucial notifications in programmes or built-in tasks. As they are presented above the programme on-screen, they cannot be obscured, and they are consistent across devices given that they are an integral element of Android's functionality. The utilised

script may be seen in the image below.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class sendToast : MonoBehaviour
{
    AndroidJavaObject currentActivity;

    public void Start()
    {
        AndroidJavaClass UnityPlayer = new AndroidJavaClass("com.unity3d.player.UnityPlayer");
        currentActivity = UnityPlayer.GetStatic<AndroidJavaObject>("currentActivity");
    }

    public void toastMessage(string message)
    {
        AndroidJavaObject context = currentActivity.Call<AndroidJavaObject>("getApplicationContext");
        AndroidJavaClass Toast = new AndroidJavaClass("android.widget.Toast");
        AndroidJavaObject javaString = new AndroidJavaObject("java.lang.String", message);
        AndroidJavaObject toast = Toast.CallStatic<AndroidJavaObject>("makeText", context, javaString, Toast.GetStatic<int>("LENGTH_LONG"));
        toast.Call("show");
    }
}
```

Figure 14: C# Script of Android Toast Message Functionality

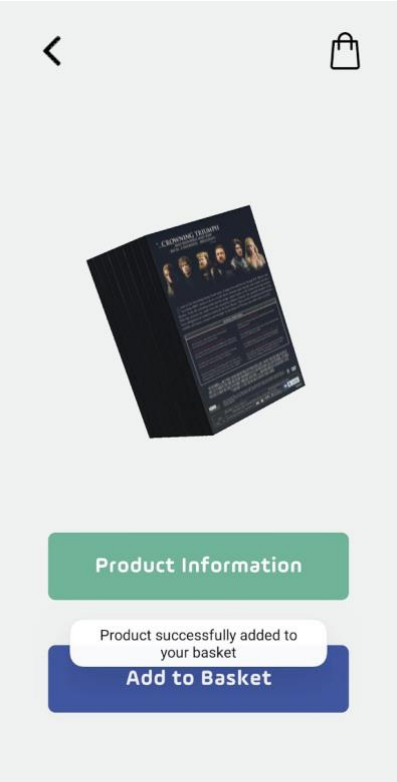


Figure 15: An example of a Toast message

The script instructs Unity to show an Android Toast message. It accomplishes this using the following code: *AndroidJavaClass("android.widget.Toast").* This script also accepts a public variable that may be assigned in the Unity editor and passes it to the engine as a string that is shown as a toast message. There are two length options available for toast messages: long and short. A long toast message stays on screen for 5 seconds, while a short one appears for 3 seconds.

What went wrong

As anticipated, not everything went as planned. For example, the largest challenge I faced was implementing an email capability within the application. I developed a script that utilises the SMTP email protocol. When the user presses a given button, the script signs into a specified email account and sends an automated email containing the requested product name. Nevertheless, I spent weeks attempting to determine what was wrong with my script. I contacted several YouTubers and posted on forums, but to no avail. After exploring how this would operate for over a month, I discovered an article stating that this function will no longer be available as of the end of October 2022, as Google has modified their privacy protocols, so further development in this area was ceased.

```
using System.Collections;
using System.Collections.Generic;
using System.ComponentModel;
using UnityEngine;
using UnityEngine.UI;
using System.Net;
using System.Net.Mail;
using System.Net.Security;
using System.Security.Cryptography.X509Certificates;

public class sendEmail : MonoBehaviour
{
    // Start is called before the first frame update
    void Start()
    {
        // Command-line argument must be the SMTP host.
        SmtpClient client = new SmtpClient("smtp.gmail.com", 587);
        client.Credentials = new System.Net.NetworkCredential(
            "shopicaapp@gmail.com",
            "shopicauwe123456");
        client.EnableSsl = true;
        // Specify the email sender.
        // Create a mailing address that includes a UTF8 character
        // in the display name.
        MailAddress from = new MailAddress(
            "shopicaapp@gmail.com",
            "Shopica",
            System.Text.Encoding.UTF8);
        // Set destinations for the email message.
        MailAddress to = new MailAddress("atanasvoynov@gmail.com");
        // Specify the message content.
        MailMessage message = new MailMessage(from, to);
        message.Body = "This is a test email message sent by an application. ";
        message.BodyEncoding = System.Text.Encoding.UTF8;
        message.Subject = "test message 1";
        message.SubjectEncoding = System.Text.Encoding.UTF8;
        // Set the method that is called back when the send operation ends.
        client.SendCompleted += new SendCompletedEventHandler(SendCompletedCallback);
        // The userState can be any object that allows your callback
        // method to identify this send operation.
        // For this example, the userToken is a string constant.
        string userState = "test message1";
        client.SendAsync(message, userState);
    }

    private static void SendCompletedCallback(object sender, AsyncCompletedEventArgs e)
    {
        // Get the unique identifier for this asynchronous operation.
        string token = (string)e.UserState;

        if (e.Cancelled)
        {
            Debug.Log("Send canceled "+ token);
        }
        if (e.Error != null)
        {
            Debug.Log("[ "+token+" ] " + " " + e.Error.ToString());
        }
        else
        {
            Debug.Log("Message sent.");
        }
    }
}
```

Figure 16: The script I intended to use to send email confirmations

Another challenge I abandoned was developing a completely functional inventory system. A system that will add a product to the basket, display the product price, and stack the items inside the basket if the same item is added twice. Due to time constraints and a lack of topic expertise, I was unable to achieve this goal and the final version of the inventory system included only a function that added the products to the basket without stacking them.

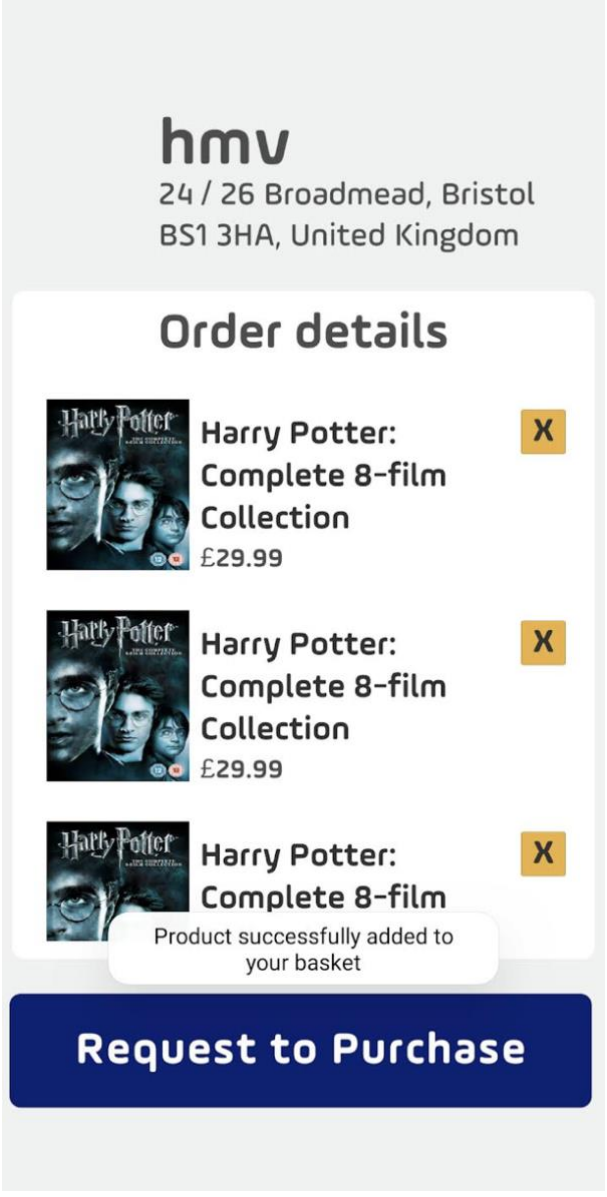


Figure 17: An example of the same product added a few times inside the basket

User Testing

As soon as I had a working prototype of my application, I proceeded with doing user testing, a vital step in the development process. The Likert scale (1932) was used to test the application with different user groups. It is a five-step scale that allows an individual to express how much they agree or disagree with a particular statement. Participants were told that this was not a test of their abilities but rather of the usefulness of the application. In addition, they were reminded that there was no time restriction, and they could take as much time as they wanted. In addition, participants were informed that they might opt out at any moment. The Google Form was sent to 20 people who are Android users along with the application itself. Four of them were not able to complete the form because their devices did not support the AR function. Thus, a total of 16 responses were received.
The 5-step protocol for this test is as follows:

- The user downloads "Shopica."
- The user makes sure to have a clear understanding of how the application works after reading and watching the documentation provided.
- Users should ensure that the trackers provided are easily visible.
- The user interacts with the application for 10 minutes.
- The user completes a post-test Google Form (the form contains 7 questions with a box at the end for any additional feedback).

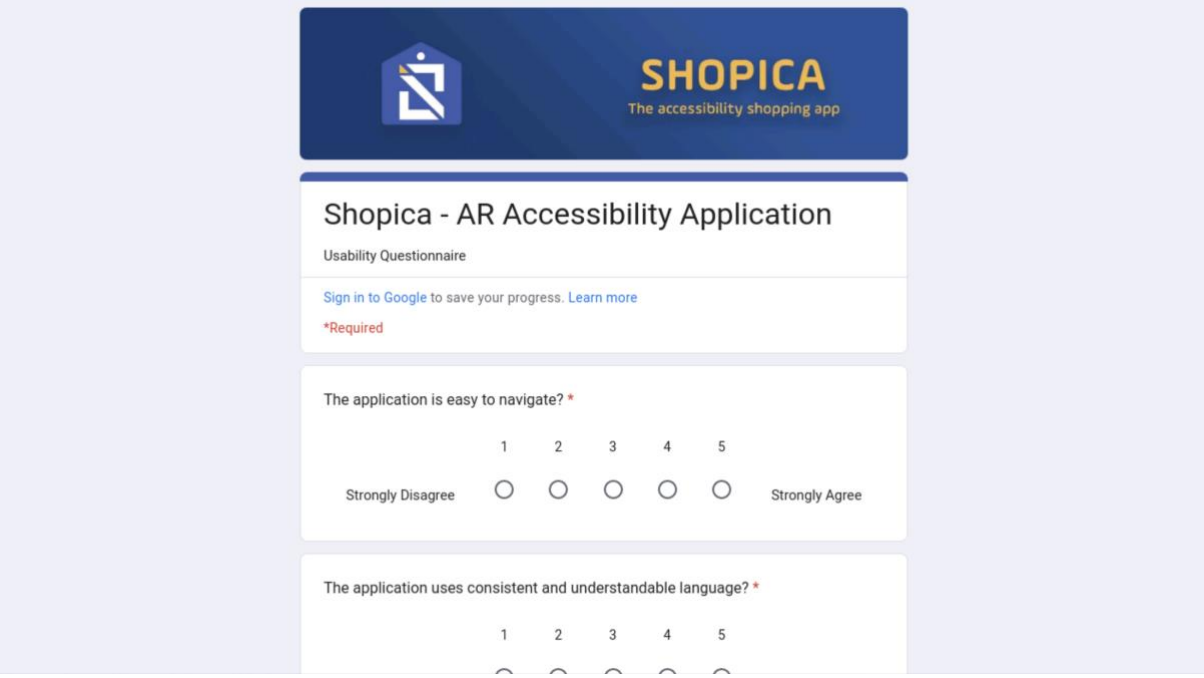


Figure 18: The Usability Questionnaire - https://forms.gle/2jh78hPWF7yNqraV9

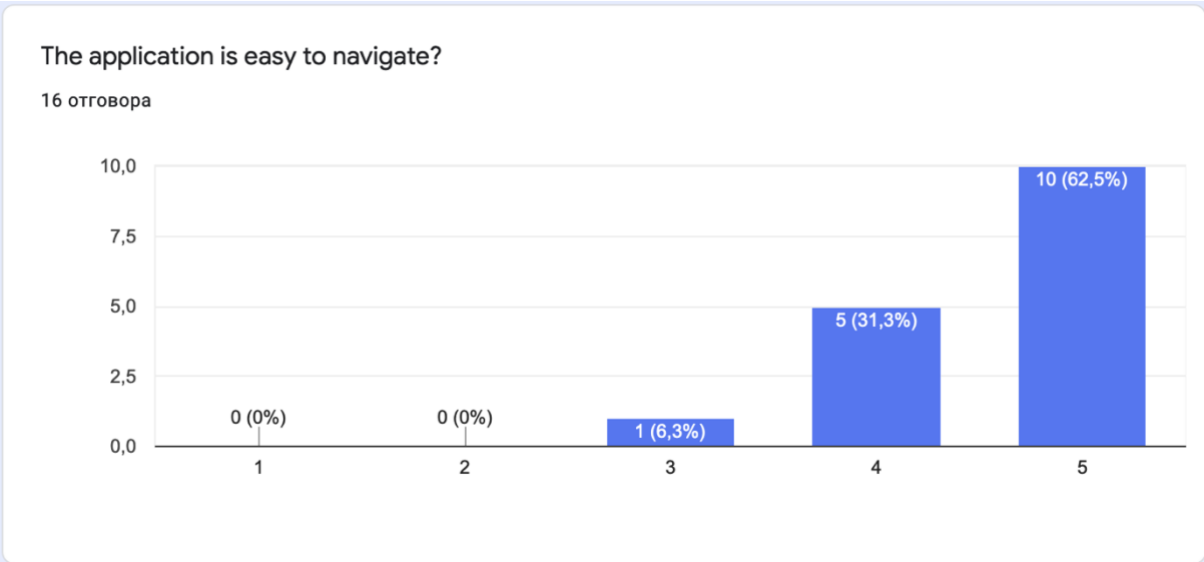


Figure 19: The answers to Question 1

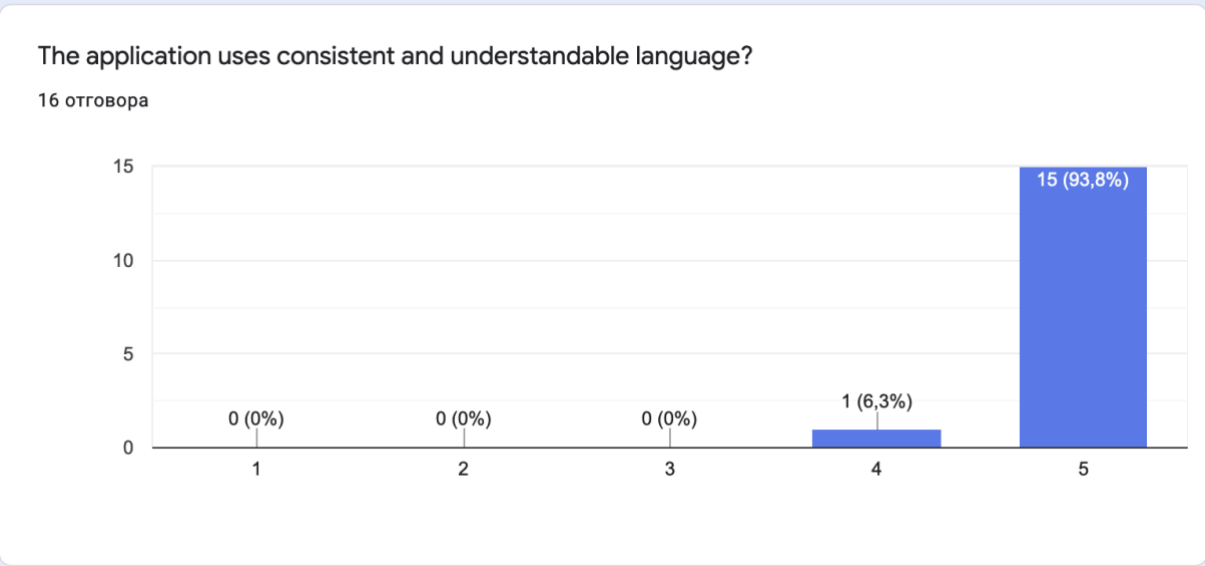


Figure 20: Question 2 answers

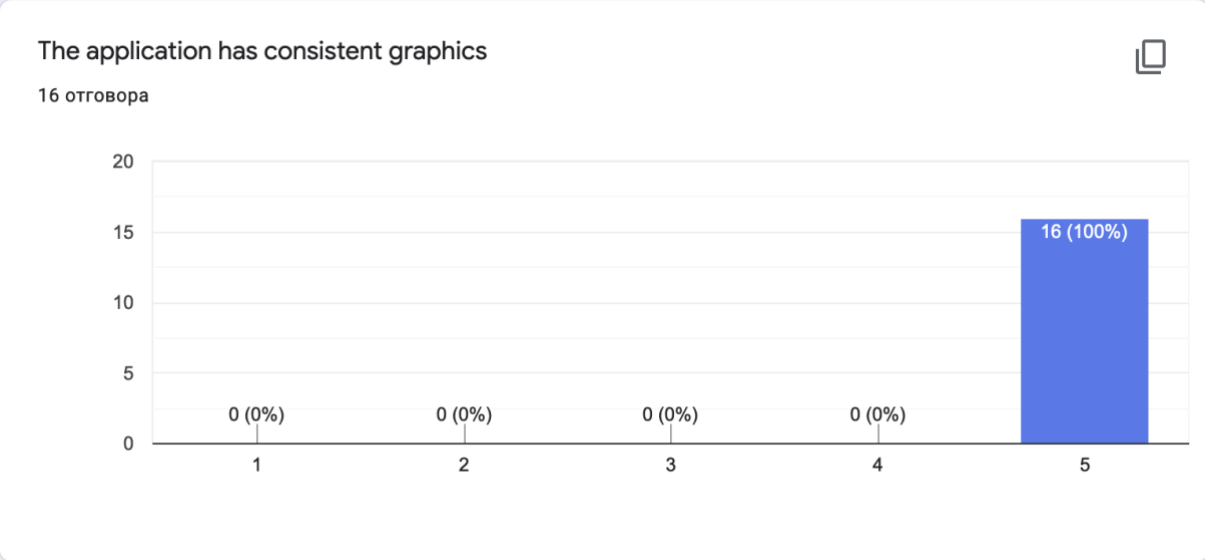


Figure 21: Question 3 answers

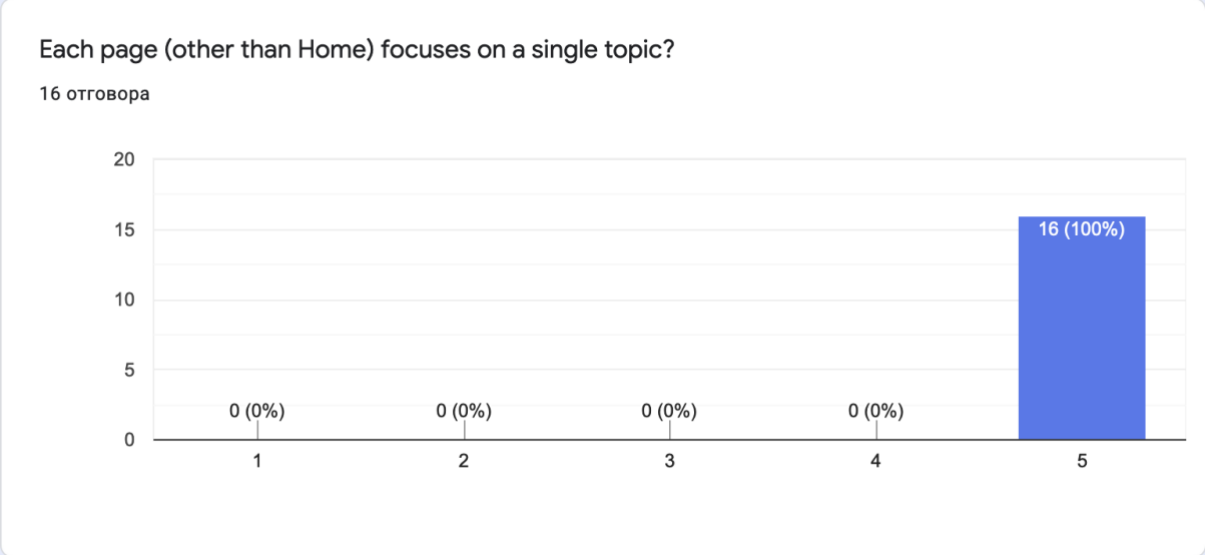


Figure 22: Question 4 answers

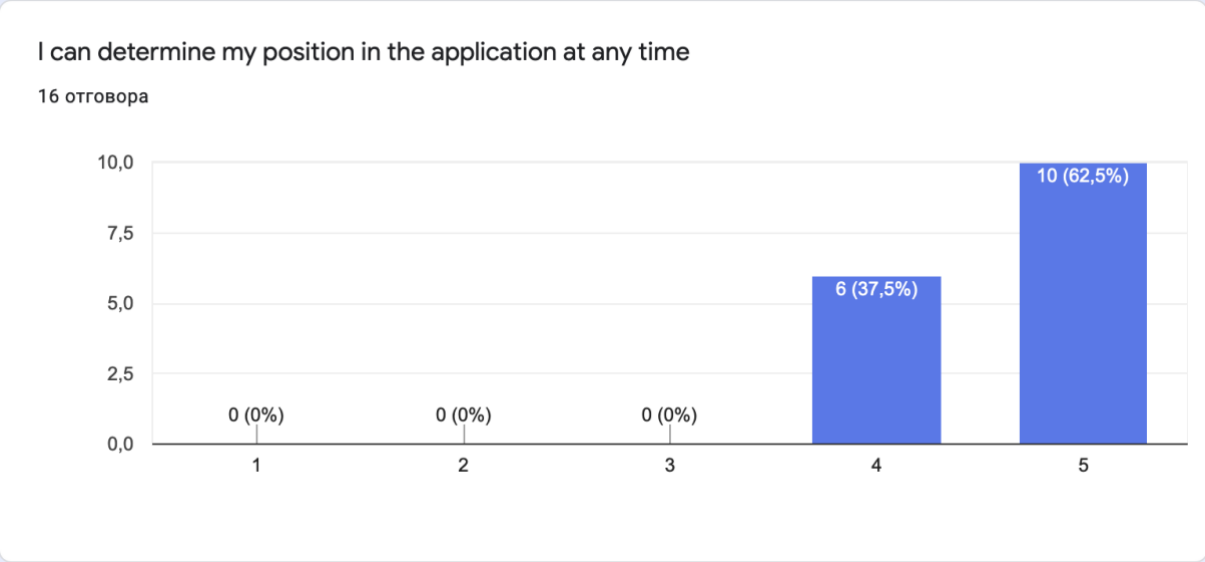


Figure 23: Question 5 answers

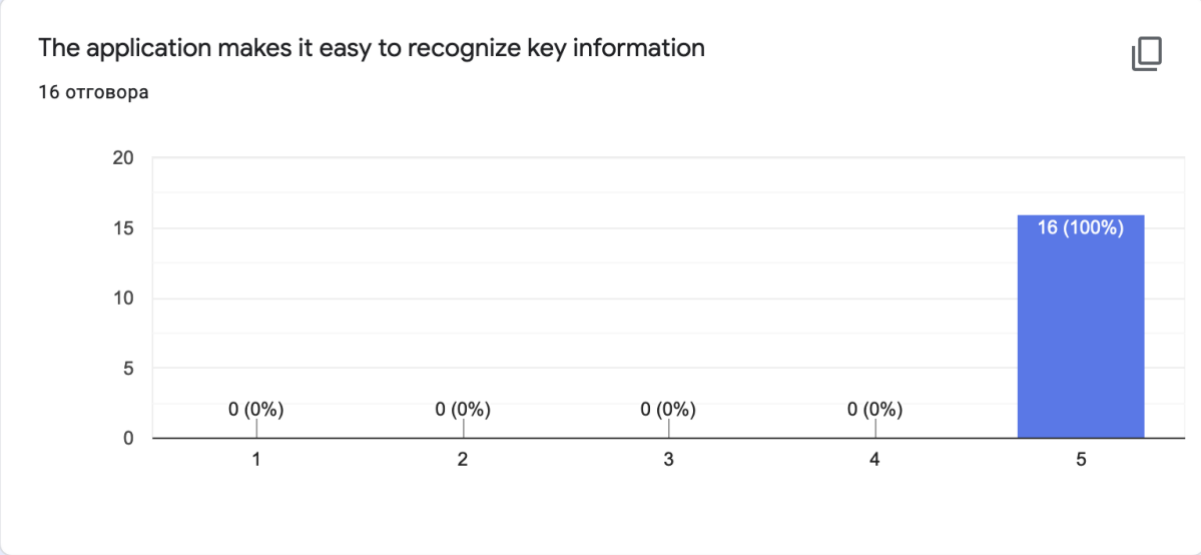


Figure 24: Question 6 answers

Conclusion

In response to the research question stated at the beginning of this essay, this study has explored how the utilisation of AR as a new medium of experience benefits those with disabilities by making shopping more accessible. Despite its modest size, Shopica as an augmented reality experience has the potential to develop into one that can stand proudly within this medium. AR assists the user in overcoming both physical and mental barriers. I feel that I have identified a way to assist a marginalised community that businesses have not. In the future, I would explore server-side implementation of augmented reality, storing 3D models and product data on a server. I would also consider adding animation, because I feel this would give the application a more fluid appearance. I feel that the project described in this paper has effectively explored the main goal despite the elaborated-on limits. However, Shopica's primary objective is usability, therefore the simpler it is, the better. The process of development has helped me advance as a professional by exposing me to guidance and constructive criticism, which has allowed me to improve my application. I have also amassed extensive Android developer skills and expertise.

Appendices

Project files:

OneDrive:

https://uweacuk-my.sharepoint.com/:f:/g/personal/atanas2_voynov_live_uwe_ac_uk/EiwWMEIHRsdKjChhoVPw9mABnD78TV-J2ldybQi_MPleDw?e=gCmC8Q

Alternative Google Drive link:

https://drive.google.com/drive/folders/1UOCNUIbgEw8fJwOnHEuVfc32vynq82kQ

Shopica's website:

https://www.shopica.frostedkiwi.com

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